City of Wanneroo

Coastal Hazard Risk Management and Adaptation Plan

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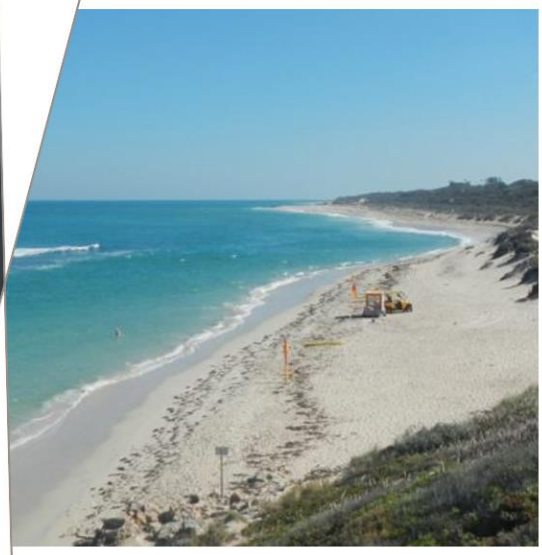

Prepared for

City of Wanneroo

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Executive Summary

The City of Wanneroo is preparing for the threats of climate change and sea level rise to its coastal assets and values. This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared to provide a long term view of the potential future coastal hazards for the City, and highlight possible strategies to adapt to the changing future oceanic and coastal conditions.

Development of the City's CHRMAP has followed the requirements of *Western Australian State Planning Policy No. 2.6: State Coastal Planning Policy* (SPP2.6) (WAPC, 2013a) and supporting guideline documents. Initially, a coastal hazard assessment was undertaken to determine potential extents of coastal erosion and inundation hazards over future planning timeframes to 2120 (MRA, 2015a). From this, key vulnerable areas were identified along the City's coastline. The risk and vulnerability assesment was applied to each area and results identified the most vulnerable assets and vulnerability timeframes, for which more detailed assessment of adaptation options were investigated. This assessment was guided by the values of the community, ascertained through stakeholder engagement.

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

The recently released *Draft Planned and Managed Retreat Guidelines* (WAPC, 2017) outline the recommended process for implementing future managed retreat, which includes compensation to landholders under provisions in the *Land Administration Act (1997)*. Managed retreat is unlikely to be financially feasible on a large scale, in the immediate term in the City, unless the State or Commonwealth Governments provide the majority of funding to acquire property. It is important to note that while the eventual implementation of the managed retreat option is recommended in this CHRMAP, its future implementation will need further investigation of the implications for both Governments and Private stakeholders. Nevertheless, the City should engage with its community and begin preparations to adopt adaptation pathways involving eventual managed retreat of vulnerable assets, as this will be the most economically responsible and equitable approach over the long term. This approach is also likely to be required to ensure beach amenity and a suitable foreshore reserve is preserved for the community, as mean sea level rises.

Through further detailed economic and feasibility assessment, it is likely that the implementation of interim protection measures in some areas will be found to provide overall benefit to the City. Interim protection would also delay the expensive implementation of managed retreat. A number of options have been identified that aim to protect developed areas likely to become highly vulnerable to coastal erosion in the short to medium term (i.e. by 2050). The implementation of protection measures should be carried out under the "beneficiary pays" principle, and ensure that the provision of a beach and foreshore for the enjoyment of the wider community is not compromised. A key challenge for the City will be determining who the beneficiaries of coastal management are, and installing methods to apportion costs appropriately.

The CHRMAP process is designed to be ongoing, with regular updates associated with the emergence and collection of new information. This information could be collected by the City to refine the accuracy of predicted risk to its assets. It could also be based on environmental factors that are largely beyond the City's control, such as changes to mean sea level and the rate of sea level rise. Key recommendations have been made, based on the findings of this CHRMAP, for implementation before 2030 and in the lead up to the next CHRMAP revision. These are summarised in the table below, with details around the recommendations provided in **Section 6** of this report.

ID	Recommendation
R1	***Engage the community to present the results of this CHRMAP and formally assess their willingness to contribute to funding.***
R2	***A detailed economic assessment should be undertaken to establish the economic value/contribution of natural assets in key vulnerable areas.***
R3	***Investigate and establish a fund for ongoing coastal adaptation and management, and allocate funding sources.***
R4	***Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.***
R5	***Investigate the benefits of amending DPS2 to directly reference SPP2.6 and include vulnerable areas as Special Control Areas (SCAs).***
R6	***Landholders that may be affected by coastal hazards by 2120 should be notified directly and by the application of notification on Certificates of Title, where possible.***
R7	***Initiate/continue targeted beach nourishment in vulnerable areas.***
R8	***Undertake a detailed options assessment for management of coastal vulnerability at Yanchep.***
R9	***Undertake a detailed cost-benefit analysis to accompany the existing options assessment at Two Rocks.***
R10	***Set up a coastal asset inventory and emergency/damage response plan to respond to potential coastal impacts.***
R11	***Initiate a long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, and coastal asset condition assessments.***
R12	***Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment.***
R13	***Undertake a full revision of the City's CHRMAP, identifying and incorporating relevant new information.***

Abbreviations and Acronyms

Abbreviation	Description
ARI	Average Recurrence Interval
AEP	Annual Exceedance Probability
AS	Australian Standard
BoM	Bureau of Meteorology
CHRMAP	Coastal Hazard Risk Management and Adaptation Plan
DoP	Department of Planning (now part of DoPLH)
DoPLH	Department of Planning, Lands and Heritage
DoT	WA Department of Transport
GIS	Geographic Information System
HSD	Horizontal Shoreline Datum (see SPP2.6)
IPCC	International Panel on Climate Change
LAA	Land Administration Act (1997)
LGA	Local Government Area
MCA	Multi-criteria analysis
MRA	MP Rogers & Associates
MRS	Metropolitan Region Scheme
MSL	Mean sea level
SCA	Special Control Area
SLR	Sea Level Rise
SPP	State Planning Policy
SPP2.6	State Planning Policy No 2.6: State Coastal Planning Policy (WAPC, 2013)
The City	City of Wanneroo
TPS2	Town Planning Scheme No. 2
WA	Western Australia
WAPC	Western Australian Planning Commission

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1 Introduction

1.1 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], 2014), 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. *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. The WA State Government revised the State Coastal Planning Policy in 2013 to incorporate a projected SLR for WA of 0.9 m between 2010 and 2110 (**Figure 1-1**).

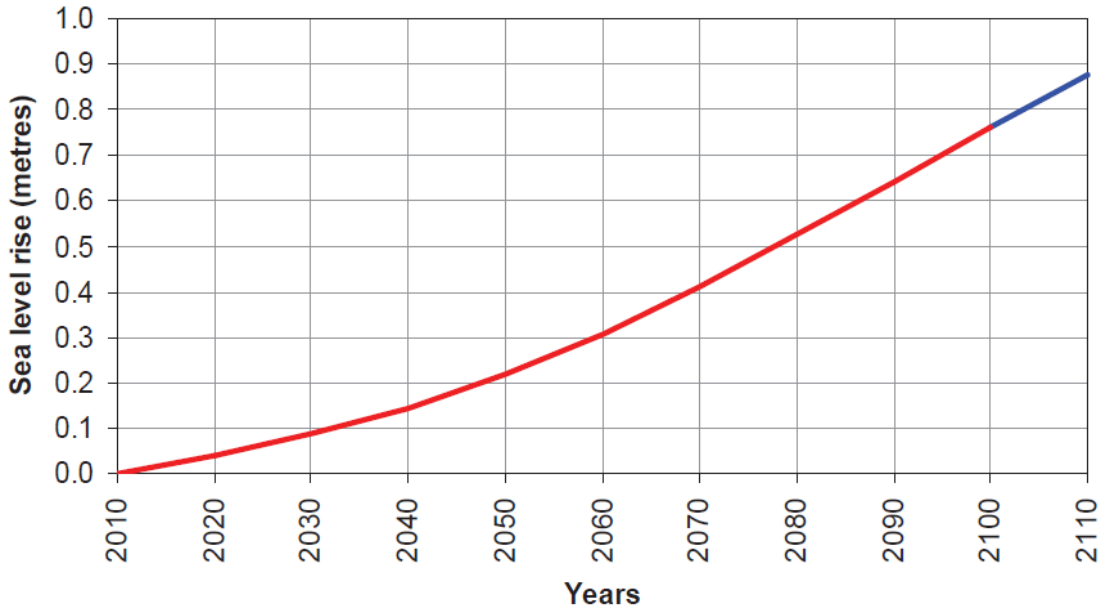

Figure 1-1 Recommended allowance for sea level rise in coastal planning in Western Australia (DoT, 2010).

The Wanneroo Local Government Area (LGA) coastline is generally sandy with intermittent limestone outcrops, featuring coastal dunes, nearshore reefs, islands and seagrass meadows. For sandy coastlines, increases in local MSL generally result in shoreline recession, with a “rule of thumb” often used, that a 1 cm rise will result in 1 m of landward recession of the shoreline (**Figure 1-2**; CoastAdapt, 2017). It should be noted that this is based on the “Bruun Rule” which is generally considered a conservative approach (Rosati et al, 2013; Cooper & Pilkey, 2004).

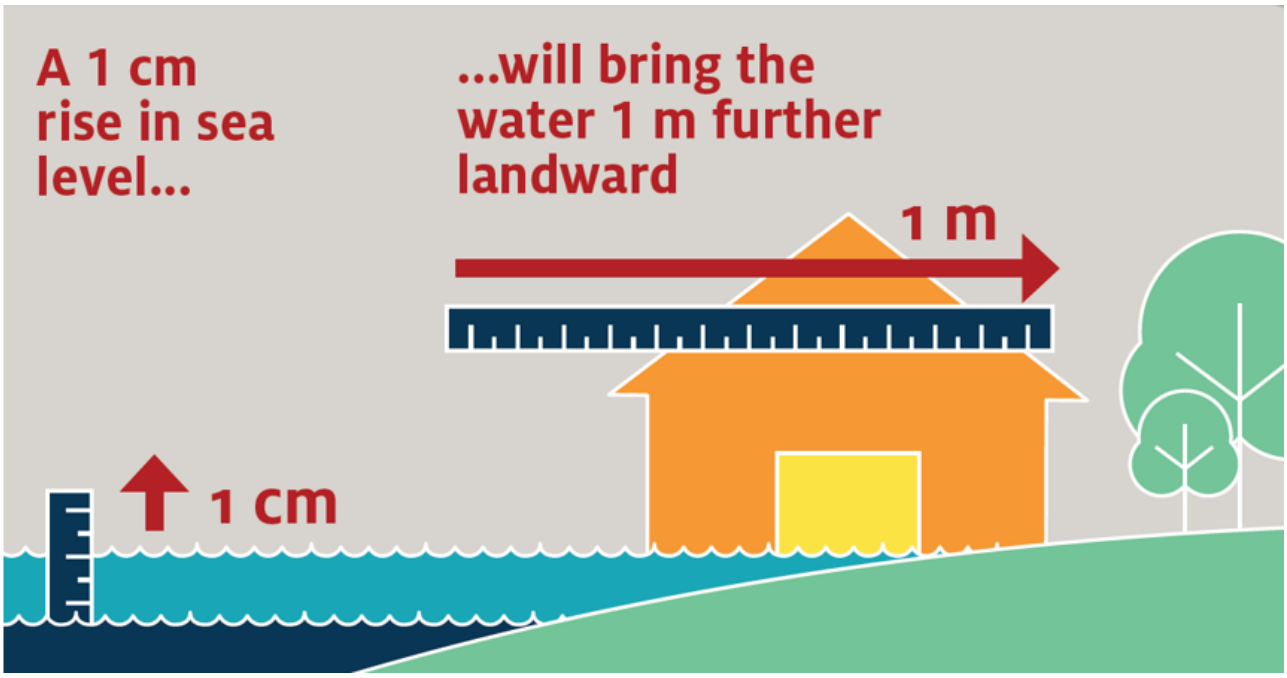

Figure 1-2 Simplified schematic of how sea level rise will impact shorelines (CoastAdapt, 2017).

The City of Wanneroo (the City) has developed a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP), with technical input from Cardno, to identify risks and plan to adapt to the potential impacts associated with predicted SLR along their coastline.

The purpose of the CHRMAP process is to:

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

1.2 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], 2013a) (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, 2013b) contain prescriptive details, for example in relation to scales of assessment, storm event types and SLR allowances.

The WAPC (2014a) has also developed the *Coastal hazard risk management and adaptation planning guidelines* (the CHRMAP Guidelines) which are less prescriptive, but are aimed to ensure that planning is carried out using a risk based approach with due regard given to stakeholder engagement, community consultation and education, and that a full range of adaptation options is considered. An overview of the CHRMAP process followed in this project 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) and *Statement of Planning Policy No. 3: Urban Growth and Settlement* (WAPC, 2006).

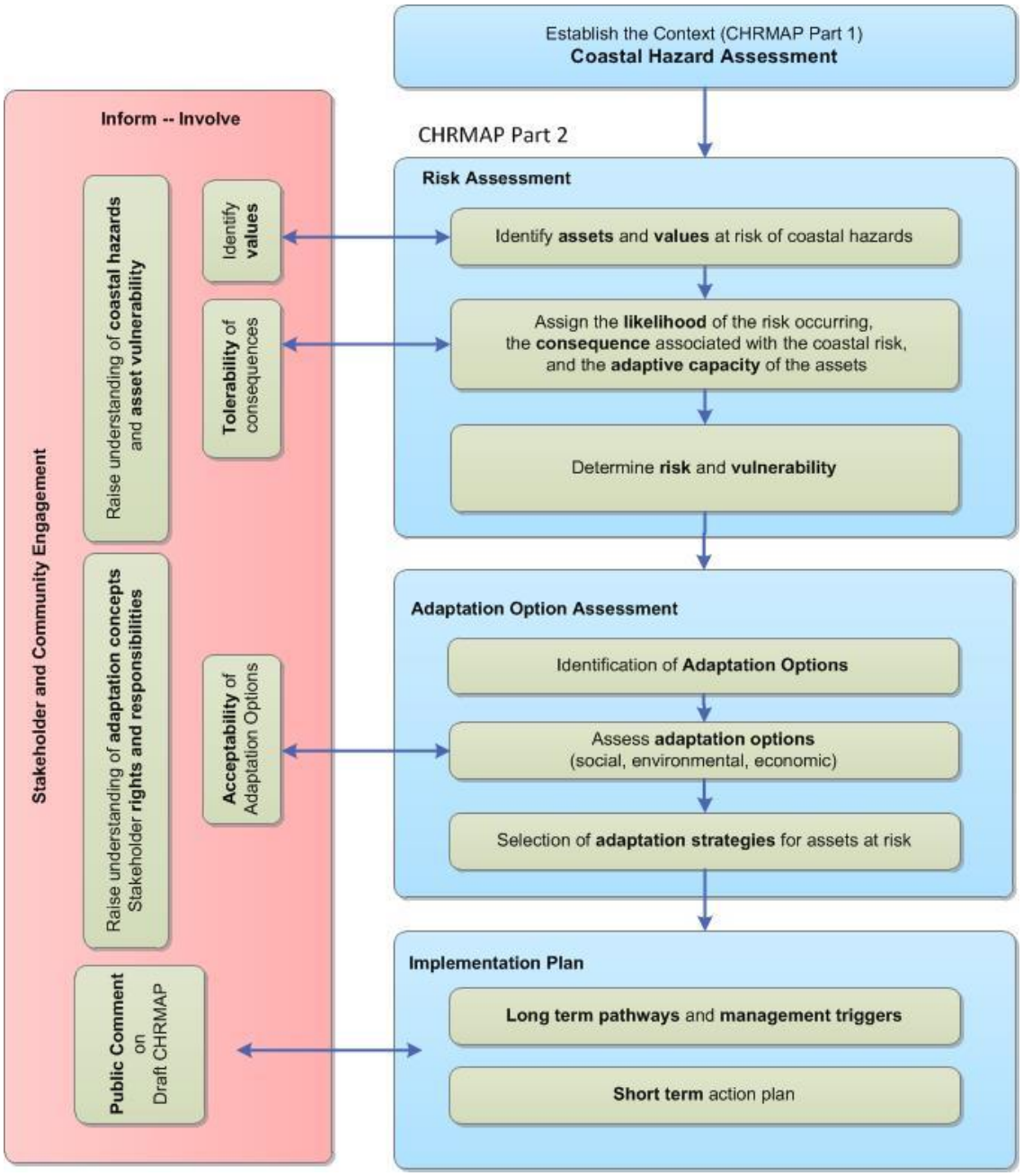

Figure 1-3 CHRMAP methodology flow chart (adapted from the CHRMAP Guidelines (WAPC, 2014a)).

1.3 Success Criteria

The success criteria have been developed based on the results of the Coastal Values Survey, to underpin the CHRMAP process. Details of the survey and other community engagement is contained within the Community Engagement Summary Report (**Appendix A**). These criteria were incorporated to determine consequence ratings during the risk assessment process. They have also been considered and referred to during the identification and assessment of adaptation options. The criteria are as follows:

SC1. Preservation and protection of important environmental sites and plant and animal communities;
SC2. Prioritisation of public safety at beaches and in foreshore areas;
SC3. Encouragement of coastal use through the provision and maintenance of public access and facilities at beaches and foreshore areas;
SC4. Protection and preservation of beaches and foreshore areas for recreational and passive use;
SC5. Provision and protection of foreshore areas for housing*;
SC6. Use and protection of foreshore areas for local economic benefit;
SC7. Provision and protection of beach and foreshore access infrastructure (e.g. roads, carparks, paths); and
SC8. Maintenance and protection of indigenous and archaeological heritage sites within the beach and foreshore areas.

*This success criteria refers to the protection and preservation of adequate public foreshore areas with existing development on their landward side. It should be noted that while this success criteria (SC5) received some support from the community, it is not compliant with SPP2.6 with respect to new development (assuming 'foreshore areas' are within the coastal foreshore reserve). Selecting the 'Protect' approach is considered least desirable, in general, under the risk management and adaptation hierarchy, as outlined in the CHRMAP guidelines (WAPC, 2014). All other success criteria have implications that are generally equitable to all community members, now and into the future, with respect to the use of coastal and foreshore areas. Alternatively, the implications of SC5 are likely to be beneficial to a select group of community members (i.e. protected landowners) and potentially detrimental to other members of the community, such as beach users and ratepayers contributing to the protection measures.

It is also noted that legally there is no obligation of the State or Local Governments to either protect public and private assets within the coastal erosion zone, nor to compensate for any losses incurred due to erosion. While SC5 was considered a community aspiration it must be recognised that assets currently located in future potential impact zones are subject to a rigorous procedure for determining there suitability to attract State or Local Government funding for mitigation works.

1.4 Guiding Principles and Concepts

Underlying the CHRMAP process are a number of guiding principles and concepts which are fundamental to understanding the purpose and outcomes of the process. These are outlined in the following subsections.

1.4.1 Equity

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

Responsibility for coastal planning lies with both State and Local Governments, and in making decisions these authorities need to consider equity of access, equity of enjoyment and equity in terms of who benefits, who is disadvantaged, who should pay and the subsequent allocation of public resources.

Equity is also relevant to considerations about how a protection structure (for example a groyne) might impact coastal processes. Protection structures may exacerbate erosion adjacent to the structure, and limit sediment availability for maintaining beaches and community values 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). Coastal protection may create beneficiaries (those who are protected from hazards) and potentially disadvantage others who would be considered to be affected parties. In this regard, coastal management has similarities to the management of water rights, if one user takes all

the water upstream and leaves none for downstream users then this is not considered fair and equitable. In a future of eroding coastlines due to SLR, sand can be a valuable commodity.

Intergenerational equity is also a key consideration of the CHRMAP process, underpinned by the 100-year planning timeframe considered. Continuing to develop the coast as it has been developed in the past will create 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. The challenge is to ensure that planning and management is as transparent and equitable as possible.

1.4.2 Coastal Foreshore Reservation

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

SPP2.6 Schedule One provides guidance for calculating the component of the coastal foreshore reserve required to allow for coastal processes, to be contained in an appropriate coastal foreshore reserve (determined in accordance with SPP2.6 Clause 5.9) of greater width. This should ensure that, at the end of the planning timeframe, a coastal foreshore reserve is still present and not exposed to the adverse impacts of erosion and inundation. It is behind this reserve that additional development is able to be considered. Having said this, Schedule One also contains Clause 7 – Variations, which outlines specific instances where certain types of development may be considered appropriate within a coastal foreshore reserve, regardless of the allowance for physical coastal processes.

The allowance for physical processes is based on the 100-year coastal erosion hazard line (the 2120 planning timeframe in this CHRMAP), determined in accordance with SPP2.6. In addition to the allowance for physical processes, the foreshore reserve should include land allocation for maintaining the values, functions and equitable use of the coast over the 100-year planning timeframe (see **Figure 1-4**).

Providing easy public access to the beach and coastal foreshore reserves is a fundamental coastal planning objective. The coast and coastal foreshore reserves are public assets which should not, now or in the future, become the exclusive domain of private landholders by virtue of the erosion of coastal reserves or other coastal processes. Coastal reserves should be wide enough to perform recreation and/or conservation functions (according to the reasons for their initial designation) even if they are permanently affected by coastal erosion due to SLR. Where existing assets and/or infrastructure are located within the coastal hazard areas, the existing coastal foreshore reserve may not be sufficiently wide to ensure that the values, functions and equitable use of the coast can continue to be provided for over the 100-year planning timeframe without management intervention.

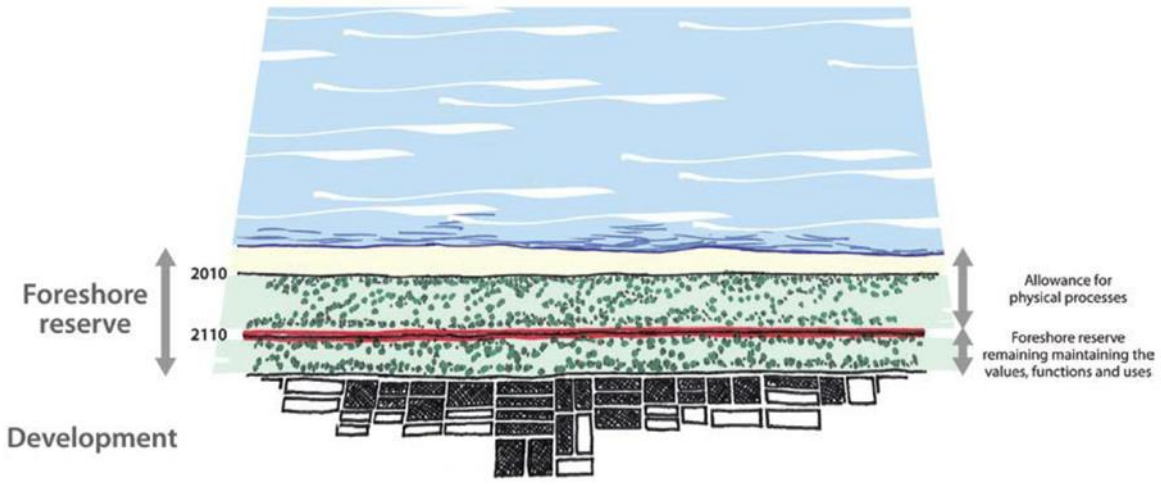

Figure 1-4 Coastal foreshore reserve – sandy coast example (WAPC, 2013b).

