GHD

City of Fremantle

TOWN OF MOSMAN PARK

Our Coastal Future

Port, Leighton and Mosman Beaches

Coastal Adaptation Plan

Executive Summary

Sections of the Port, Leighton and Mosman beaches are exposed and vulnerable to coastal processes, including erosion and inundation. Over time, the coast will become increasingly vulnerable to the impacts of sea level rise, storm surges and changes in sediment transport and natural sediment stores.

This plan has been prepared to adapt to the changing coast at Port, Leighton and Mosman Beaches, and provides recommended timeframes and trigger points for decision-making and planning for the area. The plan has been prepared as the first iteration of an evolving, long-term planning and decision-making process for the City of Fremantle and Town of Mosman Park, the community and key stakeholders to adapt our settlements and infrastructure to coastal processes – including risks of coastal erosion and inundation.

The coastal adaptation plan includes an implementation framework that recommends specific coastal adaptation activities to be delivered in the short and medium-term planning horizons. Supporting this, the plan provides a road map for incorporation of adaptation planning into the City of Fremantle and Town of Mosman Park's strategic plans, land use planning framework, long-term financial plan, and decision-making processes. The plan also identifies key regional strategic planning activities recommended to be delivered by the state government to facilitate adaptation planning at the local scale.

The adaptation recommendations are based on developing a flexible adaptation pathway for the City of Fremantle and Town of Mosman Park. As risk to coastal assets increase from tolerable to intolerable over time, decisions will need to be made about how we adapt to that risk. These points in time - when decisions are required - are trigger points for adaptation planning, see Figure 0-1.

The flexible adaptation pathway combines decision-making on specific adaptation options (avoid, retreat, accommodate, interim protection) at the time of triggers with an ongoing strategic planning process that plans for, and therefore maintains, the same range of adaptation options for future decisions in the longer term. In this way, by choosing to accommodate or protect in the short-term, we are not binding future communities to the long-term cost of that decision beyond the design life of the infrastructure or asset.

Coastal hazard mapping indicates that short-term triggers requiring major protection works or retreat are reached for Mosman Park and Port Beach, with Leighton Beach reaching triggers in the medium and long-term planning horizons. The flexible

adaptation pathway will enable the community and decision makers to be ready for these triggers when they occur in the long-term planning horizon and beyond. A flexible adaptation pathway for the area is shown in Table 0-1.

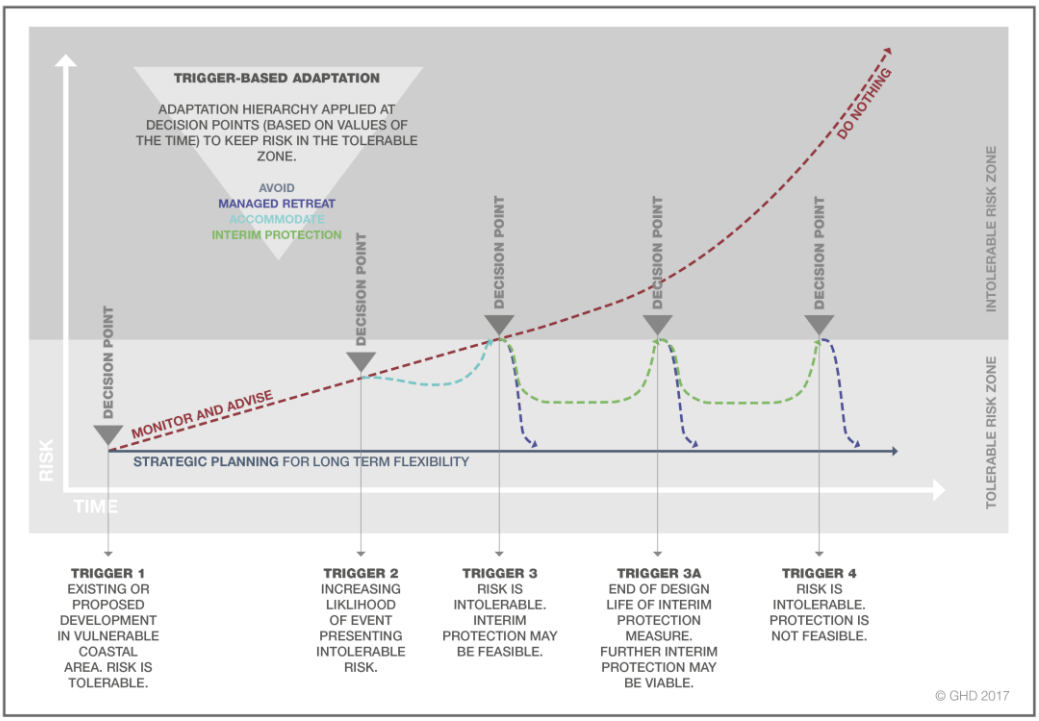

Figure 0-1 Flexible adaptation pathway

Section 7 of this coastal adaptation plan includes implementation actions to establish the flexible adaptation pathway for the long-term planning horizon, and specific adaptation measures to manage coastal risks in the immediate planning horizon within the City of Fremantle and Town of Mosman Park.

The adaptation plan identifies focus areas/actions for implementation by state government, particularly in relation to policy, expansion of the foreshore reserve (where necessary in the longer term), and major infrastructure. This plan does not bind state government or other stakeholders to the actions. However it recognises that long-term adaptation requires the support of these key stakeholders. The City of Fremantle and Town of Mosman Park, will work closely with the state government and other key stakeholders to deliver the actions necessary to achieve an adaptation pathway.

Table 0-1 Flexible adaptation pathway for Port, Leighton and Mosman Beaches.

CMU	Short		Medium		Long	
	Present	2030	2050	2070	2090	2110
1. Mosman Beach	Engineered dune stabilisation with revegetation and replenishment			Interim Protection or Retreat	Interim Protection or Retreat	
2. North Leighton	Beach monitoring and dune stabilisation		Beach monitoring and dune stabilisation		Interim Protection or Retreat	
3. Leighton Beach- Vlamingh Parkland	Beach monitoring and dune stabilisation		Beach monitoring and dune stabilisation		Interim Protection or Retreat	
4. Leighton Beach - Surf Club Precinct	Beach monitoring and dune stabilisation		Interim Protection or Retreat		Interim Protection or Retreat	
5. Leighton & Port Beach Dunes	Beach monitoring and dune stabilisation		Interim Protection or Retreat		Interim Protection or Retreat	
6. Port Beach North	1 Seawall and replenishment or 2. Dune stabilisation, revegetation & replenishment			Interim Protection or Retreat	Interim Protection or Retreat	
7. Port Beach South - Sandtracks	1. Seawall and replenishment or 2. Dune stabilisation, revegetation & replenishment			Interim Protection or Retreat	Interim Protection or Retreat	

Budget estimates to implement the recommended adaptation pathway for the Port, Leighton and Mosman Beach are estimated to be in the order of $34 million over the next 50 years. This budget estimate is indicative only and is based on average typical cross sections and does not consider specific physical conditions of each site. These estimates were initially prepared for reference in the multi criteria decision making

process and were not produced specifically for the implementation plan and budgeting purpose. As a result, further investigation could show that costs vary significantly from these values.

This plan should be reviewed regularly, alongside the ten-yearly review of the City of Fremantle and Town of Mosman Park strategic plans.

Review processes should include targeted community and industry consultation to update values and views about coastal development and assets that will be at risk both within a short-term planning horizon and beyond. Revised values and new learnings should be used to test recommendations of this adaptation plan, and determine whether adaptation strategies for the short-term planning horizon require modification as a result of changing values.

It will be necessary to update the hazard mapping from time to time to reflect actual sea level rise, updated projections of future sea level rise and the response of the coast to changing conditions. These updates should occur as new information becomes available.

Contents

1 Introduction

The City of Fremantle and the Town of Mosman Park have collaborated to identify the vulnerability of Port, Leighton and Mosman Beaches and adjacent land to coastal processes through a Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) project.

The overall objective of the project is to identify coastal hazard risks and to properly plan for adaptive land use and development along the Port, Leighton and Mosman Beach coast in light of a changing coastal environment, through a coastal adaptation plan.

1.1 Purpose of this Plan

This coastal adaptation plan provides a decision-making framework and recommended adaptation actions, based on a coastal hazard risk assessment, to assist the City of Fremantle and Town of Mosman Park adapt to coastal risks in the short, medium and long-term.

This coastal adaptation plan is the beginning of the conversation and journey with the community and stakeholders to understand and respond to the changing coast. The plan has a very long-term planning horizon – considering decisions that will need to be made from now until 2110. This plan will specify priority coastal management options to inform appropriate investment in coastal reserves for future management, with a focus on the implementation and management of short-term measures in the next five years.