1.4.3 Rights and Responsibilities

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

Nonetheless, it is the aim of all levels of government to protect the interests of all Australians, and the CHRMAP process ultimately intends to minimise risks and maximise beneficial use of the coast from an economic, social and environmental perspective. Mechanisms for managed retreat may require public expenditure and in some instances, where overall public good can also be demonstrated, protection may also be publicly funded. Where the benefits of a particular coastal protection measure are limited to private beneficiaries, the cost should be borne by those beneficiaries under the "beneficiary pays" principle.

1.4.4 Hazards and Risks

A hazard is a potential source of harm or adverse impact. SLR is predicted to lead to an increase in hazardous erosion and coastal inundation along the Wanneroo LGA coastline. Coastal erosion and inundation hazards have been calculated in accordance with SPP2.6 and have been interpreted to identify assets and values at risk from these hazards (**Figure 1-5**).

Risk is defined as a hazardous event or circumstance and the consequences that may arise from it. Risk is measured in terms of a combination of the likelihood of a hazard occurring and the consequence of that hazard occurring (likelihood and consequence) (**Figure 1-6**).

1.4.5 Assets and Values

An asset is defined as a useful or valuable entity. In the current CHRMAP, assets include:

- Natural features such as beaches and natural vegetation;
- Buildings and other structures (residential and commercial property);
- Roads, paths and walkways; and
- Coastal structures, such as jetties, boat ramps, seawalls and groynes.

As defined in *Climate change adaptation for settlements and infrastructure – A risk based approach* (AS 5334-2013) an asset's value can be tangible or intangible, financial or non-financial. Examples of non-tangible assets include ecological function and coastal views. The value of an asset includes consideration of risks and liabilities, and can be positive or negative at different stages of the asset's life. Economic assets can be further categorised as public or private.

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

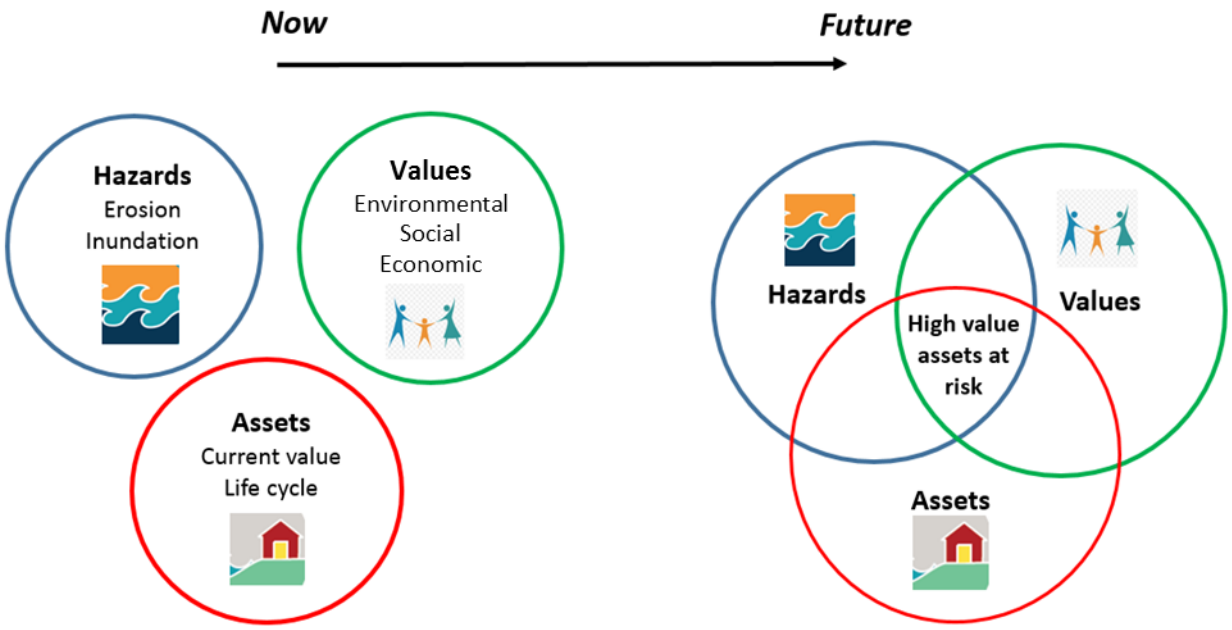

Figure 1-5 Conceptual relationship between key inputs to the coastal risk assessment process

1.4.6 Vulnerability

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

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

The CHRMAP uses vulnerability as the final outcome of the risk assessment process, combining likelihood and consequence of hazards with the adaptive capacity of assets in a stepwise process (**Figure 1-6**).

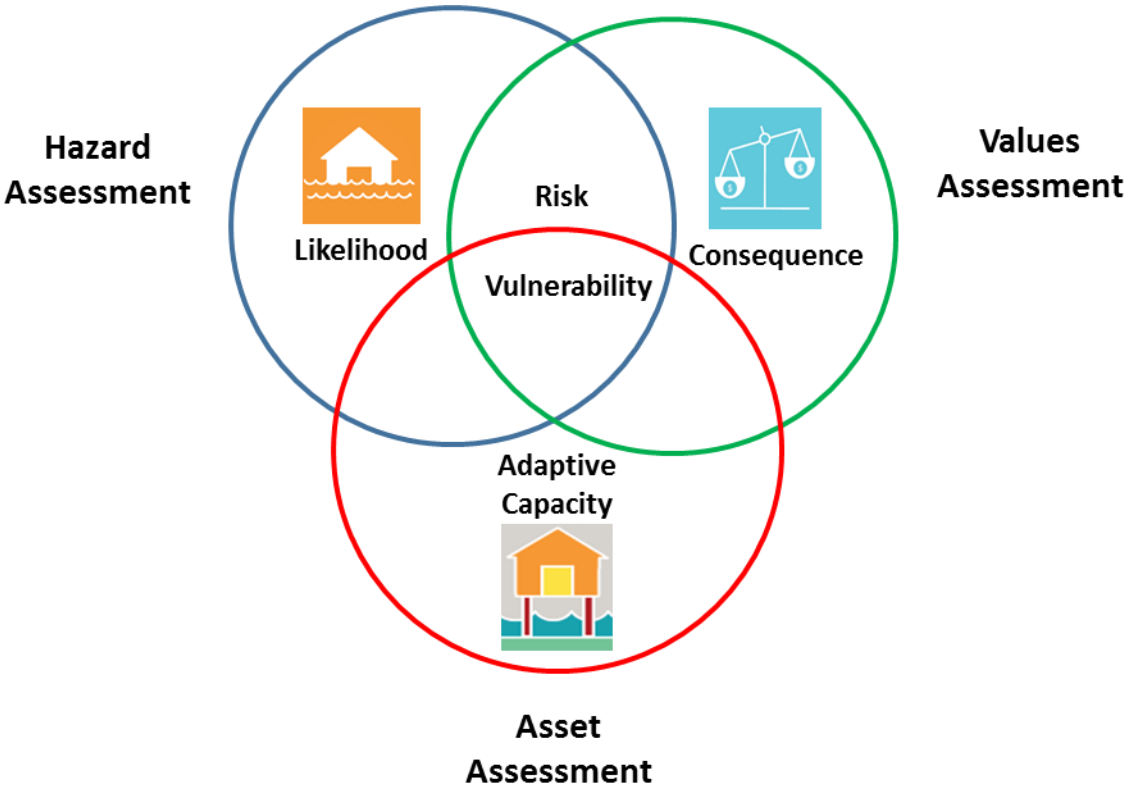

Figure 1-6 Conceptual relationship between risk assessment components.

1.4.7 Temporal Scales

Coastal hazard assessment and management needs to consider a number of different timeframes. SPP2.6 specifies the need for identifying risks and extending planning considerations out to a 100-year planning horizon (also described as 'long term' in this report). Practical planning for implementation, from the City's point of view, requires a focus on the 'short term' (i.e. up to the 2030 planning timeframe) and also 'medium term' referring to the period up to the 2070 planning timeframe.

The need for identifying potential long term risks is important to ensure that these risks are taken into consideration in the City's asset management strategy and statutory planning framework. The long term perspective is also important for management of community expectations and gives potentially impacted stakeholders prior notice of the potential hazards.

This CHRMAP includes an assessment of immediate (2015) to long term vulnerability of coastal assets associated with predicted SLR. Long term adaptation pathways have been developed for all areas of the coast being assessed, as required by SPP2.6. A short term implementation plan has also been developed, focusing on actions that will or may require implementation by the 2030 planning timeframe. This short term implementation plan is designed such that the actions do not prevent long term pathways from being realised.

1.4.8 Spatial Scales

In accordance with SPP2.6, the coastal hazards along the City's coastal zone have been identified at a Coastal Sediment Cell scale. The policy requires assessment at this scale to account for the impact of existing controls and future management techniques on areas of the coast that are away from the direct area of interest (a common example of this is erosion down-drift of a groyne or marina). For more information on the classification of coastal sediment cells and their function see Stul et al. (2015).

Using the hazard lines derived for the broader sediment cell scale this CHRMAP then looks at selected vulnerable areas, to assess the vulnerability of assets and to simplify management planning. For each of these areas, identified through Part 1 of the CHRMAP (MRA, 2015a), assets are considered individually or grouped according to the type of asset and in consideration of current land use. The risks and vulnerability of individual or groups of assets within each sector have then been assessed.

1.5 Key Coastal Processes Concepts

A basic understanding of coastal processes is important for understanding the issues and constraints associated with managing the hazards of SLR and coastal erosion. **Figure 1-7a** illustrates the multiple processes involved in adding (accretion; yellow) and removing (erosion; red) sediment from the shoreline. The size of the arrows broadly represent the volume of sediment movement involved in each process. **Figure 1-7b** shows how a storm can remove sediment from the beach and reshape the shoreline profile, due to a combination of elevated water level and wave action. As MSL increases, storms can have a greater inland 'reach' and less of the removed sediment returns to the beach, leading to long term recession.

A key step in the coastal hazard identification is the definition of a horizontal shoreline datum (HSD) along the coastline, which "should define the active limit of the shoreline under storm activity" (WAPC, 2013a). Effectively, the HSD is the shoreline at a particular point in time that can then be used as a bench mark or reference for assessing historic and future potential shoreline movement. The HSD is the benchmark from which the extent of coastal hazards, at each planning timeframe, is measured. The HSD is constantly moving and its position, relative to the location of assets is one of the key triggers for implementing management responses. It must be noted that future revisions of this CHRMAP will be based on new information, and the HSD and hazard lines should be recalculated accordingly.

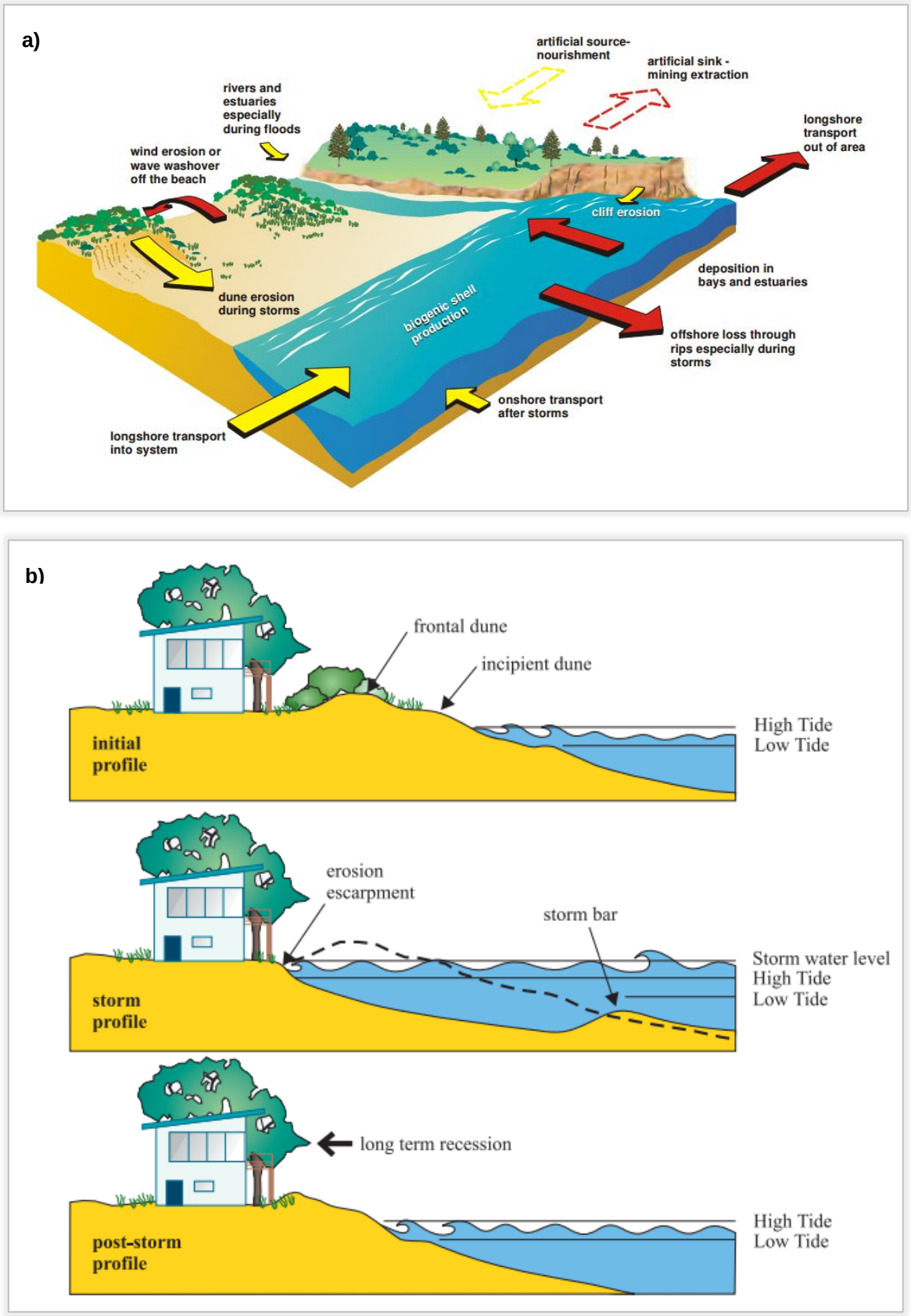

Figure 1-7 Conceptual representation of key coastal erosion concepts; a) sediment transport processes and b) long-term beach recession due to permanent sand loss (source: NSW Department of Land and Water Conservation, 2001)

1.6 Purpose and Structure of this Report

The purpose of this report is to describe the CHRMAP process and summarise the methodology and results of the process, in relation to the City's coastline. The CHRMAP also outlines long term adaptation and management pathways for the City. Key recommendations for implementation by the 2030 planning timeframe have been made, predominantly relating to the identified, vulnerable areas of the City's coastline. The report is broken down into the following sections:

- **Section 1** provides an introduction to the CHRMAP process and its purpose;
- **Section 2** summarises the coastal hazard risk modelling component of the CHRMAP;
- **Section 3** summarises the coastal hazard risk assessment component of the CHRMAP;
- **Section 4** summarises the risk management and adaptation options assessment;
- **Section 5** looks at long-term management and adaptation pathways for each of the coastal sectors;
- **Section 6** discuss key issues around implementation of the CHRMAP's recommendations;
- **Section 7** makes recommendations for monitoring and further investigations; and
- **Section 8** summarises the key recommendations of the CHRMAP and outlines the short term implementation plan.

For ease of reading and to summarise key information at the front of this report, previous Chapter Reporting that documents the CHRMAP process, as well as other key information, has been included as appendices. The appendices are arranged as follows:

- **Appendix A**: Community Engagement Summary Report;
- **Appendix B**: Coastal Hazard Mapping (MRA, 2015a);
- **Appendix C**: Quinns Beach Coastal Hazard Identification Report;
- **Appendix D**: Quinns Beach Coastal Hazard Mapping;
- **Appendix E**: Risk Assessment Chapter Report;
- **Appendix F:** Adaptation Planning Chapter Report;
- **Appendix G:** Adaptation Options – Concepts; and
- **Appendix H:** Sovereign Drive, Two Rocks – Management Concept Designs (MRA, 2015b).

2 Coastal Hazard Modelling

The Hazard Identification (see **Figure 1-3**) was conducted by M P Rogers and Associates (MRA) in Part 1 of the CHRMAP (2015) and incorporates the S1, S2 and S3 erosion allowances, and the S4 inundation allowance (WAPC, 2013a).

2.1 Erosion

The natural coastline is constantly susceptible to erosion through short term processes, such as storm surge, and long term processes, such as rising sea levels and changes to alongshore sediment transport. The various forms of erosion are defined in the SPP2.6 as:

- (S1 Erosion) Allowance for the current risk of erosion;
- (S2 Erosion) Allowance for historic shoreline movement trends; and
- (S3 Erosion) Allowance for erosion caused by future sea level rise.

The overall hazard extents associated with these processes is calculated by the summation of the above allowances, plus an additional allowance for uncertainty. SPP2.6 requires consideration of the 1 in 100 year average recurrence interval (ARI) storm event to assess potential impacts of the S1 component of erosion.

2.2 Inundation

Coastal inundation is flooding of water from the ocean, usually due to the combined effects of storm surge and wave run-up during severe weather events. All coastlines are exposed to this hazard and low lying areas can be particularly vulnerable. SPP2.6 requires consideration of the one in five hundred year ARI (0.2% AEP) water level to assess potential impacts of coastal inundation.

2.3 Outcomes

MRA (2015a) produced hazard maps to define the extents of coastal hazards at various planning timeframes (**Appendix A**). A number of areas (study sites) were identified that contained assets which were deemed vulnerable over timeframe's up to 2120. For this CHRMAP the City has elected to focus on those that contain assets which were deemed vulnerable prior to 2050 (**Table 2-1** and **Figure 2-1**). As such, Cardno has undertaken the risk assessment and adaptation planning with a focus on these study sites. For each of the study sites, a number of different assets have been identified to encompass the social, environmental/heritage and economic aspects to be considered in the planning process. These typically include the beach, natural foreshore reserve (with a particular focus on conservation areas), public infrastructure (for example carparks and roads), commercial and residential properties.

Table 2-1 Key vulnerable areas (Study Sites) and their locations (derived from MP Rogers, 2015)

Description	Suburb	Span of coastline assessed (Northings in MGA zone 50)	Estimated vulnerability timeframe
Priority Ecological Community	Two Rocks	6518012 m S to 6517304 m S	2030
Sovereign Drive and residential lots	Two Rocks	6515735 m S to 6514908 m S	From 2050
Beach access road and carpark 'The Spot'	Two Rocks	6512303 m S to 6511583 m S	2050
Capricorn Groyne carpark	Yanchep	6510151 m S to 6509517 m S	2050
Brazier Road carpark	Yanchep	6508882 m S to 6508431 m S	2030
Residential lots	Yanchep	6508418 m S to 6507918 m S	From 2030
Heritage site Karli Springs	Alkimos/Jindalee	6500433 m S to 6499585 m S	2050
Jindalee Boulevard carpark*	Jindalee	6497539 m S to 6497155 m S	Present day
Residential lots	Mindarie	6493848 m S to 6493217 m S	2050
Priority Ecological Community	Mindarie	6492655 m S to 6490505 m S	Present day

*The vulnerability of the study site containing the Jindalee Boulevard carpark and adjacent assets will be affected by the coastal protection works being planned for Quinn's Beach. As such, the City has agreed that the coastal hazard lines should be revised to incorporate these works (see **Section 2.4**). Cardno has, therefore, not carried out a detailed risk assessment for this area as part of this project.

Figure 2-1 CHRMAP Study Sites

2.4 Quinns Coastal Hazard Assessment

The Tertiary Sediment Cell 29b (Stul et al, 2015), containing Quinns Beach, was not included in the coastal hazard assessment undertaken in Part 1 of the CHRMAP (MRA, 2015a). The area was excluded due to ongoing management works at Quinns, including the addition and extension of groynes to manage ongoing erosion in the area. These works will change the behaviour of the shoreline in the area going forward. As the layout and confirmation of these works was not finalised at the time of the project, it was not considered appropriate to make future hazard predictions.

During Part 2 of the CHRMAP, greater certainty on the management approach for Quinns Beach has been confirmed. This CHRMAP project has also identified the importance of implementing planning controls to reduce future risk, and these controls are guided by hazard extents. As such, the City recently commissioned Cardno to develop coastal erosion hazard extents for the coastline comprising Tertiary Sediment Cell 29b, as part of this project (**Appendix C**). Given the significant controls placed along the shoreline over past decades, as well as those to be installed, traditional techniques for determining the S1, S2 and S3 components (as outlined in SPP2.6) required some interpretation for application to this area. Cardno has used numerical modelling that incorporates the protection structures, to predict the behaviour of the shoreline over the next 50 years. Beyond this period, the structures have been considered to no longer exist, as management pathways beyond their design life cannot be committed to at this stage. Hazard mapping for the area is provided in **Appendix D**.

It must be noted that a risk and vulnerability assessment has not been undertaken for assets along the coast in the area. This was not considered appropriate at this stage, given an interim *protect* strategy for the area has already been committed to by the City. The risk and vulnerability assessment will be undertaken as part of the next CHRMAP review. The hazard lines, however, should be used by the City to implement planning controls. It should also be noted that a separate CHRMAP is currently being undertaken for Lot 211 Quinns Road, Mindarie, which required the calculation of hazard extents at the southern part of Cell 29b. Although different modelling techniques were used for that assessment, the hazard extents are consistent between studies in that portion of the study area. The lines presented in this CHRMAP should now take precedence over those calculated for the Lot 211 Quinns Road CHRMAP, as they are based on more recent information.

3 Coastal Hazard Risk Assessment

The coastal hazard risk assessment has interpreted the results of coastal hazard risk modelling to estimate risk and vulnerability for the City's assets. The **Risk Assessment Chapter Report** is presented in **Appendix E** (Cardno, 2016). The assessment has been applied to identify risk and vulnerability for coastal erosion (which is more extensive than inundation), for the present day (2015) and over future planning timeframes to 2120. Determining risk for each asset or group of assets, at each study site, involved combining the likelihood of impact with the consequences should this impact occur. Vulnerability is then assessed by combining the risk to assets with their respective adaptive capacities (see also **Figure 1-6**). A brief description of these inputs is provided in the following sections.