This plan has been prepared as the first iteration of an evolving, long-term planning and decision-making process for the community and key stakeholders to adapt settlements and infrastructure to coastal processes, including risks of coastal erosion and inundation. The purpose of this plan is to assist with coastal management decision-making and is not to provide recommendations on coastal setbacks for development purposes. As the City of Fremantle and Town of Mosman Park, stakeholders and the community learn more and understand more about how the coast will change in the future, this plan and recommended adaptation responses will evolve to reflect and respond to the values, aspirations, and learnings of the community and stakeholders.

This plan assesses coastal hazards within the study area identified in Figure 1-1. Coastal adaptation measures consider the overall dynamics within the secondary sediment cell which extends between North Mole and Mudurup Rocks. More details on sediment cells are discussed in section 3.7.3 of this report.

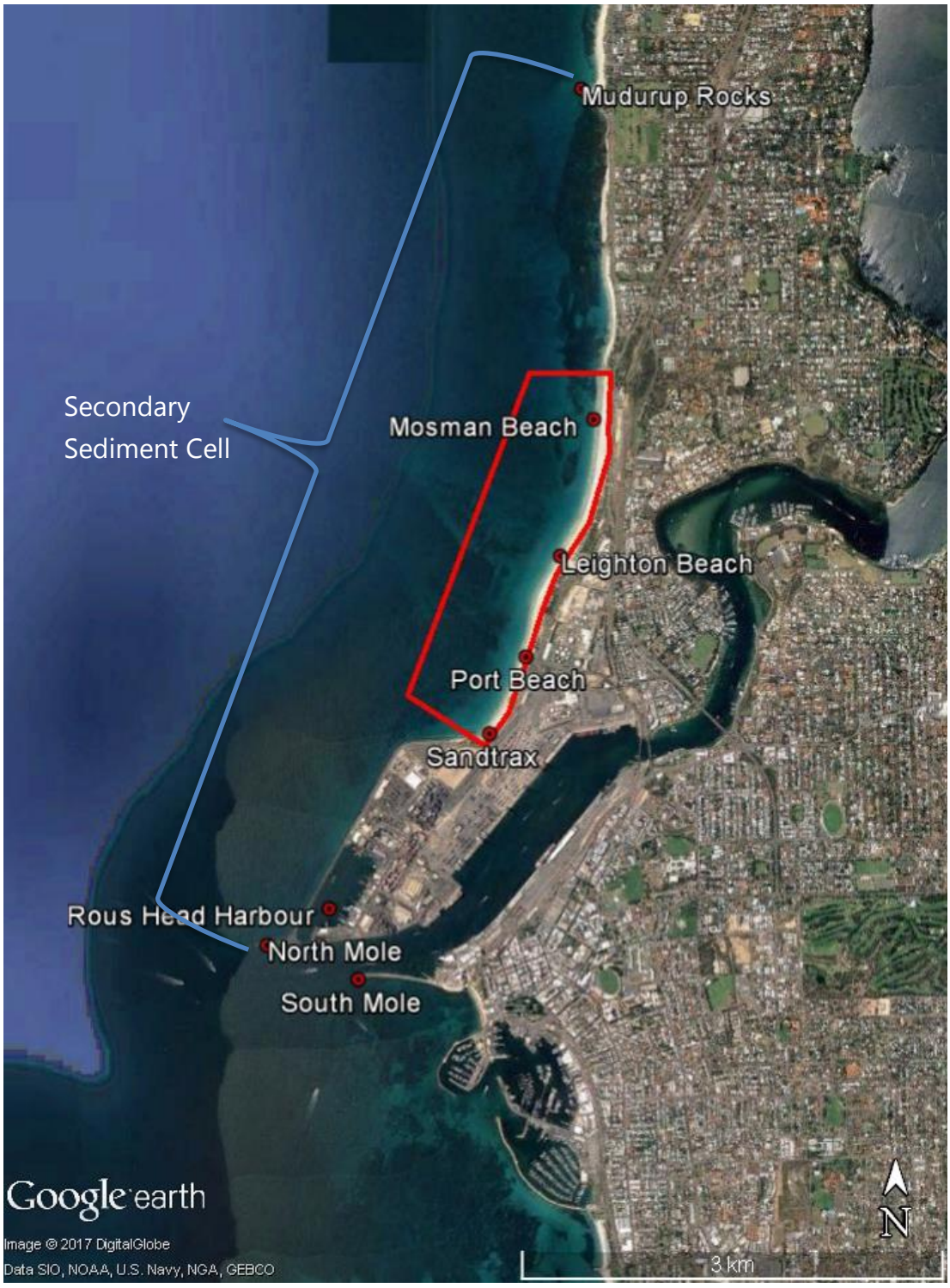

Figure 1-1 Site map depicting study area boundary for coastal hazard identification in red and extent of the secondary sediment cell.