3.1 Likelihood

According to WAPC (2014a) and for the purposes of this study, likelihood is defined as the chance of erosion or storm surge inundation impacting on existing assets and their values. In this CHRMAP, likelihood has been assigned based on the mapping of coastal erosion extents with respect to the location of assets. The erosion hazard extents are made up of a number of components. Each of these is based on a suite of assumptions and each has a degree of uncertainty, which may influence the likelihood of the predicted extent of erosion occurring at each planning horizon. SPP2.6 also requires the modelling of coastal hazard events with a very low probability of occurrence, which are difficult to translate to the actual likelihood of coastal impact over the specified planning timeframes. A methodology for consistently assigning likelihood to each asset (or asset group) across the planning timeframes has been developed by Cardno (see **Appendix E, Section 4**) using professional judgement and coastal processes expertise.

3.2 Consequence

Consequence is the result of a hazard impacting an area, asset or group of assets. The consequence ratings for this risk assessment have been adapted from those presented in AS 5334-2013, and WAPC (2014a), which focus on the social, economic and environmental consequences. A heritage component has also been incorporated alongside environmental impacts to ensure impacts to heritage sites are accounted for in the risk assessment process. Generally, the consequence categories incorporate all of the values outlined by the Success Criteria (see **Section 1.3**) and align comparatively between categories with the level of response to these Success Criteria.

3.3 Adaptive Capacity

The adaptive capacity is based upon the potential for an asset to be modified or acclimatise to cope with the impacts of identified hazards. An asset or group of assets with a high adaptive capacity is one that can easily (i.e. at low cost) be adapted or one that has some capacity to self-adapt with changing conditions (e.g. beaches and dune systems can migrate across shore as the MSL changes). Assets with a high risk level and low adaptive capacity are deemed highly vulnerable and management options should be investigated.

3.4 Outcomes

In general, the results of the risk assessment show the beach at each study site to be the first asset to have vulnerability raised above low, as you move across the planning timeframes. This has come about partly because the beach naturally has the closest proximity to the ocean and impacts of coastal hazards. It is also because of the substantial social value attributed to beaches, defined in the success criteria. Traditionally only built assets such as buildings and roads, with easily definable economic value, may have been considered in such an assessment. The beach and dune system are often the first line of defence for built infrastructure against the impacts of coastal hazards, so it is also appropriate in that regard that their urgency for treatment has been highlighted through this process.

The risk prioritisation has identified three sites (effectively two areas) with some immediate urgency. Residential lots, Brazier Road and its carparks in the vicinity of Yanchep lagoon were assessed as two sites for the risk assessment, but were assessed together for adaptation planning (see **Section 4**). This area was found to be of the highest priority, due to the immediate vulnerability of a highly valued beach and the proximity of valuable built infrastructure behind it. Sovereign Drive, its residential lots and associated assets were also found to have raised vulnerability in the short term. This is due to the value of infrastructure assets and the perceived vulnerability of the affronting beach to erosion.

4 Risk Management and Adaptation

An assessment of risk management and adaptation options has been undertaken based on the results of the completed risk and vulnerability assessment. The assessment identified potential responses to the coastal hazard risks at each Study Site, and provided a preliminary evaluation of the available options, to inform stakeholder and community engagement. The **Adaptation Planning Chapter Report** is presented in **Appendix F** (Cardno, 2017). The objectives of the adaptation options assessment were:

- To define a range of adaptation measures for each of the Study Sites;
- To carry out a multi-criteria analysis (MCA) as a framework and starting point for stakeholder and community consultation, and to identify options for further assessment;
- To supply relevant information to inform future detailed options assessments for individual sites;
- To provide preliminary recommendations for the implementation of management options and planning responses, with consideration of equity implications; and
- To identify further investigations that may be required.

The adaptation options assessment, particularly the MCA, was guided by the Project's Success Criteria (see **Section 1.3**), defined through the City's Community Values Survey. These criteria were used to undertake a preliminary assessment of the social acceptability of potential adaptation options.

As recommended in the CHRMAP Guidelines (WAPC, 2014a), the MCA was used as a preliminary step to identify potentially suitable adaptation options for each Study Site, as well as to discount unviable options. The analysis uses a broad range of criteria and a simple 'traffic light' rating system to evaluate the acceptability of each option. Through the MCA, various options have been either recommended, not recommended or identified as requiring further investigation for each sector. Concept maps for adaptation options are provided in **Appendices G** and **H**.

In general, the proposed adaptation options provide technical mitigation approaches for adapting to the effects of landward migration of the shoreline, due to future SLR and associated coastal erosion and inundation. A summary of the range of planning instruments available to effect changes in the character and use of the coastal zone have also been outlined.

In general, options recommend that:

- Where there is currently no existing development seaward of the predicted 2120 coastal erosion hazard line, planning controls and coastal zone boundaries be adjusted to preclude development within the zone;
- Where assets that provide significant environmental and social value, such as beaches and foreshore areas, exist seaward of the 2120 coastal erosion hazard line, adaptation options and pathways which maintain the present values of these assets should be favoured;
- Where public built assets exist seaward of the 2120 coastal erosion hazard line, managed retreat options should be considered; and/or
- Where private land and dwellings are located seaward of the 2120 coastal erosion hazard line, options to retreat or provide interim protection should be considered.

5 Long-term Management and Adaptation Pathways

A key purpose of this CHRMAP is to plan for the responsible use of coastal areas up to the year 2120, and beyond. It is clear that planning decisions made decades and even centuries in the past, prior to understanding the implications of climate change and SLR, are a key contributor to the current situation where assets are becoming increasingly vulnerable to coastal hazards.

Recommended long-term pathways have been proposed for each of the City's Study Sites in **Sections 5.2** to **5.9** below. These pathways should provide perspective and guidance for any short-term actions recommended for implementation. The long-term pathways presented should be viewed as flexible and likely to evolve. They should, however, have a focus on avoiding the creation of additional risk to be managed. They should also seek to move towards managing the retreat of valuable built assets, as this is generally the most economically responsible approach over the long term. Managed retreat is also likely to be required to maintain beach amenity and a suitable foreshore reserve for the public, as MSL rises.

Long term pathways are presented in tables where columns represent planning timeframes from the short term (between now and 2030) into the future (beyond 2120). For each Sector, applicable asset types have been separated, given that different management options and triggers will be required for different asset types. These asset categories include:

- Undeveloped land;
- Minor public infrastructure, such as beach access infrastructure, minor carparks, footpaths and drainage infrastructure;
- Major public infrastructure, such as roads and major carparks, and
- Residential and commercial property; and
- Natural assets such as beaches and dunes.

For each of the asset categories, applicable management options are presented in rows beneath them. Management options and their codes are presented in **Table 5-1**, below, for reference. As is shown in the tables, multiple management options will be applicable for each asset category, as these options are not mutually exclusive. For example, while interim protection may be the appropriate option for a developed area, options that prepare for future managed retreat (*MR3*) and that accommodate risk (*AC1*, *AC2*) are also likely to be implemented in tandem.

It must also be noted that the display of a certain option at a certain planning timeframe does not necessarily indicate that the option should/will be implemented at that timeframe. This comes back to the flexibility of management pathways. Further to this, future management options are not yet certain for all assets, particularly major infrastructure. For these cases the pathways split the available options (predominantly managed retreat vs protection) to identify that the pathway is yet to be determined. Further investigation and preparation will be required to confirm these future pathways, with decision points occurring beyond 2030. Adaptation pathways are likely to be adjusted through future revisions of the CHRMAP, as hazards, risk and vulnerability for the City are better investigated and understood.

The uncertainty around management pathways increases significantly as you advance across timeframes to 2120. Although pathways have been forecast based on the hazard and risk assessment outcomes for the CHRMAP, it is important to note that changes in management and adaptation approaches should be based on triggers (**Section 5.2**). Using triggers to guide management responses should ensure that they are appropriately timed. Implementing management to mitigate a level of risk that is not yet present would be an unnecessary use of resources. Conversely, if risks become present earlier than was predicted, there should be a prepared management response in place to react to the issue.

Long-term pathways contain a large amount of information in a simplified format and can seem confusing. This level of detail, however, is necessary given the broad range of asset types located in some study sites and the multiple adaptation options available to be implemented.

Table 5-1 Adaptation and management options (adapted from WAPC, 2014a).

Option Category	Option Name	Option Code	Description
Avoid	Avoid development	**AV**	Avoidance of freehold residential or commercial development within the coastal foreshore reserve.
Managed Retreat	Leave unprotected / repair	**MR1**	Assets are left unprotected and loss is accepted following hazard event. Repairs may be implemented to extend life and for public safety in the short-term. In the case of natural assets, such as beaches and vegetation, allow the impacts of hazards to occur. Drainage infrastructure repaired to ensure operation for future rainfall events.
	Remove / relocate	**MR2**	Assets located in the hazard zone are permanently removed or relocated. For residential and commercial property, this option may require voluntary or compulsory acquisition of land. Drainage infrastructure relocated to an area which will not be impacted again within asset life. Drainage to be removed if no other assets are left to service.
	Planning controls for managed retreat	**MR3**	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. This option also includes mechanisms for ensuring that Local Government, land owners and prospective buyers are made aware of the risk.
Accommodate	Planning controls to accommodate/identify risk	**AC1**	Indicates to current and future landholders that an asset is at risk from coastal hazards over the planning timeframe. Helps owners 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 controls	**AC2**	Implement plans for assets/areas that are at risk of coastal erosion. Have procedures in place for before, during and after the events for safety. E.g. signage/barriers to prevent access.
	Redesign to withstand impact	**AC3**	Usually applicable to flood/inundation prone areas (e.g. flood plains) where an area may continue to be inhabited, despite elevated risk, by designing infrastructure to withstand flood events. This option is not generally applicable for coastal erosion hazards.

Protect	Dune care / sand management	**PR1**	Development of an ongoing program for revegetation and rehabilitation of the dune system. Installation of signage and access restrictions to prevent degradation of the dunes and vegetation by people. Incorporation of education programs on the importance of preserving natural dunes. Sand fencing to manage wind-blown erosion also falls under this category.
	Beach nourishment / sand management	**PR2**	Addition of sand to the beach, dune and/or nearshore area to replace lost material and/or create additional buffer. This option is 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 (i.e. via sand bypassing or back passing).
	Groyne(s)	**PR3**	Construct groynes 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 erosion issues elsewhere, such as to the down drift side of a groyne, and can have significant impact on coastal ecosystems.
	Nearshore reef(s) / breakwater(s)	**PR4**	Construct offshore reef(s)/breakwater(s) or raise existing natural nearshore reef structure to maintain level of protection as sea level rises. Hard protection generally diverts erosion issues elsewhere, such as to beaches either side of the nearshore structures, and can have significant impact on coastal ecosystems.
	Seawall(s)	**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. They can also have significant impact on coastal ecosystems.
Do nothing	Do nothing	**DN**	Take no action. No limitations on development or implementation of adaptation planning. Accept risk.

5.1 Quinns Beach

The Quinns Beach area (Sediment Cell 29b) has not been attributed a long-term management and adaptation pathway as part of this project. A protect strategy is currently in place for the Quinns area, involving the construction and extension of groynes, a buried seawall and ongoing sand nourishment. The City has committed to this strategy for at least the short term. A full risk and vulnerability analysis of the area should be carried out as part of the next CHRMAP revision. A coastal hazard identification has been undertaken for the area, incorporating the protection strategy, and is included as **Appendix C**, with associated hazard mapping included as **Appendix D**.

5.2 Triggers

The Draft Guidelines for Planned or Managed Retreat ('the Draft Guidelines', DoPHL, 2017) provide guidance on the appropriate triggers or criteria to commence actioning the transfer of land to the public realm. The guidelines suggest the following:

> *Planned retreat allows development to remain and be safely used until the coastal hazard risk becomes unacceptable. Initiation of the process to remove at risk development can be controlled by triggers such as:*
>
> *Trigger 1. Where the most landward part of the Horizontal Shoreline Datum (HSD) is within 40 metres of the most seaward point of a development or structure.*
>
> *Trigger 2. Where a public road is no longer available or able to provide legal access to the property.*
>
> *Trigger 3. When water, sewage or electricity to the lot is no longer available as they have been removed/ decommissioned by the relevant authority due to coastal hazards.*

The Draft Guidelines state that *Trigger 1* can be varied where modelling has been undertaken in accordance with SPP2.6, to determine an S1 erosion distance. As this modelling has been undertaken as part of the CHRMAP, the nominal 40 metre distance should be replaced with the calculated S1 distance for this trigger.

The triggers defined in the Draft Guidelines are based on physical drivers and focus on triggering a managed retreat approach. For the purpose of guiding management pathways in this CHRMAP, various additional triggers have been defined. These look at additional drivers for management actions, including social and economic drivers. The triggers also relate to the implementation of management responses other than managed retreat, such as the implementation of interim protection where this can be demonstrated to be appropriate. The triggers also help to define when preparatory actions should be undertaken, such as the implementation of planning controls. The triggers used to guide the long-term pathways for the CHRMAP are outlined in **Table 5-1**, below.

Table 5-2 CHRMAP triggers, the method(s) for assessing when they are reached and some examples of responses.

Trigger name	Trigger	Method(s) of assessment	Example response(s)
T1	The HSD is within the S1 distance of an asset's most seaward extent.	> Ongoing shoreline monitoring (survey profiles) to determine present location of HSD; > S1 defined by modelling, with data collected during shoreline and storm monitoring used to validate/refine the S1 value.	> Remove major infrastructure (roads, carparks), residential and commercial buildings, and transfer land to public realm; > Provide interim protection for major infrastructure (roads, carparks), residential and commercial buildings; > Prepare response plans for minor infrastructure that could be impacted.
T2	A public road is no longer available or able to provide legal access to a property.	> Liaison with/notification by relevant State Government departments;	> Remove residential and commercial buildings, and transfer land to public realm;
T3	Water, sewage or electricity to a lot is no longer available as they have been removed/ decommissioned by the relevant authority due to coastal hazards.	> Liaison with/notification by utilities providers;	> Remove residential and commercial buildings, and transfer land to public realm;
T4	Residential or commercial property lies seaward of the most up to date 100-year coastal erosion hazard line.	> Definition of hazard extents through this CHRMAP; > CHRMAP and hazard extent updates due to the availability of more relevant/recent information (such as updated SLR predictions) and changes in environmental conditions (such as changes to MSL);	> Include all affected land in a SCA and ensure the hazard information is incorporated in structure planning; > Provide notification of potential hazards on certificates of title where reasonably practicable and by direct contact with affected landholders.
T5	An asset is damaged, destroyed or becomes unsafe due to coastal erosion.	> Inspection of coastal assets following storm events or during times of increased longshore erosion (e.g. by works staff, Rangers); > Remote coastal monitoring cameras; > Notification by the public.	> Remove asset and relocate to less hazardous area if possible/appropriate;
T6	Assets are predicted to become highly or very highly vulnerable within the next planning timeframe (by 2030 for this CHRMAP) or within 15-20 years.	> Definition of hazard extents through this CHRMAP; > CHRMAP and hazard extent updates due to the availability of more relevant/recent information (such as updated SLR predictions) and changes in environmental conditions (such as changes to MSL);	> Undertake detailed cost-benefit analysis and assessment of community acceptance of interim protection vs managed retreat of the affected assets; > Identify sources and begin to allocate funding for management.

T7	The overall community and stakeholders are no longer supportive of a specific coastal management technique or approach.	> Ongoing community engagement. > Cost-benefit analysis.	> Investigate, identify and implement a change in the adaptation pathway, if appropriate.
T8	A specific coastal management technique is forecast to no longer be economically or physically feasible within 10 years.	> Ongoing shoreline and coastal asset monitoring; > Budget expenditure and forecasts. > Cost-benefit analysis.	> Investigate, identify and implement a change in the adaptation pathway.
T9	The beach and coastal foreshore reserve is significantly diminished with respect to its original state and function.	> Long-term coastal monitoring program; > Assessment of aerial imagery; > Feedback through ongoing community consultation.	> Investigate, identify and implement a change in the adaptation pathway.
T10	Undeveloped land is identified as lying within the hazard extents	> Definition of hazard extents through this CHRMAP; > CHRMAP and hazard extent updates due to the availability of more relevant/recent information (such as updated SLR predictions) and changes in environmental conditions (such as changes to MSL);	> Implement planning controls to avoid inappropriate development of the land.

5.3 Priority Ecological Community, Two Rocks

The proposed long-term management and adaptation pathways for PEC, Two Rocks, along with potential associated triggers, are presented in **Table 5-3**. This area is currently undeveloped and, therefore, there are no built assets predicted to become vulnerable before 2120 in this area.

Inappropriate development that could lead to future risk and liability to the City should be avoided in the area, facilitated by planning controls.

The maintenance and enhancement of the beach and dune system, through dune care and sand management, should be considered in the area. These assets provide a valuable, natural protective function. As the area is currently inaccessible, these options are unlikely to be appropriate for implementation in the short term.

Table 5-3 Long-term management and adaptation pathways for PEC, Two Rocks and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Beach and Dunes**			
Pathway	*Dune care / sand management (**PR1**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

5.4 Sovereign Drive and Adjacent Residential Lots, Two Rocks

The proposed long-term management and adaptation pathways for Sovereign Drive and Adjacent Residential Lots, Two Rocks, along with potential associated triggers, are presented in **Table 5-4**. Key assets in the study site have been assessed as becoming highly vulnerable by the 2050 planning timeframe, which could require a significant change in the management approach for the area.

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

Significant public infrastructure and residential property is predicted to be highly vulnerable in the future, requiring interim protection and/or managed retreat. Managed retreat is likely to be triggered when Sovereign Drive requires removal due to intolerable risk or to maintain a suitable foreshore reserve. This would also trigger the removal of the first row of houses along the roads, due to loss of legal access. There is likely to be overall benefit in using interim protection in this area, due to the significant value of built assets.

The maintenance and enhancement of the beach and dune system, through dune care, sand management and beach nourishment, could be applied in the area. These assets provide a valuable, natural protective function. The effectiveness and value of beach nourishment and dune care would need to be carefully considered in this area. Poor access to the beach means considerable disturbance of the dunes would likely be required to place nourishment. The site also experiences active erosion and previous dune care activities have shown limited success. The City should carefully consider the value in applying these techniques for this site, particularly as protection mechanisms in their own right.

Table 5-4 Long-term management and adaptation pathways for Sovereign Drive and Adjacent Residential Lots, Two Rocks and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Minor Public Infrastructure and Drainage Infrastructure**			
Pathway	*Leave unprotected/repair, remove/relocate (**MR1**, **MR2**)*			
Trigger(s)	Asset damaged (**T5**)			
Pathway	*Emergency plans and controls (**AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**)			
Assets	**Major Public Infrastructure and Residential Property**			
Pathway	*Planning controls, emergency plans and controls (**AC1**, **AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**), Property lies seaward of 100-year erosion hazard (**T4**)			
Pathway	*Planning for Managed Retreat (**MR3**)*			
Trigger(s)	Property lies seaward of 100-year erosion hazard (**T4**), Assets predicted to be vulnerable in 15-20 years (**T6**)			
Pathway	*Dune care/sand management, beach nourishment (**PR1**, **PR2**)*	*Protect (**PR1, PR2, PR3, PR4, PR5**)* **and / or** *Remove/relocate (**MR2**)*		*Remove/relocate (**MR2**)*
Trigger(s)	Diminished beach and foreshore reserve (**T9**)	**T1, T7, T8, T9** **T1, T2, T3, T5, T7, T8, T9**		**T1, T2, T3, T5, T7, T8, T9**
Assets	**Beach and Dunes**			
Pathway	*Dune care/sand management, beach nourishment (**PR1**, **PR2**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

T2 = Loss of legal access, **T3** = Loss of utilities, **T7** = Loss of community/stakeholder support for existing management, **T8** = Existing management will not be economically viable within 10 years.

5.5 Beach Access Road and Carpark at 'The Spot', Two Rocks

The proposed long-term management and adaptation pathways for the Beach Access Road and Carpark at 'The Spot', Two Rocks, along with potential associated triggers, are presented in **Table 5-5**.

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

Inappropriate development that could lead to future risk and liability to the City should be avoided in the area, facilitated by planning controls.

The maintenance and enhancement of the beach and dune system, through dune care and sand management, should be considered in the area. These assets provide a valuable, natural protective function. It is understood that such rehabilitation has occurred in the past in this area, is association with the Two Rocks Board Riders Club. The City should consider partnering with this stakeholder group for similar management in the future.

Table 5-5 Long-term management and adaptation pathways for beach access road and carpark 'The Spot', Two Rocks and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Minor Public Infrastructure**			
Pathway	*Leave unprotected/repair, remove/relocate (**MR1, MR2**)*			
Trigger(s)	Asset damaged (**T5**)			
Pathway	*Emergency plans and controls (**AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**)			
Assets	**Beach and Dunes**			
Pathway	*Dune care / sand management (**PR1**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

5.6 Carpark South of Capricorn Groyne, Yanchep

The proposed long-term management and adaptation pathways for the Carpark South of Capricorn Groyne, Yanchep, along with potential associated triggers, are presented in **Table 5-6**.

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

Inappropriate development that could lead to future risk and liability to the City should be avoided in the area, facilitated by planning controls.

The maintenance and enhancement of the beach and dune system, through dune care and sand management, should be considered in the area. These assets provide a valuable, natural protective function. It should be noted that the area is currently being developed and access to the dunes and foreshore is unlikely to be possible while this is occurring.

Table 5-6 Long-term management and adaptation pathways for the carpark South of Capricorn Groyne, Yanchep and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Minor Public Infrastructure**			
Pathway	*Leave unprotected/repair, remove/relocate (**MR1, MR2**)*			
Trigger(s)	Asset damaged (**T5**)			
Pathway	*Emergency plans and controls (**AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**)			
Assets	**Beach and Dunes**			
Pathway	*Dune care / sand management (**PR1**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

5.7 Carpark Adjacent to Brazier Road and Residential Lots, Yanchep

The proposed long-term management and adaptation pathways for assets at Yanchep, along with potential associated triggers, are presented in **Table 5-7**. Key assets in the sector have been assessed as becoming highly vulnerable by the 2050 planning timeframe, which could require a significant change in the management approach for the area. It is understood that the foreshore in this area is currently being assessed for development by the City. Any proposed development should align incorporate the pathways and recommendations presented in this CHRMAP.

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

Significant public infrastructure and residential property is predicted to be highly vulnerable in the future, requiring interim protection and/or managed retreat. A significant change in the management pathway is likely to be triggered when the risk to assets is no longer tolerable or the amenity of the beach and foreshore reserve has significantly diminished. There may be overall benefit in using interim protection in this area, due to the significant value of built assets. Any protection measure should maintain the amenity of the beach and coastal foreshore reserve.

The maintenance and enhancement of the beach and dune system, through dune care, sand management and beach nourishment, should be applied in the area. These assets provide a valuable, natural protective function and also hold significant social and economic value.

Table 5-7 Long-term management and adaptation pathways for the carpark adjacent to Brazier Road and Residential Lots, Yanchep and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Minor Public Infrastructure and Drainage Infrastructure**			
Pathway	*Leave unprotected/repair, remove/relocate (**MR1, MR2**)*			
Trigger(s)	Asset damaged (**T5**)			
Pathway	*Emergency plans and controls (**AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**)			
Assets	**Major Public Infrastructure and Residential and Commercial Property**			
Pathway	*Planning controls, emergency plans and controls (**AC1, AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**), Property lies seaward of 100-year erosion hazard (**T4**)			
Pathway	*Planning for Managed Retreat (**MR3**)*			
Trigger(s)	Property lies seaward of 100-year erosion hazard (**T4**), Assets predicted to be vulnerable in 15-20 years (**T6**)			
Pathway	*Dune care/sand management, beach nourishment (**PR1, PR2**)*	*Protect (**PR1, PR2, PR4, PR5**)* ***and / or*** *Remove/relocate (MR2)*		*Remove/relocate (**MR2**)*
Trigger(s)	Diminished beach and foreshore reserve (**T9**)	**T1, T7, T8, T9** **T1, T2, T3, T5, T7, T8, T9**		**T1, T2, T3, T5, T7, T8, T9**
Assets	**Beach and Dunes**			
Pathway	*Dune care/sand management, beach nourishment (**PR1, PR2**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

T2 = Loss of legal access, **T3** = Loss of utilities, **T7** = Loss of community/stakeholder support for existing management, **T8** = Existing management will not be economically viable within 10 years.

5.8 Heritage Site Karli Spring, Alkimos

The proposed long-term management and adaptation pathways for the Heritage Site Karli Spring, Alkimos, along with potential associated triggers, are presented in **Table 5-8**. It should be noted that structure planning for the development of this area is currently being reviewed. Any management implemented in the short term will require collaboration between the City and the developer(s).

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

Inappropriate development that could lead to future risk and liability to the City should be avoided in the area, facilitated by planning controls.

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

Table 5-8 Long-term management and adaptation pathways for Heritage Site Karli Spring, Alkimos and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Minor Public Infrastructure**			
Pathway	*Leave unprotected/repair, remove/relocate (**MR1, MR2**)*			
Trigger(s)	Asset damaged (**T5**)			
Pathway	*Emergency plans and controls (**AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**)			
Assets	**Beach and Dunes**			
Pathway	*Dune care / sand management (**PR1**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

5.9 Residential Lots, Mindarie

The proposed long-term management and adaptation pathways for Residential Lots, Mindarie, along with potential associated triggers, are presented in **Table 5-9**. Key assets in the sector may become vulnerable towards the end of the century, which could require a change in the management approach for the area.

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

Significant public infrastructure and residential property may become highly vulnerable in the future, requiring protection and/or managed retreat. A significant change in the management pathway is likely to be triggered when the risk to assets is no longer tolerable or the foreshore reserve has significantly diminished. There may be overall benefit in using protection in this area, due to the significant value of built assets. Any protection measure should maintain the amenity of the coastal foreshore reserve.

The maintenance and enhancement of the beach and dune system, through dune care, sand management and beach nourishment, should be considered in the area. These assets provide a valuable, natural protective function. Defining appropriate access ways and restricting access to the other areas would benefit the natural maintenance of the dune system in this area.

Table 5-9 Long-term management and adaptation pathways for Residential Lots, Mindarie and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Minor Public Infrastructure and Drainage Infrastructure**			
Pathway	*Leave unprotected/repair, remove/relocate (**MR1, MR2**)*			
Trigger(s)	Asset damaged (**T5**)			
Pathway	*Emergency plans and controls (**AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**)			
Assets	**Major Public Infrastructure and Residential Property**			
Pathway	*Planning controls, emergency plans and controls (**AC1, AC2**)*			
Trigger(s)	HSD within S1 distance (**T1**), Property lies seaward of 100-year erosion hazard (**T4**)			
Pathway	*Planning for Managed Retreat (**MR3**)*			
Trigger(s)	Property lies seaward of 100-year erosion hazard (**T4**), Assets predicted to be vulnerable in 15-20 years (**T6**)			
Pathway	*Dune care / sand management (**PR1**)*		*Seawall (**PR5**)* **and / or** *Remove/relocate (**MR2**)*	
Trigger(s)	Diminished beach and foreshore reserve (**T9**)		**T6, T7, T8** **T2, T3, T5, T7, T8**	
Assets	**Beach and Dunes**			
Pathway	*Dune care / sand management (**PR1**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

T2 = Loss of legal access, **T3** = Loss of utilities, **T7** = Loss of community/stakeholder support for existing management, **T8** = Existing management will not be economically viable within 10 years.

5.10 Priority Ecological Community, Mindarie

The proposed long-term management and adaptation pathways for the PEC, Mindarie, along with potential associated triggers, are presented in **Table 5-10**. There were no built assets predicted to become vulnerable before 2120 in this area.

Inappropriate development that could lead to future risk and liability to the City should be avoided in the area, facilitated by planning controls.

The maintenance and enhancement of the beach and dune system, through dune care and sand management, should be considered in the area. These assets provide a valuable, natural protective function. Any management should be considered in cooperation with the Tamala Park Regional Council, who partly manage land in the area.

Table 5-10 Long-term management and adaptation pathways for PEC, Mindarie and associated triggers.

Planning Timeframe	2015 - 2030	2030 - 2070	2070 - 2120	2120 - future
Assets	**Undeveloped Land**			
Pathway	*Avoid development (**AV**)*			
Trigger(s)	Undeveloped land lies within hazard extents (**T10**)			
Assets	**Beach and Dunes**			
Pathway	*Dune care / sand management (**PR1**)*			
Trigger(s)	Diminished beach and foreshore reserve (**T9**)			

6 Implementation

A range of options for managing and adapting to the effects of coastal erosion on the coastal zone, over the next century, have been outlined in the **Adaptation Planning Chapter Report** (**Appendix F**). 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 will likely become prohibitively expensive at some point in the future. The interim nature of protection options needs to be recognised across the community and, the 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 as soon as possible, then discusses management priorities for the City.

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.

6.1 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, and compensation for affected landholders, to implement managed retreat and allow the shoreline to recede. Although part funding is possible from the State 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 funding sources for ongoing and future management. Appropriate investigations should be carried out to ensure this funding is derived from the beneficiaries of the management measures. Those parties that would be disadvantaged by any management activities should also be identified and appropriately compensated. Equity, in the context of the CHRMAP process, was discussed in more detail in **Section 1.4.1**. 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 should 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 also 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 fees etc.

R2: A detailed economic assessment should be undertaken to establish the economic value/contribution of natural assets in key vulnerable areas.

This assessment should look at the range of direct and indirect economic benefits provided by beaches and the coastal foreshore reserve (including parks). The assessment should incorporate:

- Estimates of beach visitation and surveys of beach visitors to assist in estimating tourism, external and local visitor value;
- An assessment of the effect of proximity to the beach on property values as well as the identification of any links between beach quality (beach width, useability etc.) and local property value;
- Assessment of the beach's contribution to local business revenue, for example by assessing seasonal trends in turnover;

- Assessment of the economic value of the environmental functions of the beach and foreshore; and
- Identification of existing beneficiaries and the level to which they benefit from the natural assets.

A critical information gap existing at present, that is required to inform a proper cost-benefit analysis of future adaptation options, is an estimate of the economic value/productivity of beaches and other natural assets. This input is required to establish a 'base case' for economic analysis, against which costs and benefits can be assessed. This will be required to inform detailed options assessments for site-specific coastal management.

R3: Investigate and establish a fund for ongoing coastal adaptation and management, and allocate funding sources.

Following a detailed economic assessment and the selection 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 has a fund 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.

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 management.

The requirement for developer contributions should also be considered. 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 and park entry 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.

6.2 Planning Controls

A range of planning mechanisms and considerations were presented in the **Adaptation Planning Chapter Report** (**Appendix F**). The City should look to implement appropriate planning controls as soon as possible, as many of these will help limit risk and liability for the City in the future. The following key recommendations are made with respect to planning controls.

R4: Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.

All structure planning should account for the hazards identified in this CHRMAP and the requirements of SPP2.6. The primary mechanism for achieving this through structure planning, will be the allocation of a suitable portion of land as coastal foreshore reserve. This foreshore reserve should be of adequate width to account for the 2120 coastal erosion hazard line, and also ensure a functional foreshore area will remain should this hazard extent be realised in the future. The City should review structure planning along its entire coastline, with respect to the hazard extents calculated as part of this CHRMAP.

R5: Investigate the benefits of amending DPS2 to directly reference SPP2.6 and include vulnerable areas as Special Control Areas (SCAs).

The *Draft Planned or Managed Retreat Guidelines* (WAPC, 2017) recommend that SPP2.6 be incorporated by reference into Local Planning Schemes and read as part of these schemes. The WA *Planning and Development Act 2005 - Section 77 (2)* describes the effect of incorporating a State planning policy into a local planning scheme. The City should investigate the benefits of amending DPS2 to directly reference SPP2.6 and have it read as part of DPS2. Wording and placement of this reference is specified in the guidelines. It is also recommended that DPS2 be amended to incorporate areas lying within the 2120 coastal erosion extent as a SCA, along the City's entire coastline. The SCA classification should be used to facilitate land use changes and ensure development control over the identified areas. The SCA should function as follows:

- The SCA should be based on the 2120 hazard extent, plus an additional allowance for future foreshore amenity. Factors to be considered in defining this additional allowance are outlined in SPP2.6: Section 5.9. Further guidance on the necessary allowances for these factors is provided in the *State Coastal Planning Policy Guidelines* (WAPC, 2013b) – *Section 8: Coastal Foreshore Reserve*. The City should also liaise with the DoPLH regarding how best to define this extent;
- The SCA should require that all development in the area requires approval, allowing the City to control development and ensure it aligns with the long-term pathways for the area;
- SCA's should not extend over areas reserved such that development is already prohibited, such as Parks and Recreation Reserve; and
- The details of how development might be controlled in these SCAs has been outlined in **Adaptation Planning Chapter Report** – see **Appendix F.**

R6: Landholders that may be affected by coastal hazards by 2120 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. It is recommended that the City notify holders of land lying within the 100 year erosion extents directly, via mail or email. There are also mechanisms to apply notification of the potential hazards to Certificates of Title (outlined in the **Adaptation Planning Chapter Report**), and these should be implemented where practicable. At present, it is only practicable for the City to apply notifications to Certificates of Title where a subdivision or development application is processed for a property lying with coastal hazard extents.

It should be noted that the City has already engaged affected landowners and other stakeholders regarding potential coastal hazards and the CHRMAP process, through ongoing community engagement (including direct community consultation in 2016 and 2017). This ongoing community engagement should be continued to maintain transparency.

6.3 Management Priorities

6.3.1 Ongoing protection

R7: Initiate/continue targeted beach nourishment in vulnerable areas.

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

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

6.3.2 Detailed Options Assessments

R8: Undertake a detailed options assessment for management of coastal vulnerability at Yanchep.

The City should undertake a detailed options assessment of potential mitigation measures for the Yanchep area. The study should consider the implementation of managed retreat, offshore breakwaters, seawall(s), groyne(s) and nourishment, in isolation or as a combination. A detailed options assessment should include the following:

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

This assessment may not be required prior to 2030 and should first be informed by at least 5 years of monitoring data, as recommended in **Section 7**.

R9: Undertake a detailed cost-benefit analysis to accompany the existing options assessment at Two Rocks.

Once an economic assessment has quantified the value of natural assets adjacent to Sovereign Drive in Two Rocks (**R2**), a detailed cost-benefit analysis should be undertaken based on the options presented in MRA (2015b). The assessment should also consider the cost and benefit of large scale managed retreat (i.e. of roads and properties), which has not been incorporated into the existing options assessment. Any study should be carried out in consultation with the DoT, who own and manage Two Rocks Marina.

This assessment may not be required prior to 2030 and should first be informed by at least 5 years of monitoring data, as recommended in **Section 7**.

6.3.3 Hazard Response

R10: Set up a coastal asset inventory and emergency/damage response plan to respond to potential coastal impacts.

With a changing climate and 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 (2015) and 2030 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 (inundation, 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.

7 Monitoring and Further Investigation

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

7.1 Long-term coastal monitoring (S2, S3)

R11: Initiate a long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, and coastal asset condition assessments.

Long term estimates of recession are typically derived using historic high resolution aerial imagery. This provides a useful indication of how the shoreline has moved in the past. Due to the difficulties in defining shoreline positions from aerial imagery, it is common practice to use the vegetation line as an indicator of shoreline movement. Whilst this is a useful analysis to estimate historic long term trends, it is emphasised that the vegetation line does not necessarily move at the same rate as the shoreline. For instance the vegetation could be smothered in sand due to high winds, could have been disturbed due to human interference (i.e. driving on the dunes, development, fire, pests etc.), 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 rising sea levels. 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 identify the current position of the HSD, it is recommended that the city implement regular monitoring, in addition to analysis of collected aerial imagery. It is understood that shoreline monitoring is already carried out along part of the City's coastline. That monitoring program should be assessed alongside the recommendations in this report, to achieve efficiencies and improvements where possible. 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 50 to 100 metre intervals, depending on the change in orientation of the shoreline (i.e. long straight beaches can have surveys wider apart). The surveying should prioritise areas with the highest vulnerability at present. Ideally Two Rocks, Yanchep and Quinns should have surveying commence as soon as possible, to ensure the longest dataset possible is available to inform future management. These should be timed to occur in the intervals between the Perth seasonal summer and winter (approximately April and October/November, respectively);
- Nearshore bathymetric surveys on an annual basis (or 6 monthly in association with beach profiles if feasible). These should extend to at least the depth of closure (where the seabed gradient becomes 'flat'), generally between 5m and 10m below MSL for the City's coastline;
- 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 7.2**);
- Regular analysis of collected data (every 2-5 years as required) alongside wind data collected by the BoM, and water level and wave data collected by the DoT.

The City should formalise a monitoring program for their overall coastline. This should involve the development of a monitoring manual, which also includes instruction around storm monitoring (**Section 7.2**).

7.2 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 a shift to managed retreat (see **Table 5-1** – T1). Considerable uncertainty exists around the application of storm erosion modelling techniques (Ranasinghe et al, 2013), such as SBEACH modelling commonly used in the CHRMAP process. Additionally, the lack of data available to confidently quantify what a 1 in 100-year 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 recommended long-term coastal monitoring program (see **Section 7.1**). 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 island 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 storms ability to impact the coastline. Storms should be chosen where the peak of the storm is predicted to occur at high tide, ideally during spring tides; and
- Predicted storm duration. Generally, storms with a longer duration will have higher impact on the coast. Longer duration also means there is the potential for storm peak(s) to occur during elevated water levels.

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

Profiling is critical for assessing changes in the shoreline and estimating changes in volume of sand on the beach. It is important to note that the shoreline is constantly changing and profiling provides a ‘snapshot’ in time of the beach cross section. The dynamic nature of the shoreline means it is important to profile as close to before and after a storm as possible, to avoid detecting changes that might be associated with other processes. Profiling protocols for storm monitoring should be consistent with those outlined in **Section 7.1**, 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 6.3.1**). Sediment sampling protocols for storm monitoring should be consistent with those outlined in **Section 7.1**, 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.

7.3 Coastal Asset Condition Assessment

Some built assets necessarily reside within coastal hazard areas because of their purpose. These assets include boat ramps, jetties, groynes, seawalls, breakwaters and associated access infrastructure, like carparks and access ways. Examples include groynes and access infrastructure at Quinns Beach. Such assets are generally designed to be sufficiently strong to withstand coastal hazards in their own right, or accompanied by protection against coastal hazards. As MSL has already been rising and climate change is expected to bring further changes to water levels and storm intensity, it is possible that existing coastal assets have been under designed for present and/or future coastal conditions. Assets like boat ramps, protection structures and access ways can also lose functionality as conditions change and the shoreline is altered. This is always a challenge when placing fixed infrastructure at a dynamic shoreline.

As unprecedented changes and coastal conditions are predicted to occur, 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 inspect infrastructure after major storm events, to identify any critical damage.

7.4 Further Investigation

7.4.1 Nourishment Sand Source Investigation

R12: 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 and enhance the City's beach nourishment activities. This management technique provides temporary protection, generally improves beach amenity and maintains a flexible adaptation pathway for the future. As sea levels rise, the volume of sand 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 or in areas not considered to be vulnerable;
- 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.

7.4.2 Geophysical Investigations

Geophysical investigations can be useful in identifying the depth of erodible material below the ground surface. The City's coastline contains multiple outcrops of coastal limestone, identified above and below the surface. Unless forming a high, continuous barrier, it is not well understood how this rock will influence erosion of the shoreline with rising MSL. Geophysical investigations can be used to identify and characterise the elevation and strength of coastal rock. Such investigations may be of benefit to the City prior to coastal development, to better inform and refine existing coastal hazard extents. The City should look to prospective developers of coastal land to fund, or contribute to funding, such investigations. Undertaking geophysical investigations as part of defining general hazard extents for CHRMAP revisions is not specifically recommended as any management responses are trigger based, not based on hazard predictions. At the point of triggers being reached, geophysical investigations may become pertinent.

Noting that managed retreat is a potential adaptation option in the future, geophysical investigations will also be beneficial prior to making decisions to remove major built infrastructure. The geophysical investigation could inform the managed retreat decision, ensuring assets are not removed unnecessarily.

Geophysical investigations generally involve transect and point measurements to identify layers and hardness of material below the surface. For this purpose, they would be used to identify if there is a continuous,

alongshore rock barrier located below the ground surface (e.g. within a sand dune), that has sufficient strength and height to prevent coastal hazards impacting assets on its landward side. Such investigations are carried out by geologists using specialised equipment.

7.4.3 CHRMAP Revision

R13: 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 our understanding of coastal processes is improving and given the long timeframes associated with some types of coastal processes and types of land use and development in the coastal zone. It is also impacted by uncertainty on the degree of future climate change (i.e. what the future global greenhouse emissions will be), and climate change projections that are used in the vulnerability assessments. Monitoring and reviewing the CHRMAP ensure the management and adaptation to reduce risks, their likelihood and consequences and the risk priorities, remain the most suitable and effective, and timing and cost appropriate. Where possible principles of adaptive management should be applied which involves small, flexible, incremental changes based on regular monitoring and revision of plans based on the best information available at the time."*

The key changes to any future revisions of the CHRMAP 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.

For this CHRMAP, the City has focused the risk and vulnerability assessment, and development of adaptation options, based on short to medium term hazard extents. These extents and focus areas were identified in Part 1 of the CHRMAP. For future revisions, the City should investigate extents along the broader coastline, to identify new or additional areas that warrant risk/vulnerability assessment and adaptation planning.

8 Key Recommendations

Key CHRMAP recommendations are collated and summarised in **Table 8-1**. These recommendations generally focus on actions that will or may require implementation prior to 2030. Recommendations for management actions beyond 2030 will be better informed by investigations undertaken and information collected over the next decade, which will be highlighted in the next review of the CHRMAP.

Table 8-1 Key CHRMAP recommendations

ID	Recommendation
R1	***Engage the community to present the results of this CHRMAP and formally assess their willingness to contribute to funding.***
R2	***A detailed economic assessment should be undertaken to establish the economic value/contribution of natural assets in key vulnerable areas.***
R3	***Investigate and establish a fund for ongoing coastal adaptation and management, and allocate funding sources.***
R4	***Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.***
R5	***Investigate the benefits of amending DPS2 to directly reference SPP2.6 and include vulnerable areas as Special Control Areas (SCAs).***
R6	***Landholders that may be affected by coastal hazards by 2120 should be notified directly and by the application of notification on Certificates of Title, where possible.***
R7	***Initiate/continue targeted beach nourishment in vulnerable areas.***
R8	***Undertake a detailed options assessment for management of coastal vulnerability at Yanchep.***
R9	***Undertake a detailed cost-benefit analysis to accompany the existing options assessment at Two Rocks.***
R10	***Set up a coastal asset inventory and emergency/damage response plan to respond to potential coastal impacts.***
R11	***Initiate a long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, and coastal asset condition assessments.***
R12	***Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment.***
R13	***Undertake a full revision of the City's CHRMAP, identifying and incorporating relevant new information.***

8.2 Short-term Implementation Plan

A short-term implementation plan is presented in **Table 8-2**. The table describes actions recommended for implementation by 2030, 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.

Table 8-2 Short-term implementation plan to 2030

Component	Annual cost estimate	Total cost estimate (to 2030)	Timing
Operational			
Review existing Structure Plans (***R4***)	-	-	2018
Amend DPS2 (***R5***)	-	-	2018-19
Directly notify affected landholders (***R6***)	-	-	2018
Apply notifications to title (***R6***)	TBD	TBD	From 2018
	Sub-total	**TBD**	
Monitoring			
Shoreline monitoring manual (***R11***)	$25,000	$25,000	2018
Ongoing aerial imagery analysis (***R11***)	$5,000	$60,000	From 2018
Ongoing shoreline monitoring (***R11***)	$40,000	$480,000	From 2018
Storm monitoring (***R11***)	$5,000	$60,000	From 2018
Coastal asset condition assessments (***R11***)	$5,000	$60,000	From 2020
Metocean data collection (***R11***)	$25,000	$300,000	From 2019
	Sub-total	**$985,000**	
Implementation/ Management			
CHRMAP results community engagement (***R1***)	-	$10,000	2018
Ongoing community engagement (***R1***)	$10,000	$60,000	From 2019
Establish coastal adaptation fund (***R3***)	-	-	2019
Ongoing beach nourishment (***R7***)	$500,000	$6,000,000	From 2018
Coastal asset inventory update (***R10***)	-	$10,000	2018
Asset management plan update (***R10***)	-	$10,000	2018
Hazard response preparation (***R10***)	-	$10,000	2018
	Sub-total	**$6,100,000**	
Special Investigations			
Detailed economic assessment (***R2***)	-	$150,000	By 2025
Detailed options assessment for Yanchep (***R8***)	-	$100,000	By 2020
Cost-benefit analysis for Two Rocks (***R9***)	-	$80,000	By 2025
Nourishment sand source investigation (***R12***)	-	$20,000	By 2025
Hazard line and CHRMAP revision (***R13***)	-	$150,000	By 2025
	Sub-total	**$500,000**	
	Grand Total	**$7,585,000**	

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APPENDIX

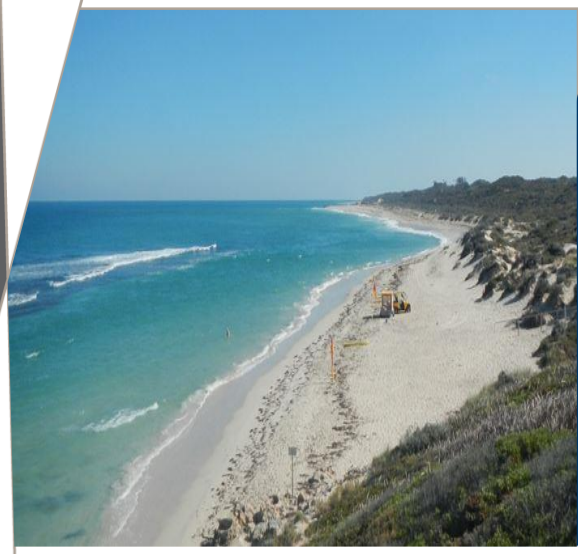
A

COMMUNITY ENGAGEMENT SUMMARY REPORT

Stakeholder Engagement Summary

City of Wanneroo CHRMAP Part 2

59916812



Prepared for
City of Wanneroo

31 July 2018

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Shaping the Future

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Author(s): James Mason
Coastal Engineer

Approved By: Daniel Strickland
Coastal Engineer

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Figures

1 Introduction

The Coastal Hazard Risk Management and Adaptation (CHRMAP) Guidelines (WAPC, 2014) acknowledge the importance of an ongoing process of engaging with key stakeholders and the broader community effectively, throughout the entire CHRMAP process. The Stakeholder Engagement Strategy (Cardno, 2016) was developed to accompany Part 2 of the CHRMAP, with the intention of engaging the local community and other relevant stakeholders. The strategy aimed to ensure transparency in the CHRMAP process and create a sense of ownership over the project's outcomes for the community. The results of Part 1 of the CHRMAP, in particular the identified coastal hazards and key vulnerable areas, were presented to the community by the City in May of 2016.