1.2 Performance Measures

Project performance measures have been developed in consultation with a steering committee established for the project. The steering committee for this project included representatives from the following local government authorities, government departments and organisations:

- City of Fremantle
- Town of Mosman Park
- Department of Water and Environment Regulation
- Department of Planning, Lands and Heritage
- Department of Transport
- Fremantle Ports
- Perth NRM Coastal & Marine Program
- Town of Cottesloe

The performance measures were established in the inception phase of the project. The following section provides the performance measures and an assessment of the project's performance against them.

Port Beach

1.2.1 Project Performance Measures

1. The project quantifies the coastal hazard risks of erosion and inundation at different timeframes to the Port, Leighton and Mosman Beaches. Sections 3.8.5 to 3.8.11 present the results of the coastal hazard risk assessment.

2. The project identifies the vulnerability of assets and values at risk through development of a coastal asset inventory and asset value database that considers short, medium and long-term coastal hazard risks. Appendix A identifies the coastal assets and values database and Appendix E identifies the risk levels to the assets and values.

3. The project contributes to an increased understanding within the local governments, communities and other key stakeholders of the risks (in terms of likelihood and potential consequence) of erosion or inundation presented by coastal processes impacting on built and natural assets affecting Port, Leighton and Mosman Beaches through to the year 2110. Section 3.8 presents the risk assessment process used and identifies the key built and natural assets at risk to 2110.

4. The project contributes to an improved understanding amongst coastal managers and other stakeholders (including the community) of the values of the services and functions that are provided by both built and natural assets (including coastal ecosystems) that are at risk from the coastal processes, thus aiding in adaptation action decision-making. Sections 3.1 to Section 3.5 provide an overview of the values and services identified in this study which has increased understanding. Sections 3.8.5 to 3.8.11 presents the results of the coastal hazard risk assessment and provides details on the values of the services and functions at risk.

5. The project develops recommendations as to the nature and timing and of the most suitable and effective adaptation actions to deal with the risks to built and natural coastal assets from the coastal processes and climate change over short, medium and long-term timescales. Section 5 provides a summary of the recommended adaptation options.

6. The project recommends financial funding (and sources) for implementation. Section 2.2 presents potential funding options.

7. The project provides recommendations for the development and implementation of statutory and local planning policy and controls. Section 6 presents a series of recommendations on planning policies.

8. The project develops and tests a methodology that “demystifies” coastal hazard risk management and adaptation planning. The approach taken is described in the appendices for each key element.

9. The project develops mapping that identifies the risk and vulnerability of existing assets for short, medium and long-term timescales. Section 3.8 presents risk mapping of existing assets for short, medium and long-term time scales.

10. The project develops coastal hazard risk and vulnerability maps for short, medium and long-term timescales related to each management zone. Appendix C and Appendix G present maps of short, medium and long-term timescales.

1.2.2 Project Team Performance Measures

1. The project team delivers an adaptation plan that is adopted by the Councils of the Town of Mosman Park and the City of Fremantle.

This final version of the plan will be presented to Councils for adoption.

1.2.3 Longer-term Enduring Measures

The following longer-term measures should be assessed in future reviews of the plan.

1. Ongoing project implementation builds capacity of relevant stakeholders in both the identification and review of assets from economic, social/cultural and ecosystem services perspectives and the development and implementation of the adaptation actions.
2. Ongoing project implementation achieves progressive implementation of adaptation actions, including adjustments to foreshore management plans and town planning schemes.
3. Ongoing project implementation delivers adaptation measures that reduce coastal risk to tolerable levels.
4. Ongoing project implementation monitors trigger points, changes in values, and updates prioritisation of actions as required.

Signage in the area

1.3 Strategic Context

In the short-term, this plan provides recommended management actions to conserve the functional and natural values of the coast and provide for sustainable land use and development. Where possible, the development of the short-term management actions should not the limit future management options unless there is justification based on conserving functional and natural values.

In the long-term, this plan provides a road map for incorporation of adaptation planning into the City of Fremantle and Town of Mosman Park's strategic plans, land use planning framework, long-term financial plan, and decision-making processes. The plan also recommends changes to state and regional planning processes to support local adaptation.

As indicated by Figure 1-2 and Figure 1-3, this plan is not an individual action plan for delivery. It is a blueprint to assist future iterations of the local governments' and the state government's strategic plans to integrate and deliver coastal adaptation, in consultation with the community. In this way, coastal adaptation planning will be delivered in the City of Fremantle and Town of Mosman Park through existing strategic and capital planning processes at the state and local level.

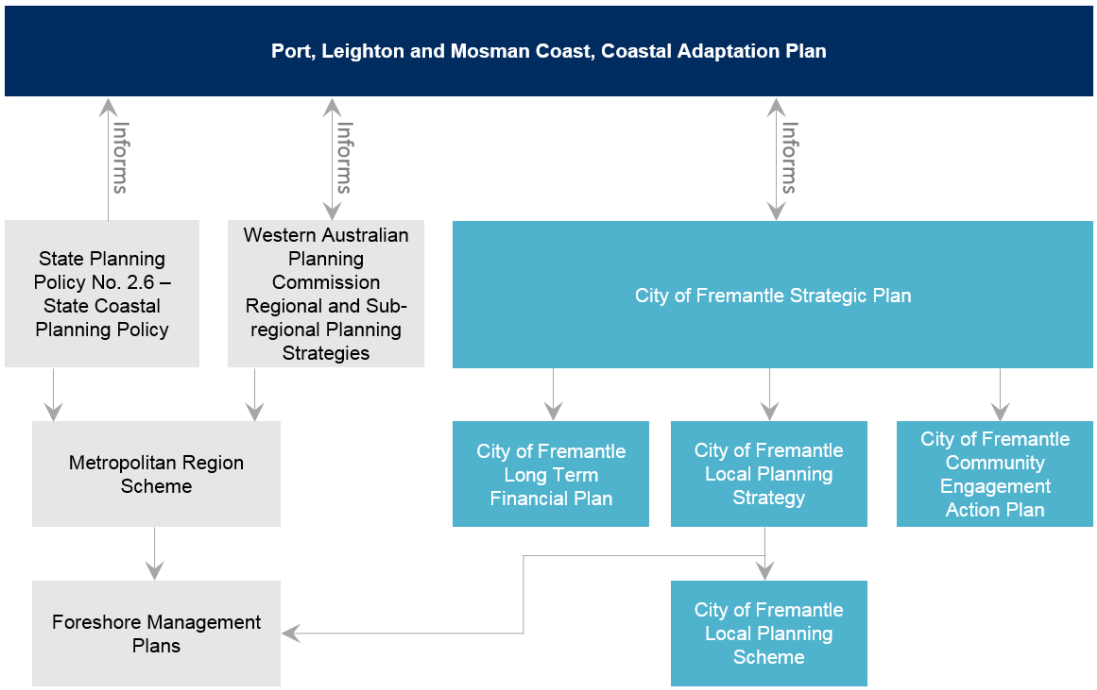

Figure 1-2 City of Fremantle Strategic context – Port, Leighton and Mosman Beaches, Coastal Adaptation Plan