In brief, the purpose of stakeholder engagement was to:

> Further enable stakeholders to understand the existing and potential future risk to the City of Wanneroo (the City) from coastal hazards, and to increase their awareness of coastal hazards;

> Seek input from stakeholders to inform the risk assessment and adaptation planning processes, through surveys and workshops; and

> Generate stakeholder support for, and/or ownership of, the CHRMAP process.

This summary report outlines the objectives and outcomes of specific stakeholder engagement activities, carried out as part of this strategy.

2 Community Engagement Phase 1

2.1 Objectives

The first phase of community engagement in Part 2 of the CHRMAP comprised the collection of feedback through the 'Coastal Values Survey'. The survey was designed to determine the key values that stakeholders hold with respect to the coastline. Additional information was also collected to assess the demographic of respondents; including the proximity to the coast that they live and work, how frequently they use the coast and for what purpose. One question was designed specifically to guide the development of the success criteria for the CHRMAP. The question asked respondents to rank the various values they associated with the coast and describe any values they held, which they believed were not covered by the available options.

The survey was available online for a period of one month during July and August 2016, and could also be completed in paper form at local community centres and libraries. The community was informed about the survey through a letter drop to those residents within approximately 500 m of the identified vulnerable areas and through various forms of traditional and social media. A summary of the project and relevant background information was provided by the City through a dedicated web page with a link to the survey.

2.2 Results

There was a generally good response to the survey with 79 responses and a good distribution of respondents in terms of their perceived attachment to the coast (i.e. not all lived near the beach or necessarily were regular beach users).

2.2.1 Profile of Respondents

The majority of the respondents (90%) resided in the City of Wanneroo, spread across multiple post codes therein. A similar number of respondents (87%) owned a residential property within the City, suggesting the majority of respondents were owner occupiers within the City. Approximately 80% of respondents live less than 5 kilometres from the coast. See **Figure 2-1**.

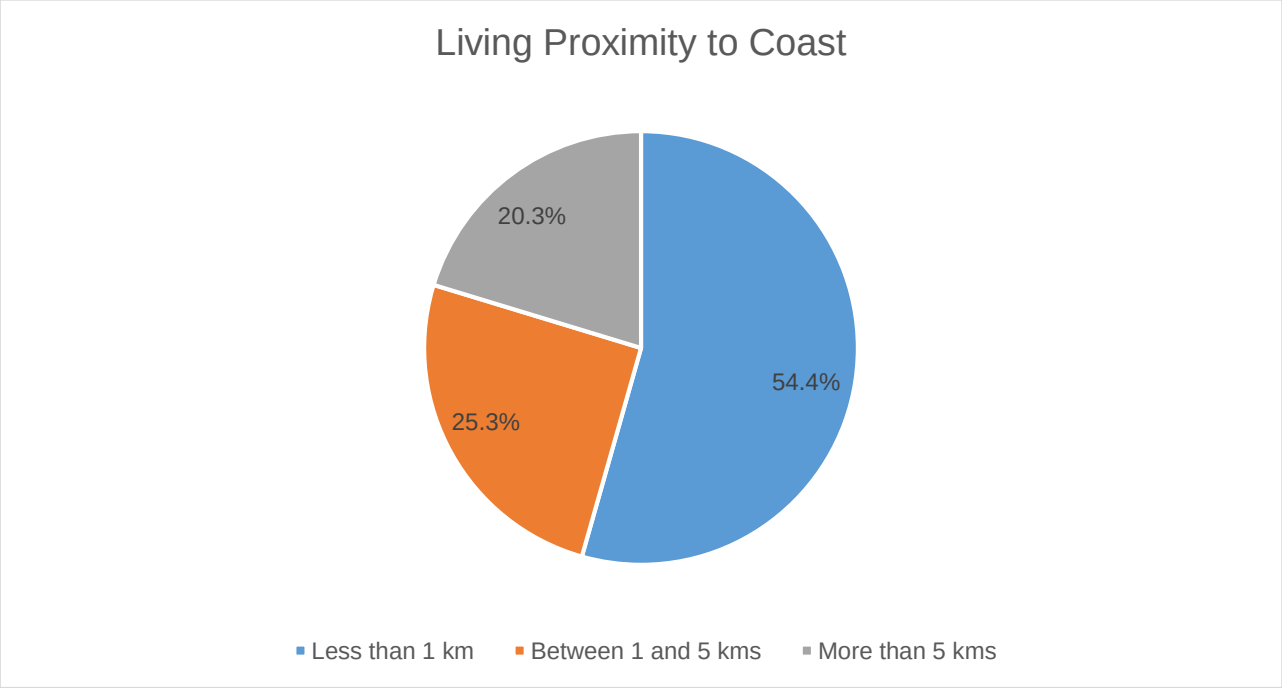


Figure 2-1 Response to the question: 'How close to the beach or foreshore area do you live?' (79 responses)

Just 4% of respondents declared themselves to be running a business related to the coast, and just over 30% identify themselves as belonging to a community, recreational or social group that use the beach. Despite these minorities, 80% of the community visit the coast at least monthly and 69% at least weekly. This frequent use of the coast appears to be predominantly for recreational purposes. See **Figure 2-2**.

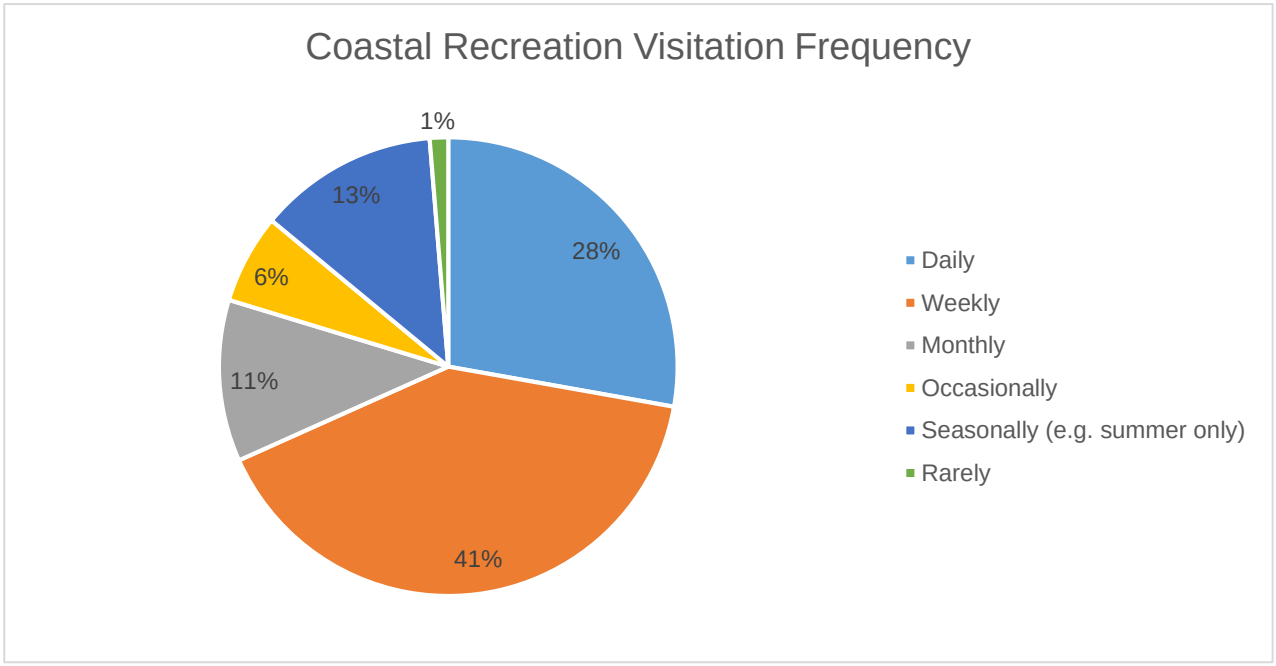


Figure 2-2 Response to the question: 'How often do you visit the beach or foreshore area for recreation?' (79 responses)

Yanchep, Two Rocks and Quinns Beaches were identified as the most popular by beach users. Beaches outside of the City were also identified by respondents as their beach of choice. See **Figure 2-3**.

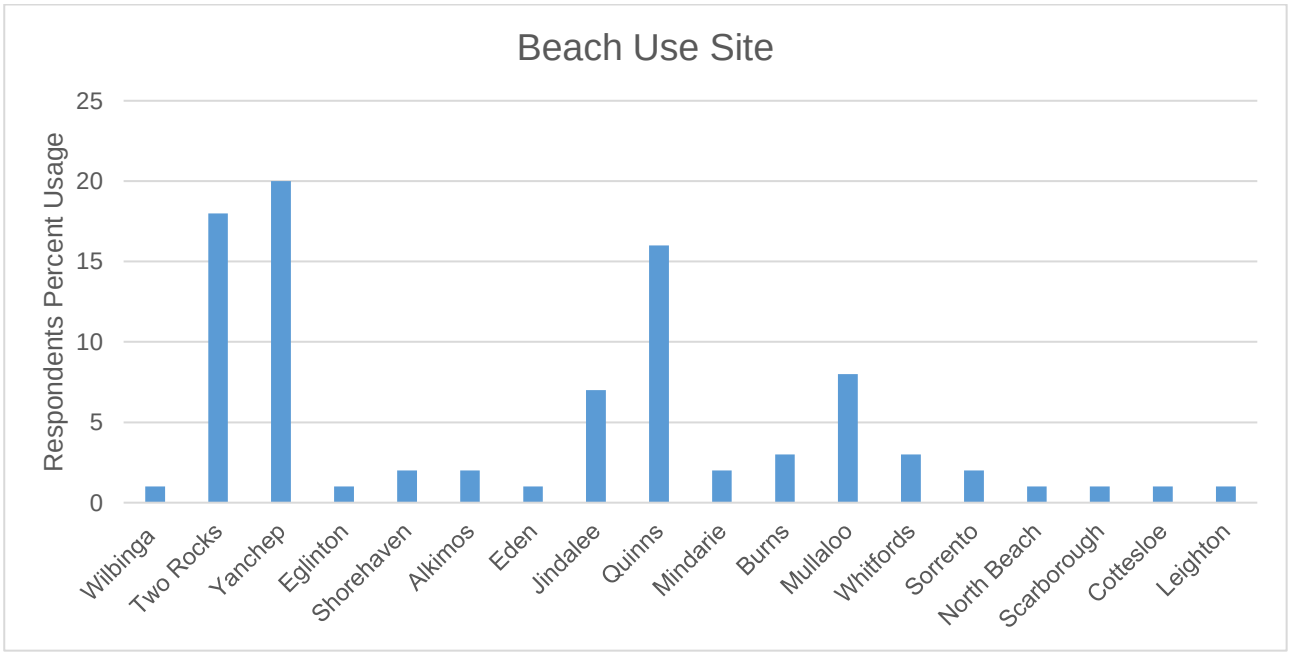


Figure 2-3 Response to the question: 'Which beach or foreshore area do you use the most?' (90 responses from 79 respondents)

A key aim of the CHRMAP process is to educate stakeholders on the threats of coastal hazards and sea level rise. Respondents were asked to declare how well informed they consider themselves regarding these issues. See **Figure 2-4**.

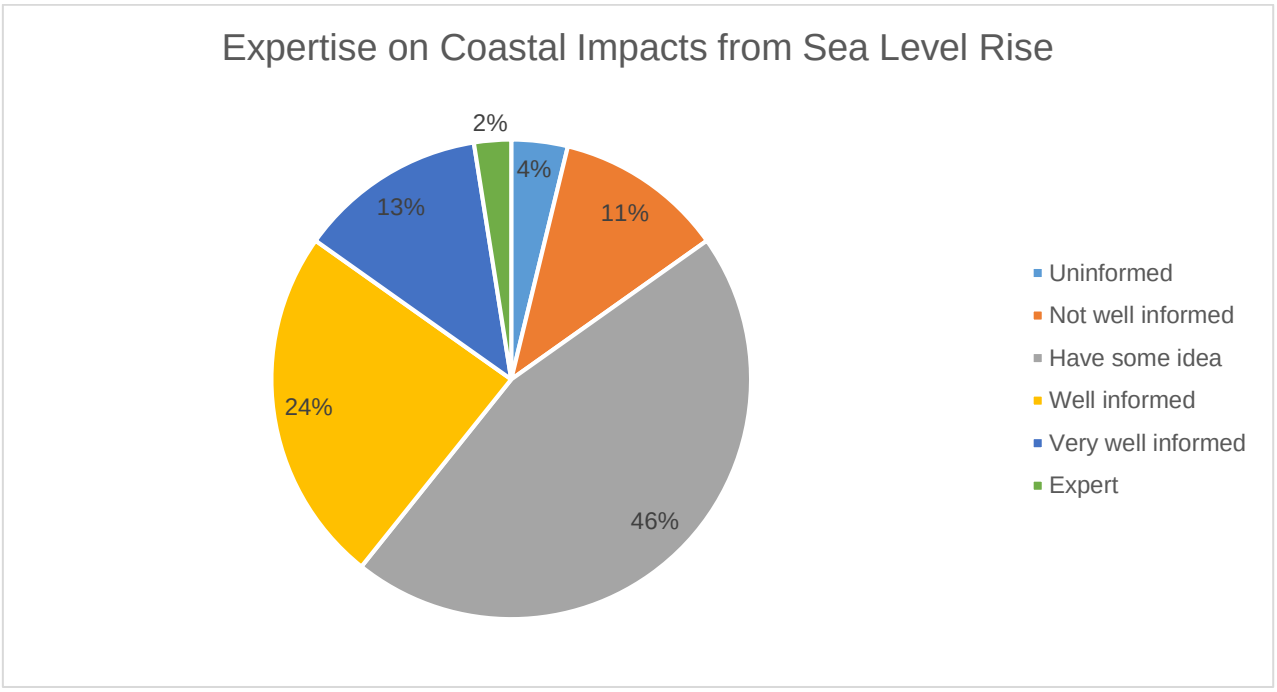


Figure 2-4 Response to the question: 'How well informed do you consider yourself to be on coastal impacts that may happen due to rising sea levels?' (79 responses)

2.2.2 Coastal Values

The question focused around coastal values asked respondents to rate the following values from what they considered most to least important:

- Value 1 – Important environmental sites and plant and animal communities should be preserved and protected;
- Value 2 – Public safety should be a priority in beaches and foreshore areas;
- Value 3 – Facilities encouraging coastal use such as surf clubs, toilets, public access areas, parks and boat ramps, should be provided and maintained;
- Value 4 – Beaches and foreshore areas should be preserved and protected to allows recreational use (such as swimming and walking) and passive use (enjoying the scenery, amenity);
- Value 5 – Foreshore areas for housing should be provided and protected;
- Value 6 – Foreshore areas should be used and protected for local economic benefit (e.g. restaurants, cafes, tourism);
- Value 7 – Infrastructure such as roads, car parks and access paths should be provided and protected to allow access to the beach or foreshore areas; and
- Value 8 – Indigenous and archaeological heritage sites within beach or foreshore areas should be maintained and protected.

The use of a ranking style question was incorporated as it will be difficult to maintain all of the present coastal value, with rising sea level. This question forced respondents to prioritise certain values over others and think about what they consider to be more important. See **Figure 2-5**.

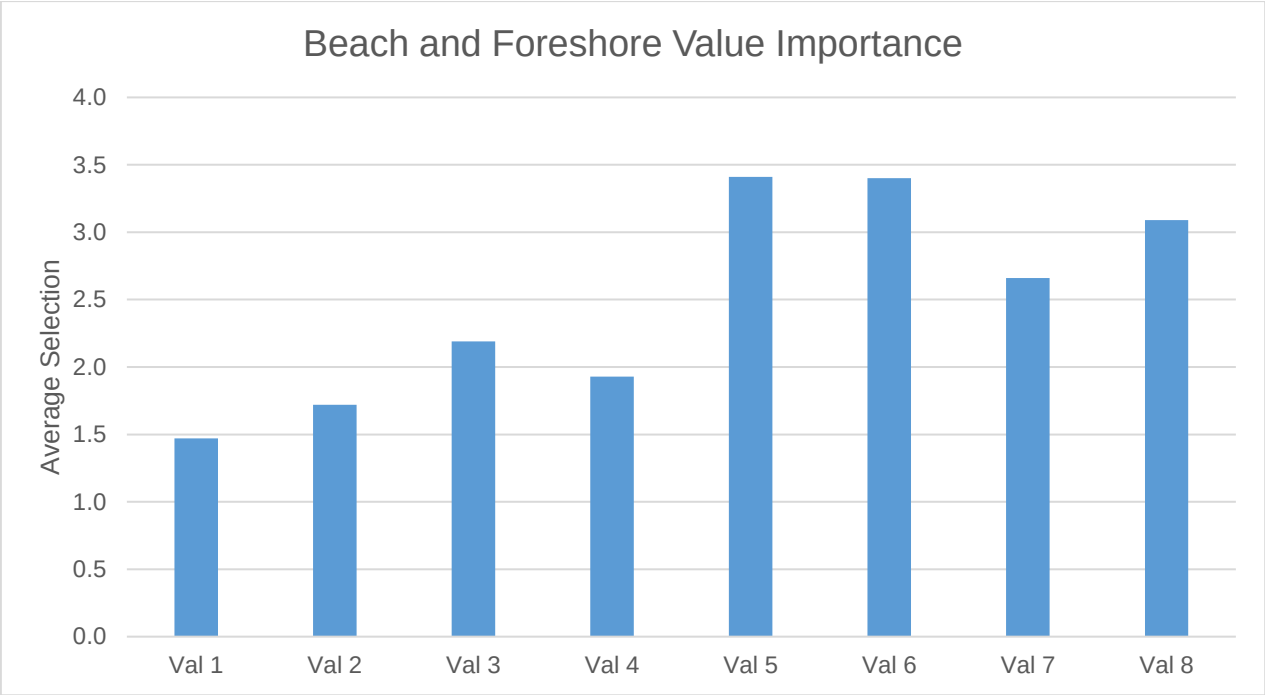


Figure 2-5 Average coastal values rankings with 1 being the most important and 8 being least important (58 responses)*

*Note shorter bars mean the values were considered more important on average.

Protection of natural environmental values was ranked highly by respondents through Values 1 and 4. Safe and accessible use of coastal areas was also ranked highly through response to Values 2 and 3.

2.2.2.2 Success Criteria

Based on the results of the Coastal Values Survey, the following success criteria were developed to guide the CHRMAP development:

SC1. Preservation and protection of important environmental sites and plant and animal communities;
SC2. Prioritisation of public safety at beaches and in foreshore areas;
SC3. Encouragement of coastal use through the provision and maintenance of public access and facilities at beaches and foreshore areas;
SC4. Protection and preservation of beaches and foreshore areas for recreational and passive use;
SC5. Provision and protection of foreshore areas for housing;
SC6. Use and protection of foreshore areas for local economic benefit;
SC7. Provision and protection of beach and foreshore access infrastructure (e.g. roads, carparks, paths); and
SC8. Maintenance and protection of indigenous and archaeological heritage sites within the beach and foreshore areas.

The success criteria were derived based on the options available for ranking in the coastal values question. All available options received sufficient support to be retained as success criteria. Comments provided in regards to additional values held by respondents did not lead to the consideration of any additional success criteria.

3 Community Engagement Phase 2

3.1 Objectives

The purpose of Phase 2 of community engagement was to further educate the community on the CHRMAP process, as well as to present potential adaptation options to deal with predicted sea level rise over the next 100 years. Feedback with regards to these adaptation options was sought through the 'Adaptation Options Survey'. The survey was again provided in paper and online formats, and advertised through traditional and social media. The engagement was conducted during November and December of 2017.

The engagement included 6 sessions, 2 at each of: the Mindarie Quinns Community Centre, Butler Community Centre and the Phil Renkin Community Centre in Two Rocks. The engagement sessions were 1.5 hours long, with a daytime and evening session at each location. The sessions were informal (i.e. no presentations) with information presented on a series of posters. City and Cardno staff were available to discuss issues with attendees. The sessions were widely advertised through the City's website, traditional and social media.

3.2 Results

There was generally good attendance at engagement sessions at Mindarie and Two Rocks. The engagement sessions at Butler were poorly attended, possibly due to the location being away from the coast.

There was a generally good response to the survey with 140 responses and a good distribution of respondents in terms of their perceived attachment to the coast (i.e. not all lived near the beach or necessarily were regular beach users).

3.2.1 Profile of Respondents

The majority of the respondents (80%) resided in the City of Wanneroo, spread across multiple post codes therein. This portion was slightly less than that for the Values Survey. A similar number of respondents (80%) owned a residential property within the City, suggesting the majority of respondents were owner occupiers within the City. Approximately 80% of respondents live less than 5 kilometres from the coast, the same proportion as for the Values Survey. See **Figure 3-1**.