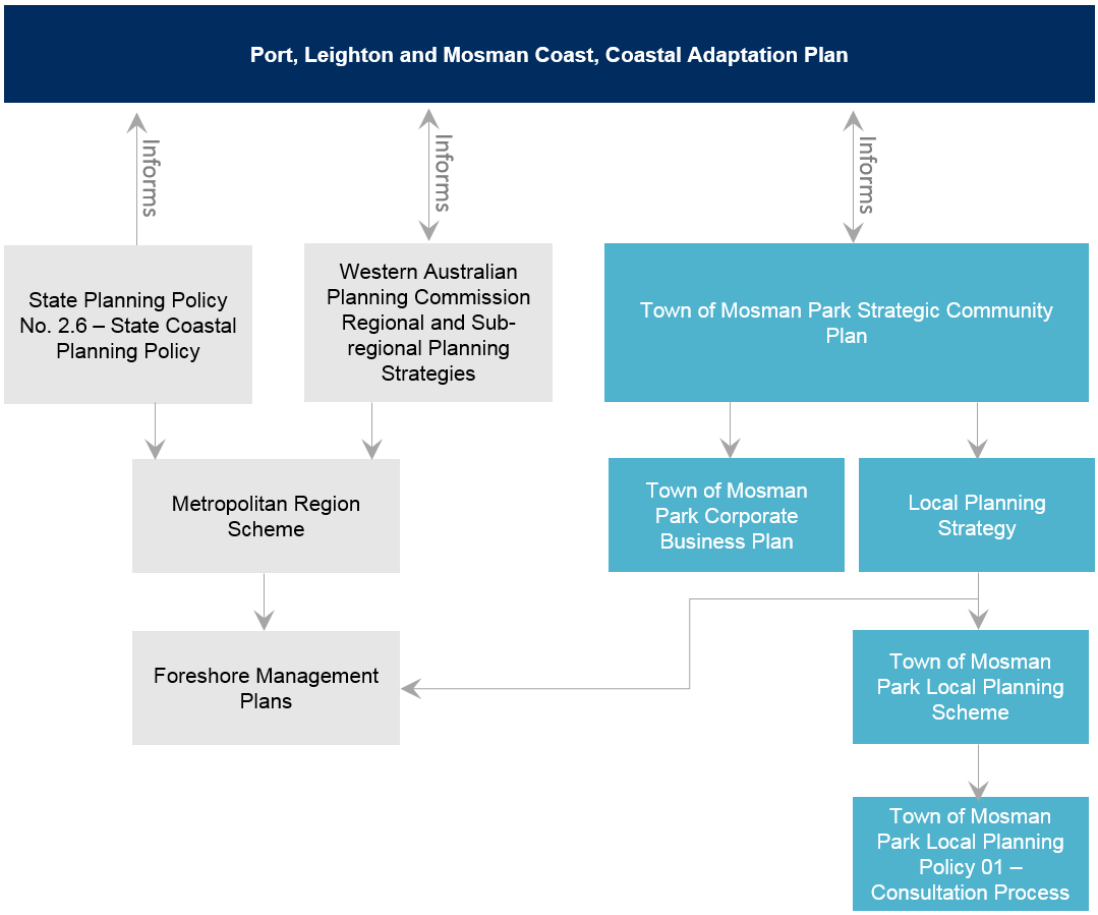

Figure 1-3 Town of Mosman Park Strategic context – Port, Leighton and Mosman Beaches, Coastal Adaptation Plan

1.4 Planning Horizons

The three planning horizons used for this study to assess coastal hazards, risks and develop adaptation plans for include:

Short-term: the 15-year planning horizon to assess and respond to immediate coastal hazard risks,

Medium-term: the 15 to 50 year planning horizon and

Long-term: the 100-year planning horizon, in line with the planning horizons recommended in the State Planning Policy 2.6

2 Adaptation Planning

2.1 What is Adaptation Planning?

The coast has always been a dynamic, changing environment. Continued changing of the coast line presents risk and impacts to coastal assets – including social, environmental, and economic assets and values. Adaptation planning is about being ready to manage the risks and impacts of changes to the coast line, by planning for the most appropriate decisions and options to implement over time.

A risk management approach is being increasingly used, nationally and internationally, to manage potential adverse impacts of coastal hazards. A risk management and adaptation planning approach is a systematic way to identify and understand coastal hazard risks, and implement controls and measures to manage those risks in consultation with the community and stakeholders.