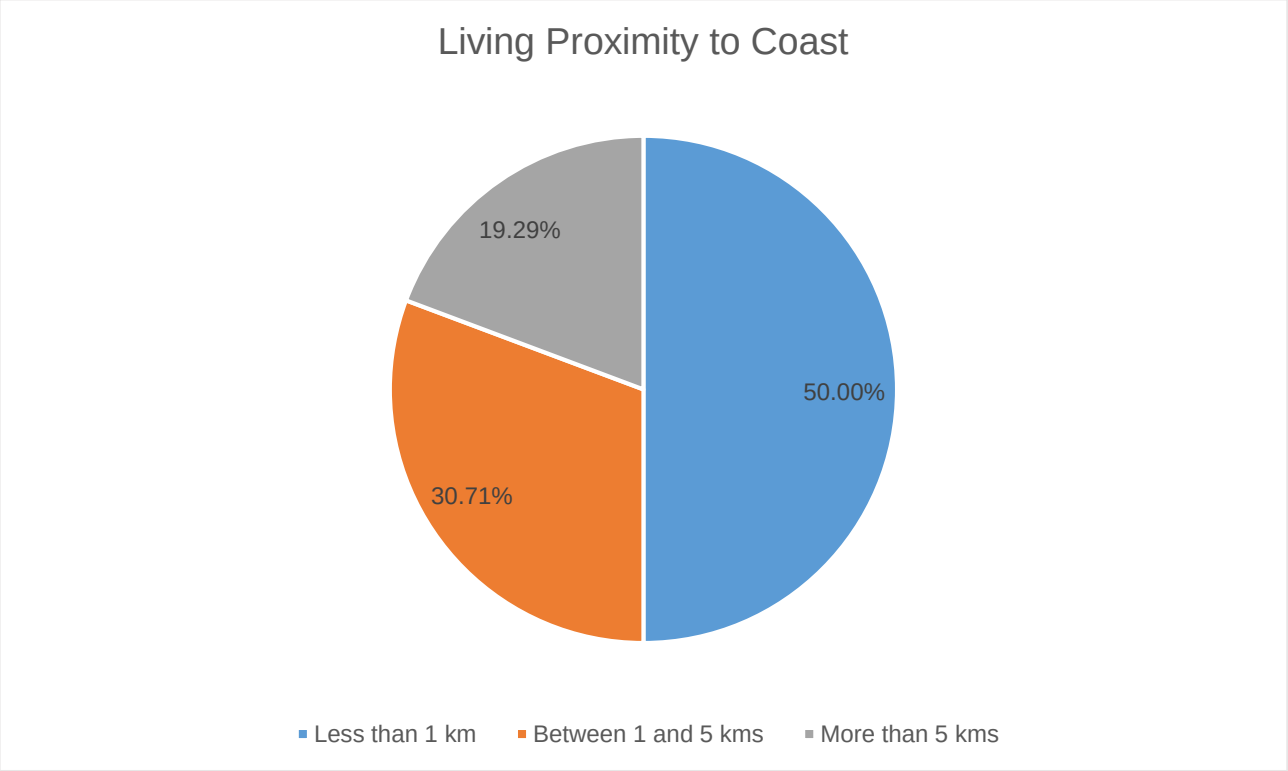


Figure 3-1 Response to the question: 'How close to the coast do you live?' (140 responses)

18% of respondents declared themselves to be running a business or in an occupation related to the coast, and 26% identify themselves as belonging to a community, recreational or social group that use the beach. 91% of the community visit the coast at least monthly and 79% at least weekly. Both these portions were about 10% higher than for response to the same question in the Values Survey. This frequent use of the coast appears to be predominantly for recreational purposes. See **Figure 3-2**.

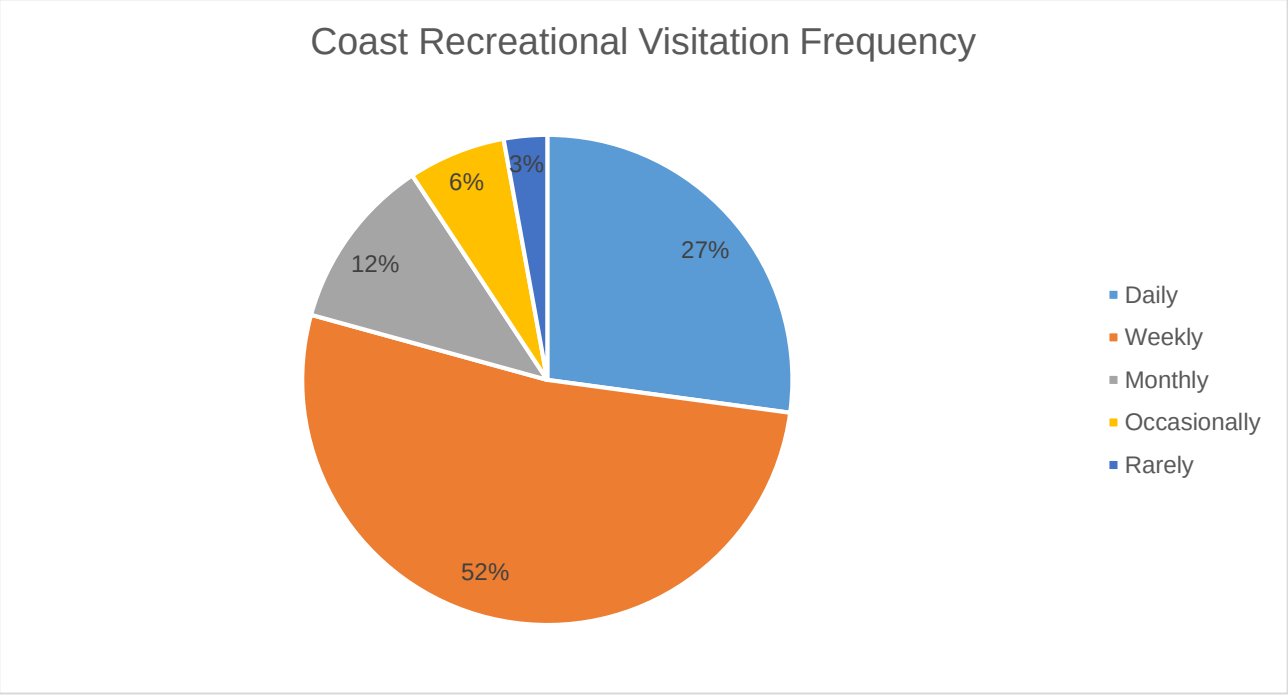


Figure 3-2 Response to the question: 'How often do you visit the coast for recreation?' (140 responses)

Quinns Beach was identified as the most popular by beach users, being the beach of choice for about a third of respondents. Two Rocks and Yanchep were also popular, however they had much less representation

than in the Values Survey. Interestingly, beaches outside of the City were also identified by respondents as their beach of choice. See **Figure 3-3**.

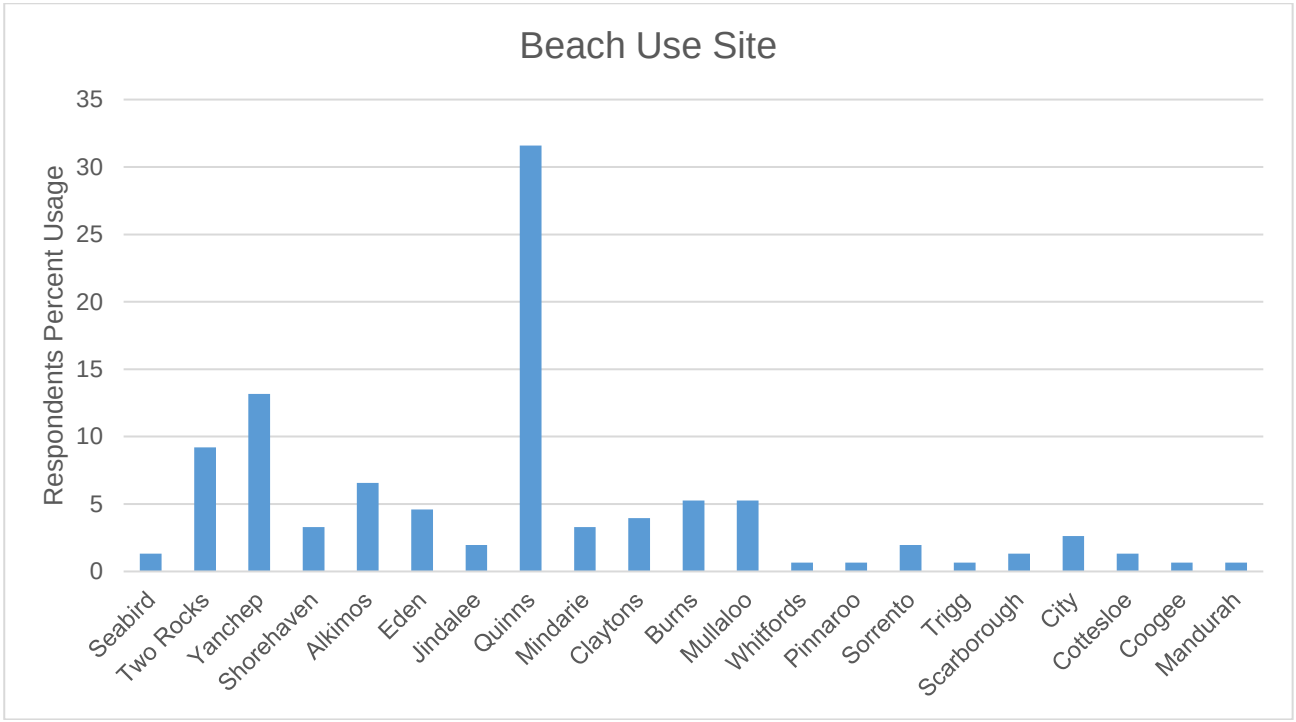


Figure 3-3 Response to the question: 'Which beach do you use the most?' (152 responses from 140 respondents)

Respondents judge themselves to be slightly more educated for this survey, compared to the Values Survey. 12% of respondents considered themselves to be 'uninformed' or 'not well informed' regarding sea level rise related coastal impacts in this survey, compared to 15% for the Values Survey.

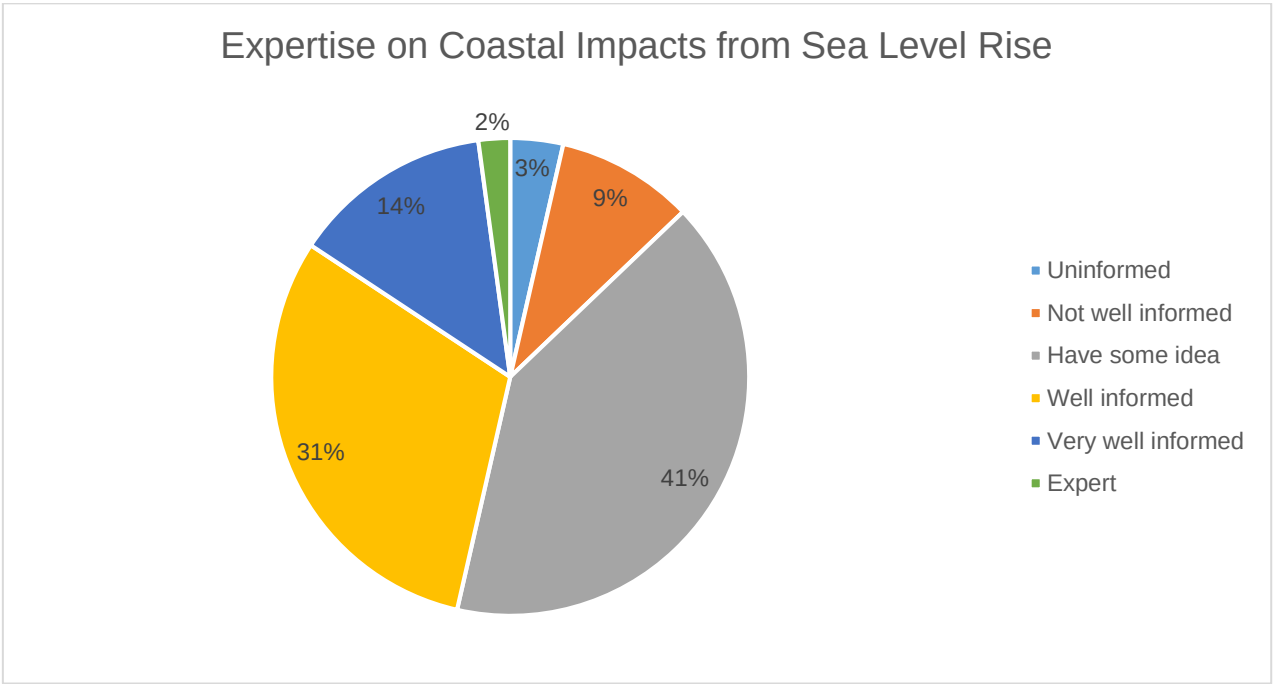


Figure 3-4 Response to the question: 'How well informed do you consider yourself to be on coastal impacts that may happen due to rising sea levels?' (140 responses)

3.2.2 Planning and Development

Statements were put to respondents to gauge their acceptability of development controls in hazardous areas. Percentage response to these statements is displayed in **Figures 3-5** to **3-7**. The notion of preventing development or intensification of development in hazardous areas had majority support. There was also majority support for allowing existing development rights to continue in hazardous areas.

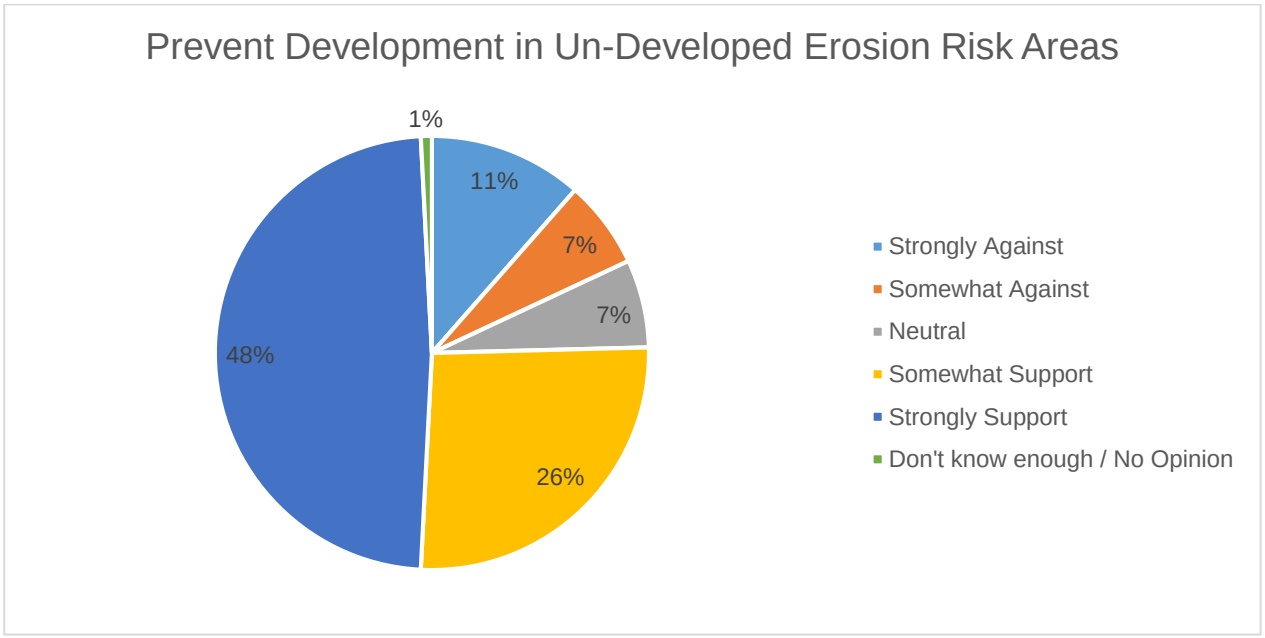


Figure 3-5 Response to the statement 'For areas that are currently not developed and are predicted to be at risk of erosion during the 100-year planning timeframe, do not allow any development in these areas' (122 responses)

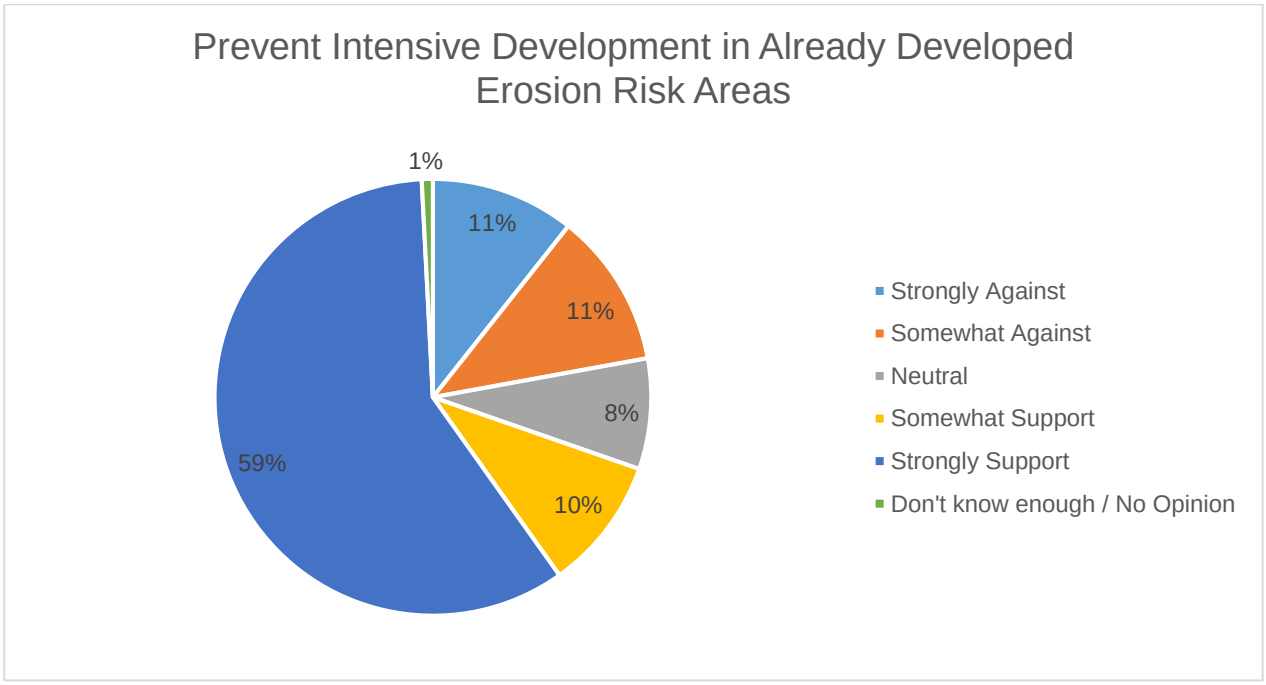


Figure 3-6 Response to the statement 'For areas that are already developed and are predicted to be at risk of erosion during the 100-year planning timeframe, do not allow any more intensive development (such as increasing residential coding)' (122 responses)

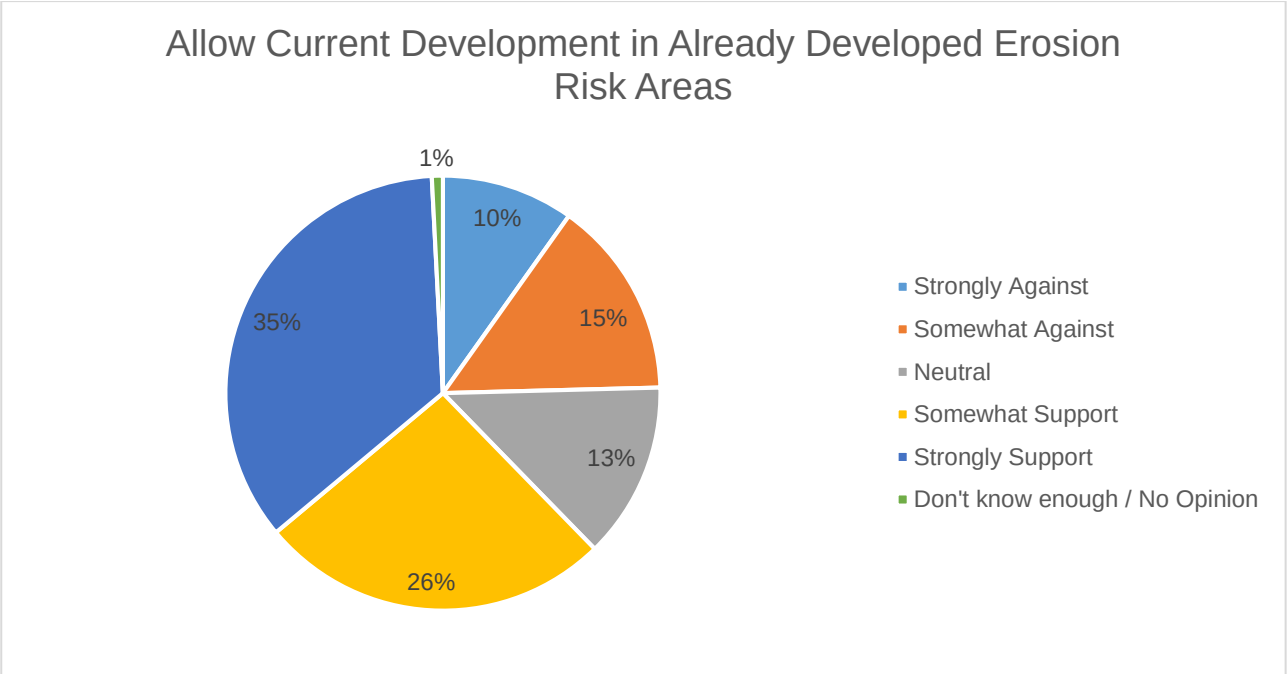


Figure 3-7 Response to the statement 'For areas that are already developed and are predicted to be at risk of erosion during the 100-year planning timeframe, allow development consistent with existing development rights (such as building a new house on a vacant block)' (122 responses)

3.2.3 Provision of Hazard Risk Information

The majority of respondents strongly supported the provision of information about coastal hazard risks to affected parties (see **Figure 3-8**).

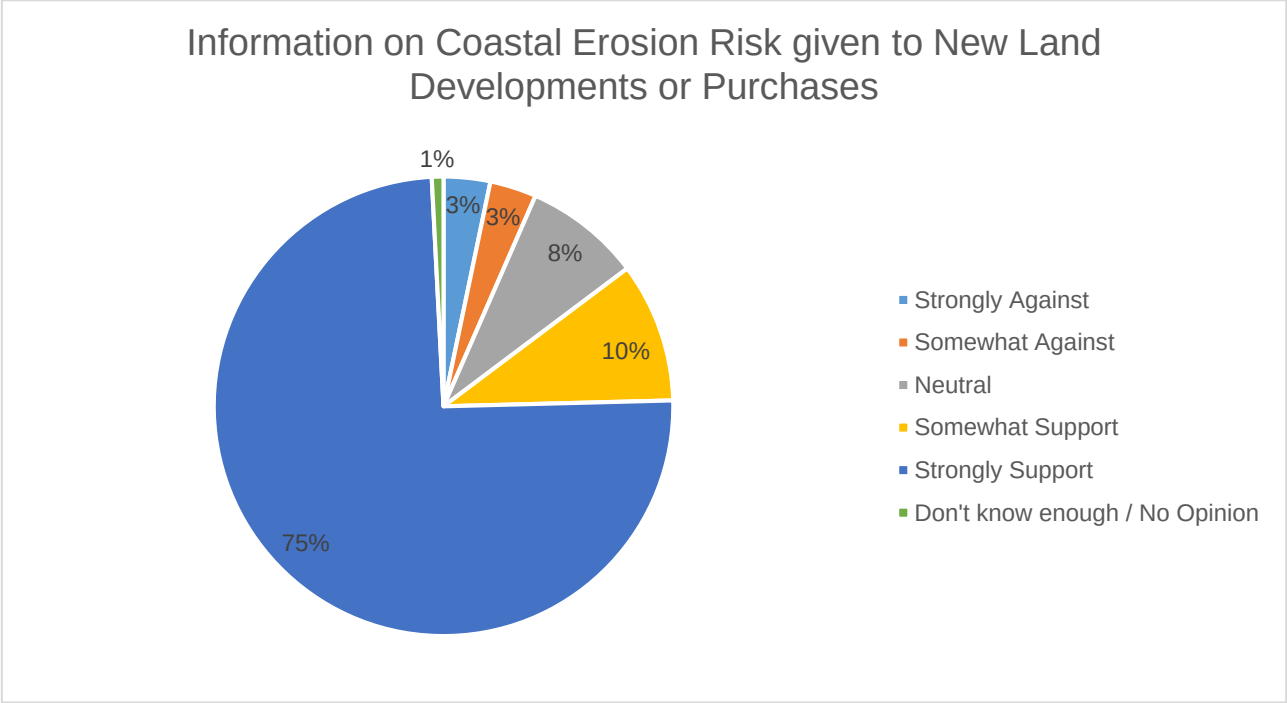


Figure 3-8 Response to the statement 'Landowners should be informed about the risks of coastal erosion and inundation before purchasing or developing in hazardous areas' (122 responses)

3.2.4 Beach Preservation and Access

The preservation of natural assets such as sand dunes and foreshore vegetation was strongly supported by the majority of respondents (**Figure 3-9**). Similarly, there was majority support for ensuring ongoing access to beaches and foreshore areas for all community members (**Figure 3-10**).

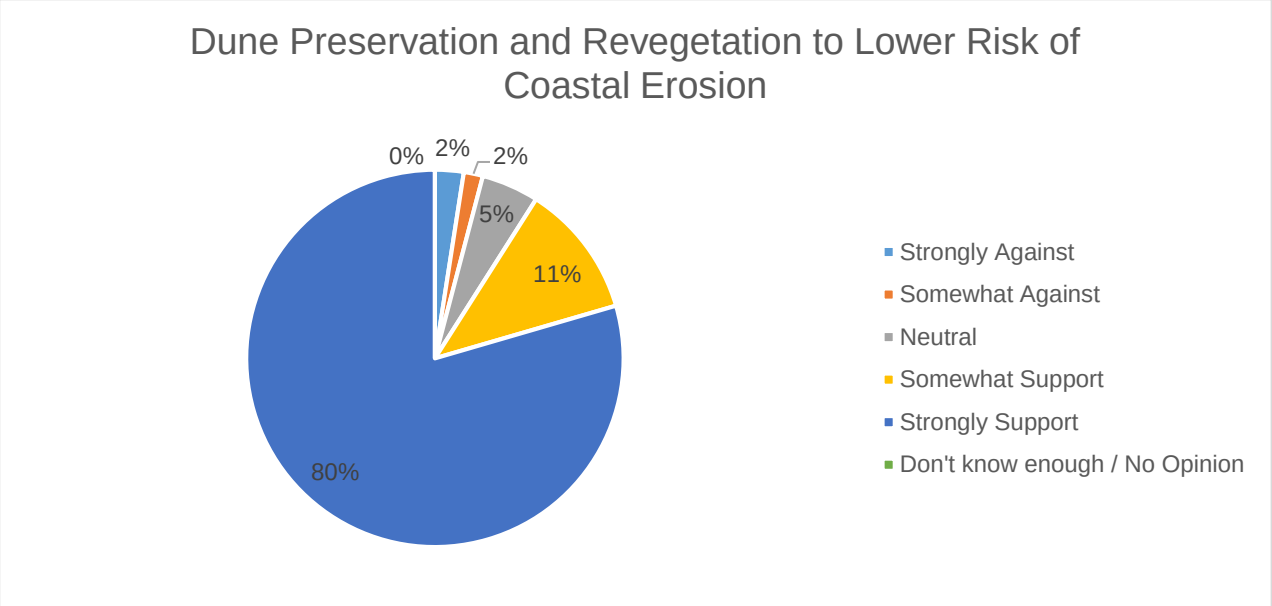


Figure 3-9 Response to the statement 'Preserve sand dunes and vegetate foreshore areas to lower the risk of coastal erosion' (122 responses)

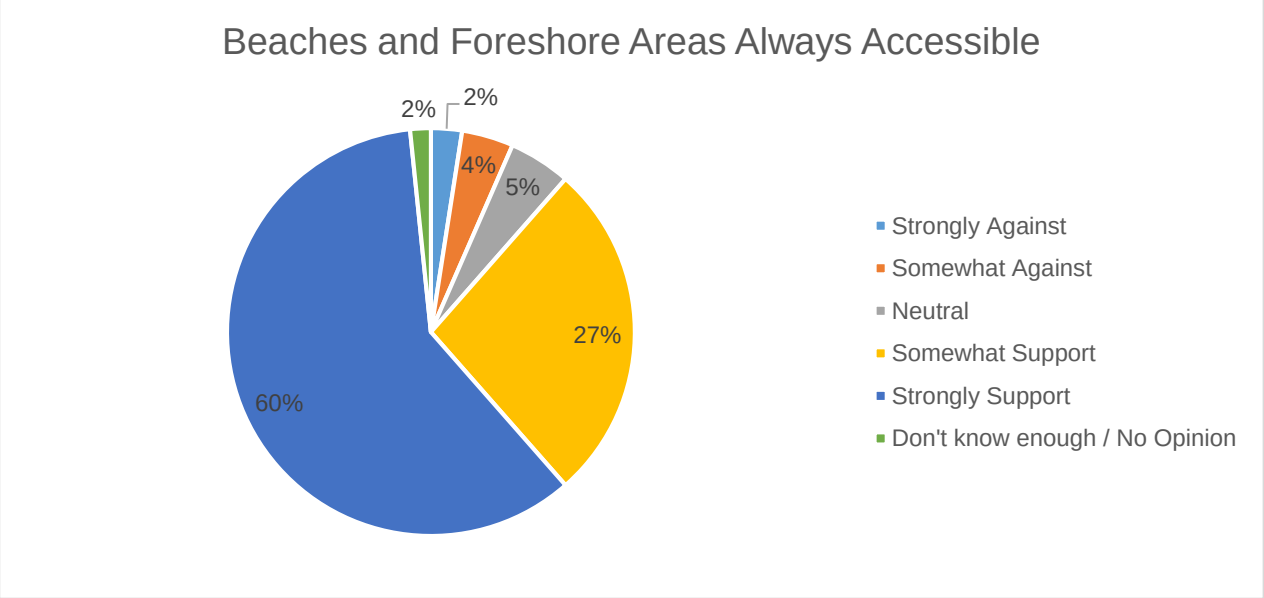


Figure 3-10 Response to the statement 'Ensure beaches and foreshore areas are always accessible and available to all members of the community' (122 responses)

3.2.5 Managing Erosion

There was mixed support for the removal of assets (i.e. managed retreat) to manage risks associated with retreat of the shoreline (**Figure 3-11**). 28% of respondents strongly supported this, while 17% were strongly against it. There was also mixed support for the notion that beneficiaries of retaining the beach and foreshore, due to the removal of assets, should pay for this (**Figure 3-12**). 46% of respondents supported this, while 32% were against it.

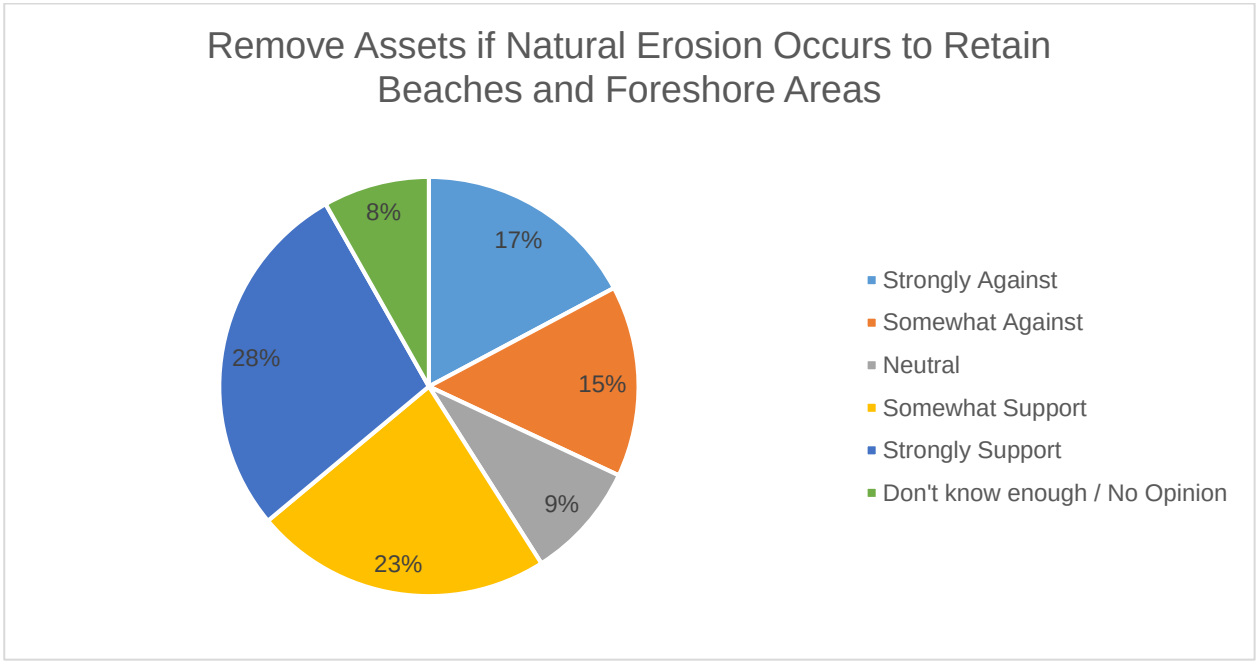


Figure 3-11 Response to the statement 'If natural erosion and inundation processes are allowed to occur, then remove assets (including private property) from the coast to retain beaches and foreshore areas' (122 responses)

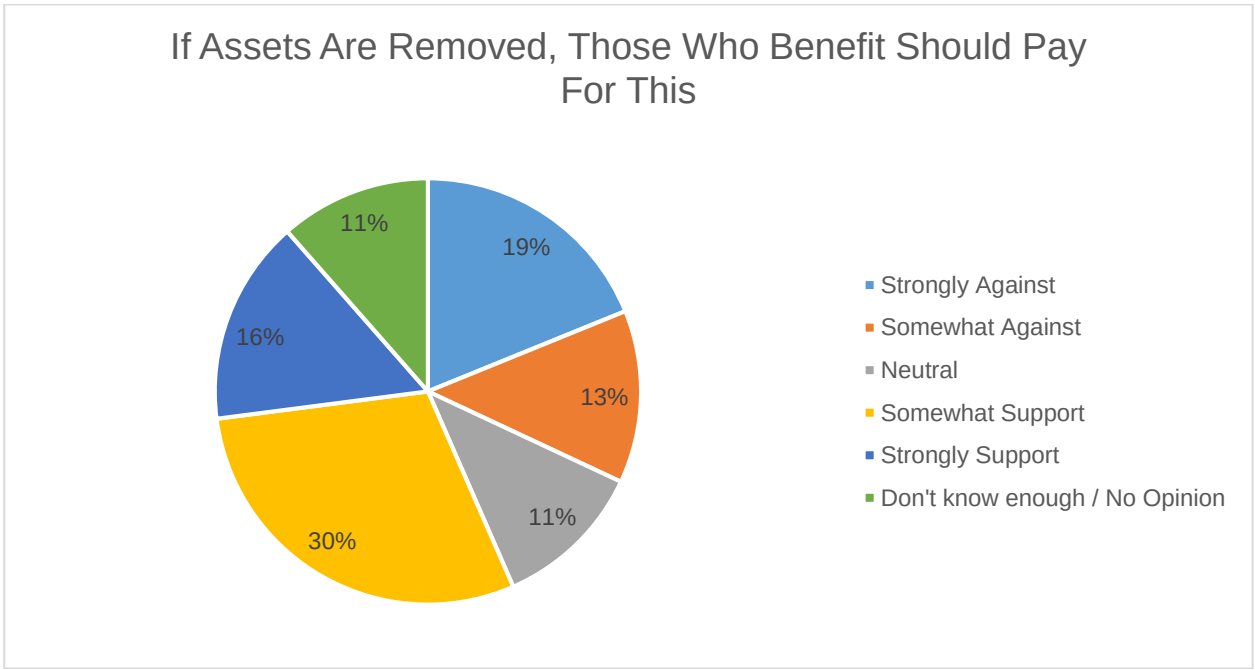


Figure 3-12 Response to the statement 'If assets (including private property) are removed from the coast to retain beaches and foreshore areas, then those who benefit from the retention of the beaches and foreshore areas should pay for this' (122 responses)

Support for the protection of private property, at the expense of beach and foreshore amenity, was divided (**Figure 3-13**). 45% of respondents were against protection, while 38% showed support for it. Levels of support were again mixed for assigning the cost of protection to private developments that will benefit from it (**Figure 3-14**). There was, however, majority support for the notion at 51%.

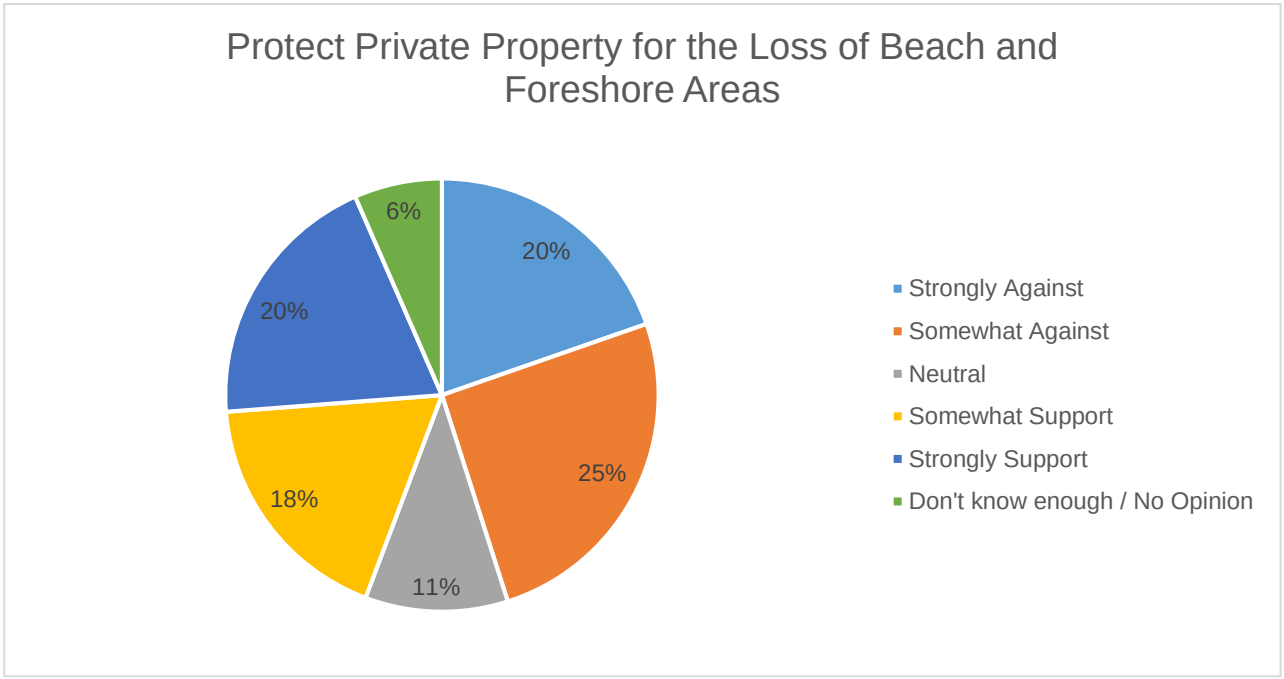


Figure 3-13 Response to the statement: 'Protect private property from erosion and inundation, even if this results in the loss of the beach and foreshore area, prevents/restricts public access or causes erosion elsewhere' (122 responses)

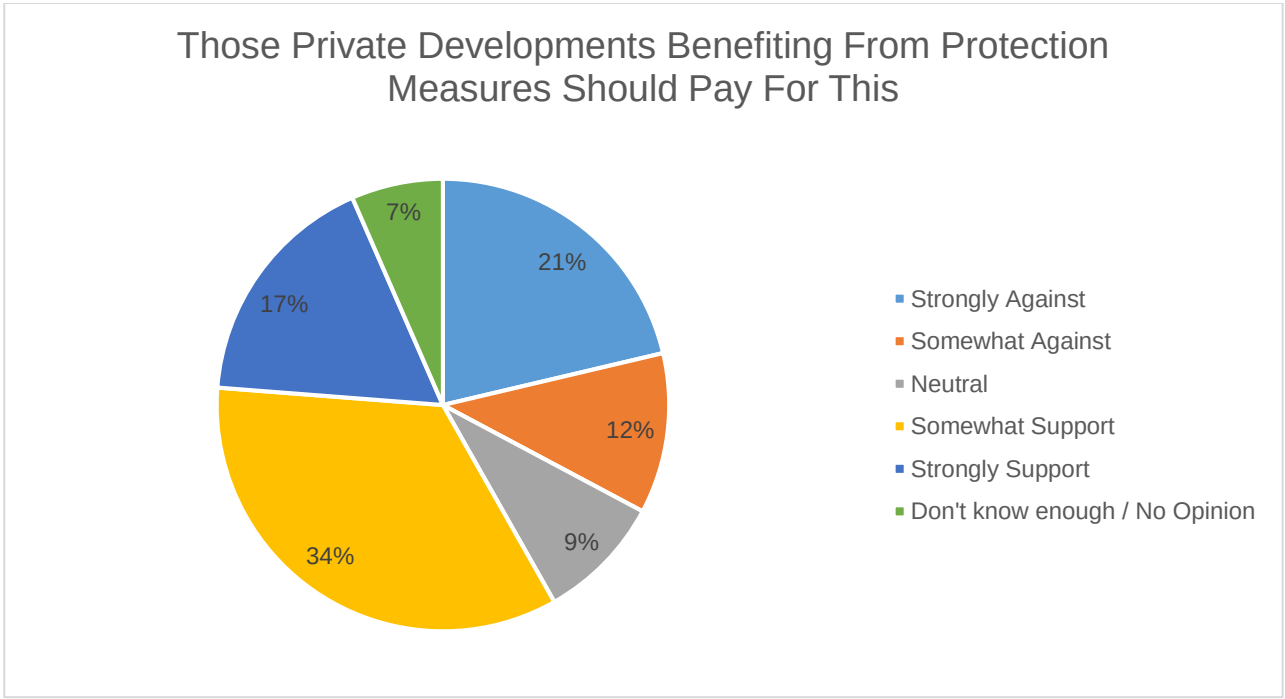


Figure 3-14 Response to the statement: 'Those who benefit from coastal protection measures should pay for those works (capital costs and ongoing maintenance costs)' (122 responses)

3.2.6 Future Pathways

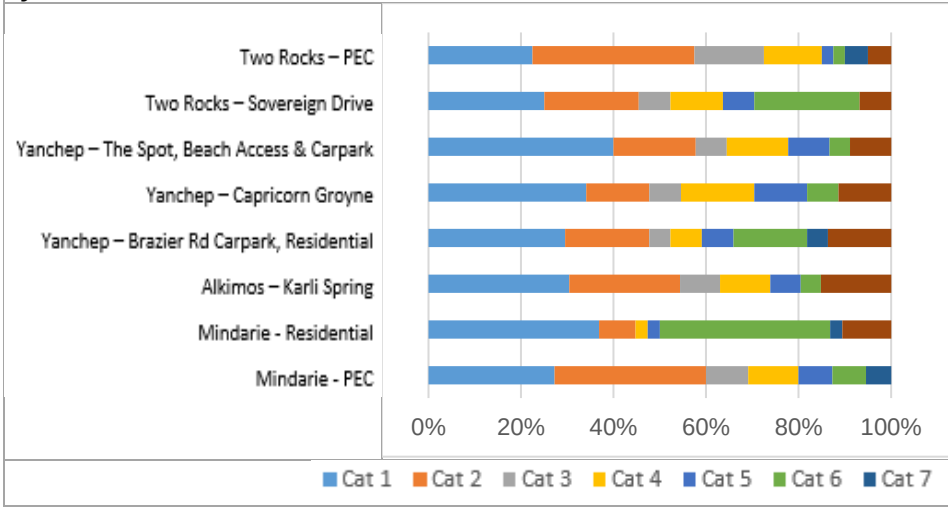
Respondents were asked to provide general comments about how they would like to see specific study sites being used and managed in 20, 50 and 100 years' time, respectively. To analyse the responses, they were assessed and assigned to distinct categories. These categories are defined as follows:

- Category 1 – Do nothing / leave as is / unchanged
- Category 2 – Conservation activities
- Category 3 – Recreational facilities
- Category 4 – Amenity / access facilities
- Category 5 – Private development
- Category 6 – Coastal protection
- Category 7 – Community activities
- Category 8 – Planning regulations / limitations

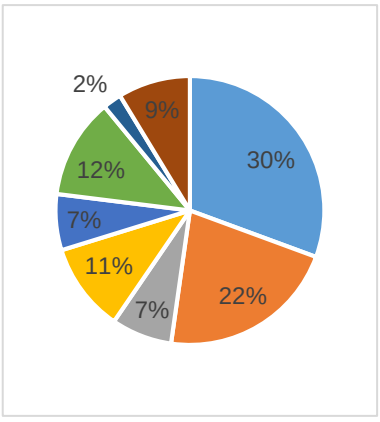
Category 1 and 2 were well represented, carrying the theme that respondents would like to see the coast preserved as it is now. Further education may be required to clarify that 'doing nothing' is not necessarily the same as preserving the present values of the coast ("leave alone" was commonly recorded). Category 8 received good response, suggesting respondents are conscious of the importance of future planning to avoid risk. There were differences in response among sites, probably given the different nature of each site (natural, developed, containing well used beach etc.). Responses across the three timeframes, however, were generally consistent, with few respondents suggesting changes in the use of the area or management approach in the future.