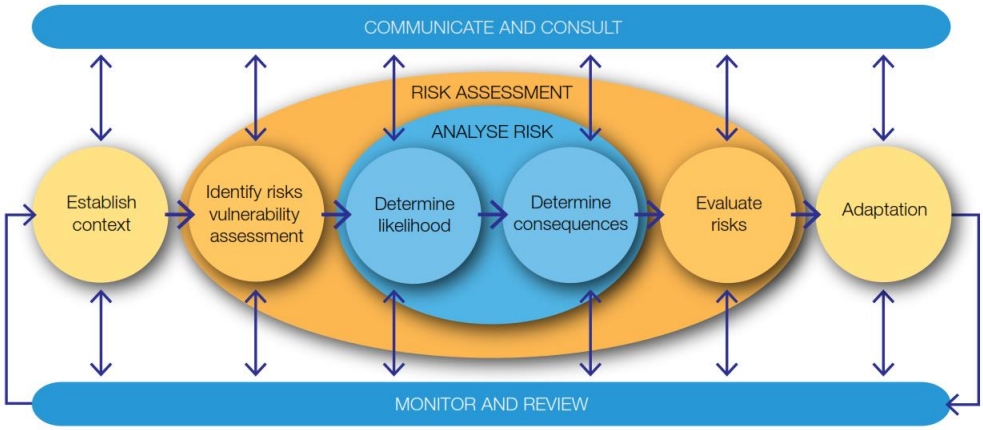

Figure 2-1 Risk management and adaptation process from Coastal hazard risk management and adaptation guidelines (WAPC, 2014)

2.2 Who is Responsible?

In July 2013, the amended State Coastal Planning Policy No 2.6 (SPP 2.6) was gazetted by the state government. The amended policy included a requirement for 'responsible management authorities' to prepare coastal hazard risk management and adaptation plans where existing or proposed development is located in an area at risk of being affected by coastal hazards over a 100 year planning horizon. For many areas of the coast, local government is the land manager. Therefore, local government in Western Australia has been leading the development of coastal adaptation plans.

Irrespective of the lead for preparing adaptation plans, there are a number of stakeholders and decision makers involved in adaptation planning. Successful adaptation planning over time requires cooperation from all levels of government and the community, along with asset owners and managers. Key stakeholders and responsibilities for adaptation planning are shown in Table 2-1.

Table 2-1 Adaptation planning – roles and responsibilities

Roles and Responsibility	Responsible Stakeholders
Strategic planning: Prepare adaptation plan for coastal land within their management. Inform coastal asset owners and users about risk and decision-making.	Western Australian Planning Commission Department of Planning Main Roads WA City of Fremantle Town of Mosman Park South West Aboriginal Land and Sea Council
Decision-making: Make adaptation decisions on land and assets within their management.	Western Australian Planning Commission Department of Planning Main Roads WA City of Fremantle Town of Mosman Park
Asset management: Manage assets in the context of coastal risk. Undertake accommodation measures, where consistent with government decisions. Decommission and relocate assets where required by government decisions to retreat.	Asset owners Private land owners Business owners and operators City of Fremantle Town of Mosman Park Infrastructure agencies Public Transport Authority Fremantle Port Authority Beehive Montessori School
Engagement: Engage with decision makers regarding the values of the coast to inform decision-making.	Other coastal users: • Community

2.3 Adaptation Measures

There are four key coastal adaptation options available when making decisions about managing coastal risks. These are:

- Avoid development in the area of risk
- Retreat (relocate) assets and development away from the risk
- Accommodate the risks (e.g. occasional flooding through retrofitting for inundation or sand replenishment and dune revegetation for storm erosion)
- Protect the assets through coastal engineering works.

The most appropriate adaptation option may differ based on the values to be protected in a certain location, the level of risk identified and the hazard causing the risk (Table 2-2). The coastal hazards impacting Port, Leighton and Mosman Beaches are detailed in Chapter 3.7, with erosion being the dominant coastal hazard in this region.

Table 2-2 Levels of risk mitigation

Adaptation Option	Description	Type of Development	Applicable Hazard
Avoid	Avoiding development in areas at risk	New development	Erosion & Inundation
Planned or Managed Retreat:	In the face of intolerable risk, eliminate the risk through relocation, demolition or removal of existing asset.	Existing development	Erosion & Inundation
Accommodate:	Design and / or management measures that reduce the risk to a tolerable level		Inundation
Protect	Where there is a need to preserve the foreshore reserve, public access and public safety, property and infrastructure that is not expendable.		Erosion & Inundation

2.3.1 Avoid

Avoid measures involve avoiding the location of new development in an area of coastal vulnerability. This does not preclude the use and enjoyment of the coast. However, it avoids locating future development in an area that would experience intolerable risk at some stage during the life of that development.

2.3.2 Managed Retreat

Managed retreat means relocating assets outside the area of risk, to allow land at risk to naturally experience erosion and/or inundation. Retreat can be on a small scale, for example relocating a car park within a large foreshore reserve to an area outside immediate risk. In the long-term, retreat strategies can occur on a significant scale, for example the expansion and remediation of the foreshore reserve, which requires the relocation of infrastructure (such as road, rail, and sewer) and acquisition of private land within the expanding foreshore reserve. Large-scale strategic retreat will require coordination and partnership across state and local government.