Response in 20 Years

By Site



All Sites



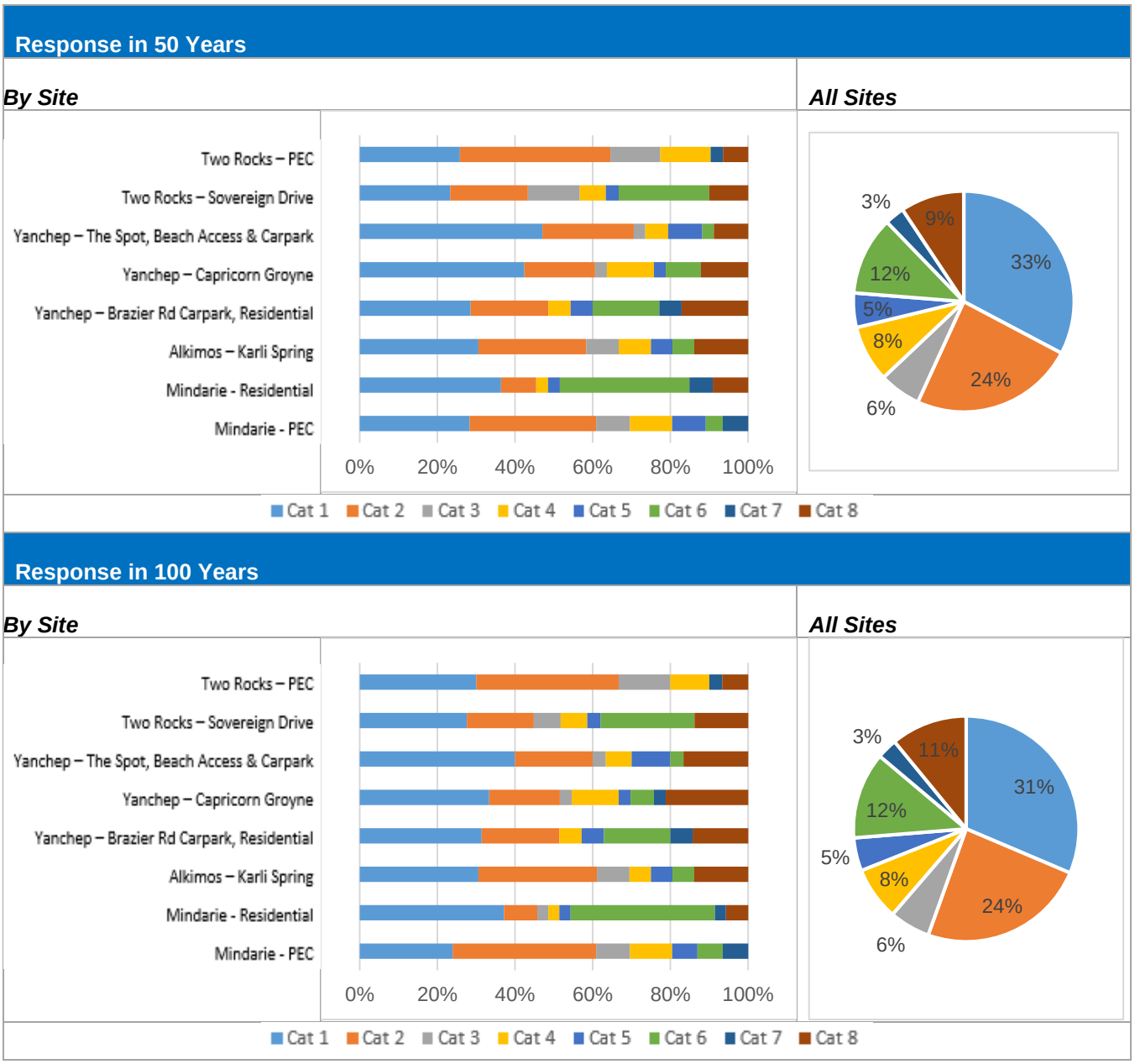


Figure 3-15 Categorised responses to the question: 'How would you like to see (site) being used and managed in 20, 50 and 100 years' time', respectively

4 Outcomes

4.1 Survey Comparison

Given the repetition of demographic questions asked in the surveys for Phase 1 and Phase 2 of community engagement, a comparison of respondent profiles can be made. There was a greater response rate for the Adaptation Options Survey, which could be attributed to seasonality (happening during a time of greater beach use) or increased awareness of, and engagement with, the project.

Interestingly, 10% more respondents were from outside the City for the Adaptation Options Survey, suggesting that broader awareness of the project might have increased between surveys. The proximity that respondents live to the coast was similar for both surveys, with good representation of people living beyond 5 km from the coast (20%), considering the nature of the survey. Approximately 10% more respondents were weekly or daily beach visitors in the Adaptation Options Survey, probably due to it being conducted in the summer season when beach users are more active and engaged. Respondents considered themselves to be slightly more educated on sea level rise and coastal hazards by the Adaptation Options Survey, which might indicate that community engagement is working to increase education and awareness.

The Values Survey showed a good spread of the City's beaches being favoured by beach users, while the Adaptation Options Survey showed Quinns to be the dominant beach of choice for beach users. This is not unexpected given the beach's profile, but is somewhat confounding given that Quinns Beach was excluded for the assessment of adaptation options.

4.2 Lessons Learnt

Some key lessons learnt and points of interest from the community engagement, to be considered during planning for future engagement, were as follows:

- For both surveys, multiple respondents failed to complete the survey beyond the demographic questions (i.e. not completing the values and adaptation options questions, respectively). This loss of response meant key data was not obtained for both surveys. This could be remedied in future by placing critical questions higher in the survey (if practical) or simplifying the questions. It would be difficult to simplify this questioning further, given the topics complexity. Despite this, overall completion rates were good, considering the complexity of these latter questions;
- There was a greater response during summer and respondents appeared more engaged and positive about beach use. This was not unexpected and engagement timing was planned for this. The use of coastal facilities to engage with the community was also more effective than for facilities away from the coast. This should be noted when planning for future engagement activities;
- Considering the focus of the surveys, having 20% of respondents live beyond 5km from the coast was a good result. It must be noted, however, that this is not representative of the City's overall community distribution. Therefore, the data cannot be interpreted to represent the views of the overall community. An even distribution of respondents could be gained in future by randomly sampling throughout the City. This would require good supporting information, to convey to some respondents why their response is critical regarding issues that don't seem to be related to them (e.g. non beach users living well inland);
- The second survey had a much stronger online response than the first, with only one paper response to the second survey. This suggests it may be possible to phase out paper surveys in future engagement activities, without necessarily affecting response rates. Online surveying allows more efficient collection and processing of data;
- The presentation posters provided a good starting point and reference point for verbal engagement during workshop sessions. They also allowed attendees to gather information without having to talk to a representative, where desired. This technique should be considered for incorporation in future engagement sessions. Similarly, the lack of presentation and informal layout provided a comfortable atmosphere for engagement;

- There was a strong response from older generations to the engagement process, but younger generations did not appear to be well represented. This is notable because the intent was to gain guidance on planning up to 100 years into the future. Efforts should be made to engage younger generations in future activities, as they are more likely to be impacted by future management approaches;
- The final question of the Adaptation Options Survey asked respondents to describe how they would like to see coastal areas at three timeframes in the future (20, 50 and 100 years). Almost all respondents repeated the answer across these timeframes, suggesting they weren't willing/able to differentiate adaptation pathways. This questioning would, therefore, have seemed repetitive to respondents and questioning effort could have been better used to gain other/additional information at this stage of the survey;
- Through the surveys and engagement sessions there was a tendency to focus on specific, short-term coastal issues. This somewhat detracted from the aim of engagement, which was to receive feedback on long term issues and management. It is difficult for the community to shift focus from immediate issues, but efforts should be made in future engagement to avoid this; and
- The nature of survey questions were quite complex, and simplifying questioning in future may lead to higher response rates. This would be difficult to do, given the topic, but should be reviewed for future survey preparation.

5 References

Cardno, 2016, *City of Wanneroo CHRMAP Part 2 – Risk Assessment Chapter Report*. Prepared for the City of Wanneroo.

WAPC, 2014, *Coastal Hazard Risk Management and Adaptation Planning Guidelines*. Perth, Australia

APPENDIX

B

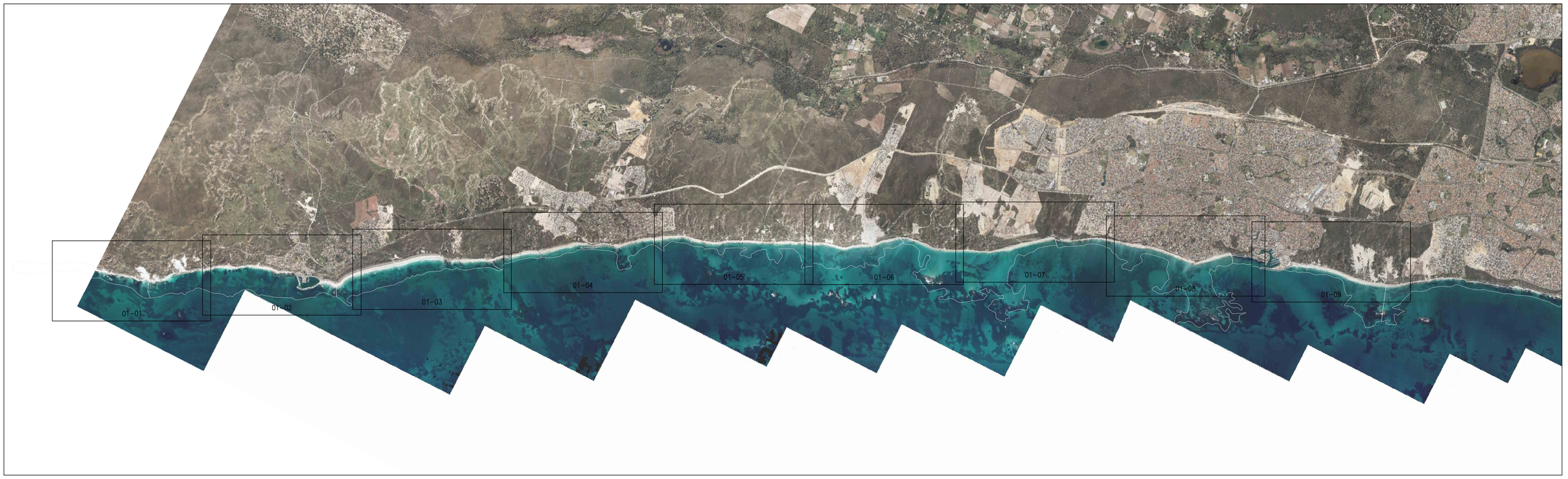
COASTAL HAZARD MAPPING (MRA, 2015A)

AT CORRECT SCALE THIS IS 100 mm

CITY OF WANNEROO

COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

DRAWING No.	TITLE
D1212-01-01	COOK LUMP
D1212-01-02	TWO ROCKS NORTH
D1212-01-03	TWO ROCKS SOUTH
D1212-01-04	YANCHEP
D1212-01-05	EGLINTON
D1212-01-06	ALKIMOS
D1212-01-07	JINDALEE
D1212-01-08	QUINNS ROCKS
D1212-01-09	MINDARIE TO TAMALA PARK



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PROJECT: COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

TITLE: EROSION HAZARD MAPPING
DRAWING LIST AND SHEET LAYOUT

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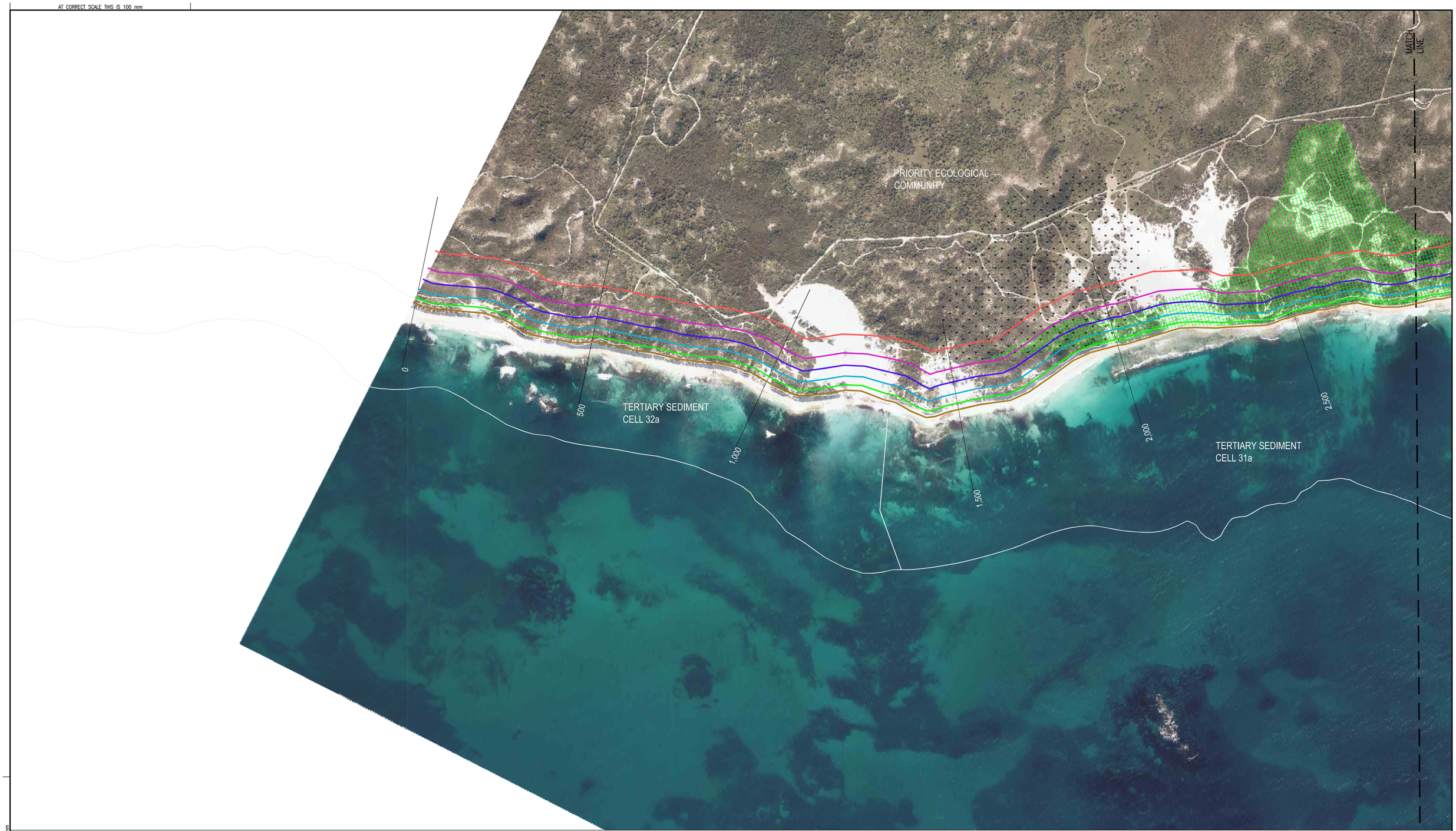

AT CORRECT SCALE THIS IS 100 mm

LAYOUT 1

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

- REGISTERED ABORIGINAL CULTURAL HERITAGE SITES

AERIAL PHOTOGRAPH TAKEN: 2014

CAD: D12120101B

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PROJECT: COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

TITLE: EROSION HAZARD MAPPING
COOK LUMP

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LAYOUT 2

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

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TITLE: EROSION HAZARD MAPPING
TWO ROCKS NORTH

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AT CORRECT SCALE THIS IS 100 mm

MATCH LINE

MATCH LINE

TERTIARY SEDIMENT CELL 30b

TERTIARY SEDIMENT CELL 30a

"THE SPOT"

7,000

7,500

8000

8,500

9,000

9,500

10,000

10,500

AT CORRECT SCALE THIS IS 100 mm

LAYOUT 3

LEGEND:

ROCKY COAST

PRESENT DAY VULNERABILITY

2030 VULNERABILITY

2050 VULNERABILITY

2070 VULNERABILITY

2090 VULNERABILITY

2120 VULNERABILITY

ENVIRONMENT

BUSH FOREVER SITE 397

HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

REGISTERED ABORIGINAL CULTURAL HERITAGE SITES

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PROJECT: COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

TITLE: EROSION HAZARD MAPPING
TWO ROCKS SOUTH

SCALE AT A1	DRAWING NUMBER	REV
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LAYOUT 4

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

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TITLE: EROSION HAZARD MAPPING YANCHEP

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MATCH LINE

14,500

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16,500

TERTIARY SEDIMENT
CELL 29d

17,000

17,500

18,000

AT CORRECT SCALE THIS IS 100 mm

LAYOUT 5

LEGEND:

ROCKY COAST

PRESENT DAY VULNERABILITY

2030 VULNERABILITY

2050 VULNERABILITY

2070 VULNERABILITY

2090 VULNERABILITY

2120 VULNERABILITY

ENVIRONMENT

BUSH FOREVER SITE 397

HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

REGISTERED ABORIGINAL CULTURAL HERITAGE SITES

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TITLE: EROSION HAZARD MAPPING EGLINTON

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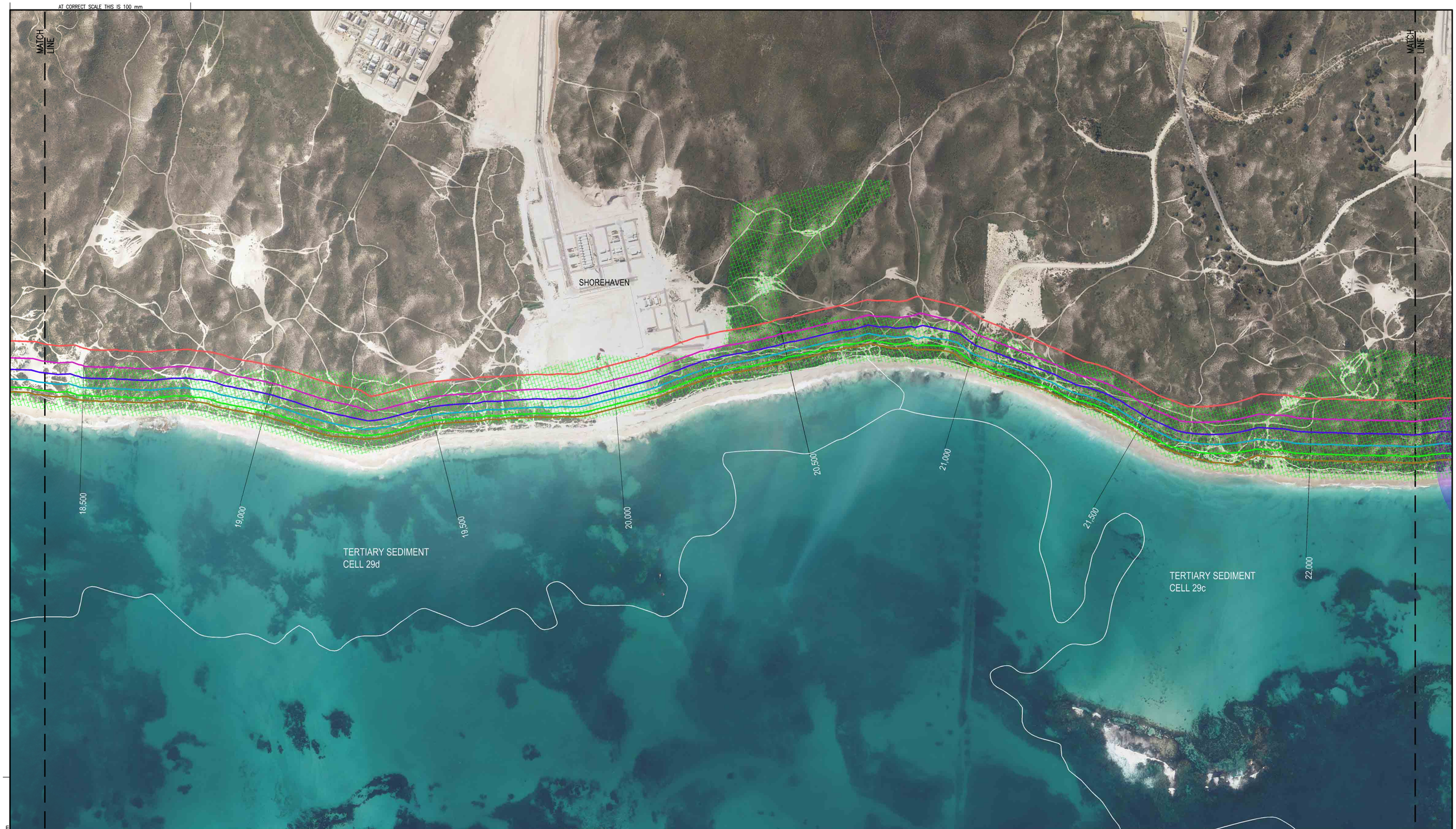

LAYOUT 6

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

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PROJECT: COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

TITLE: EROSION HAZARD MAPPING ALKIMOS

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AT CORRECT SCALE THIS IS 100 mm

MATCH LINE

MATCH LINE

TERTIARY SEDIMENT
CELL 29b

TERTIARY SEDIMENT
CELL 29c

22,500

23,000

23,500

24,000

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26,000

AT CORRECT SCALE THIS IS 100 mm

LAYOUT 7

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

- REGISTERED ABORIGINAL CULTURAL HERITAGE SITES

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PROJECT: COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

TITLE: EROSION HAZARD MAPPING
JINDALEE

SCALE AT A1	DRAWING NUMBER	REV
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AT CORRECT SCALE THIS IS 100 mm

LAYOUT 8

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

- REGISTERED ABORIGINAL CULTURAL HERITAGE SITES

AERIAL PHOTOGRAPH TAKEN: 2014

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TITLE: EROSION HAZARD MAPPING QUINNS ROCKS

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AT CORRECT SCALE THIS IS 100 mm

MATCH LINE

MINDARIE MARINA

PRIORITY ECOLOGICAL COMMUNITY

TERTIARY SEDIMENT CELL 29a

30,500

31,000

31,500

32,000

32,500

33,000

AERIAL PHOTOGRAPH TAKEN: 2014

AT CORRECT SCALE THIS IS 100 mm

LAYOUT 9

LEGEND:

- ROCKY COAST
- PRESENT DAY VULNERABILITY
- 2030 VULNERABILITY
- 2050 VULNERABILITY
- 2070 VULNERABILITY
- 2090 VULNERABILITY
- 2120 VULNERABILITY

AERIAL PHOTOGRAPH TAKEN: 2014

ENVIRONMENT

- BUSH FOREVER SITE 397
- HIGH VULNERABILITY ECOLOGICAL SYSTEM

CULTURAL HERITAGE

- REGISTERED ABORIGINAL CULTURAL HERITAGE SITES

CAD: D12120109B

REV	DATE	APPROVED	AMENDMENT	REV	DATE	APPROVED	AMENDMENT
B	1.07.15	CRD	UPDATED AND REISSUED				
A	8.01.15	CRD	PRELIMINARY ISSUE				

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This plan is not to be used for construction unless issued as Rev 0 and signed below

CLIENT: CITY OF WANNEROO

DESIGNED	CHECKED	APPROVED
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PROJECT: COASTAL HAZARD RISK MANAGEMENT & ADAPTATION PLAN

TITLE: EROSION HAZARD MAPPING MINDARIE TO TAMALA PARK

SCALE AT A1	DRAWING NUMBER	REV
1:5,000	D1212–01–09	B