2.3.3 Accommodation Measures

Accommodation measures are only appropriate when the risk levels posed by erosion are tolerable. In the face of erosion, this includes measures to accommodate increased risk, such as dune revegetation to reduce the immediate impact of wave erosion. In the context of the Port, Leighton and Mosman Beaches coastline, the dominant coastal hazard identified in the risk assessment (refer to Appendix E of the Coastal Adaptation Plan) that triggers the need for risk mitigation and adaptation is erosion.

Erosion hazards, in areas without natural ongoing sediment supply, have a higher risk profile compared to temporary storm induced inundation hazards, or areas without sediment supply, because extreme erosion hazards from storm events result in the permanent loss of land or permanent damage to assets and values without the ability for dunes and beaches to recover. Accommodation is only appropriate when adaptation measures are able to reduce risks to tolerable levels.

The higher risk profile for erosion hazards means that it is harder to develop accommodation measures to mitigate erosion risks. This is particularly applicable to areas of Port Beach where sediment supply to the system is limited due to the primary sediment cell barrier of the Fremantle Harbour dredged shipping channel and North Mole. In areas prone to erosion hazards but with natural sediment supply, such as Leighton Beach, the question transitions to how long will it take the beach to recover from an event and what is a reasonable length of time to allow before risk mitigation needs to be considered. Therefore accommodation is only a suitable adaptation option when the erosion risk profile for a coastal management unit is tolerable.

2.3.4 Interim Protection Measures

The role of coastal interim protection is to reduce the risks associated with the coastal hazards of erosion and inundation to land and assets. Engineering measures suitable to protect against these hazards can involve either soft or hard and passive or active engineering approaches. Descriptions and examples of these approaches are shown in Table 2-3.

Table 2-3 Interim protection measures

Approach	Description	Examples
Soft – Passive	Foreshore protection works that offer benefits to mitigate against erosion and inundation but do not involve construction of structures and do not directly affect coastal processes.	Sand replenishment and dune stabilisation
Hard – Passive	Foreshore protection works that involve the construction of structures which alter the coastal processes that act on the land/beach with the intention to maintain or improve beach amenity through retention of sand.	Groynes and offshore breakwaters
Hard – Active	Works that involve the construction of structures which offer a source of protection to landside assets in proximity to the foreshore. The construction of hard active engineering measures can alter the way coastal processes act on the land/beach interface. These changes to the shape of the land (e.g. erosion of a beach in front of a seawall) can have implications on land use (e.g. loss of beach amenity).	Seawalls and Levees

Examples of interim protection measures are shown in Figure 2-2 and Figure 2-3

Figure 2-2 Offshore breakwaters (A) and groynes (B) are examples of hard passive interim protection measures. This groyne example (bottom picture) is made from geotextiles. Groynes can also be constructed from rocks to extend their design life. Offshore breakwaters can interrupt open views of the ocean, and groynes can create a barrier along the beach

Figure 2-3 Sea walls are an example of hard active interim protection measures. Designed well, they can integrate well into the development of beach amenities, although they can exacerbate erosion (beach loss) in front of the wall over time if ongoing sand replenishment is not undertaken

3 The Port, Leighton and Mosman Beaches

The Port, Leighton and Mosman Beaches are a section of the Perth Metropolitan coastline that extends from the Rous Head Extension of Fremantle Port in the south to the northern boundary of the Town of Mosman Park local government boundary (Figure 1-1).

The coastline through this area includes sandy beaches, except for the northern areas of Mosman Park which are classified as mixed sandy and rocky beaches. The coastline includes the public foreshore reserves of Port Beach, Leighton Beach and Mosman Beach, with a diversity of surrounding land use and infrastructure. A typical site area of Port Beach is shown in Figure 3-1.

Figure 3-1 The local coastline at Sandtrax - Port Beach showing a narrow strip of dune vegetation, and surfers enjoying local waves.

3.1 Coastal Values

The risk of coastal hazards and the most appropriate adaptation responses are informed by the values of the coast. Coastal values considered in the risk assessment and adaptation plan are the elements of the coastal environment – both physical and intangible – that bring benefit to the community.

This plan defines the following types of values:

- Economic
- Social
- Environmental
- Infrastructure

Economic – The economic values are those elements that support employment, industry, tourism or relate to matters that have economic implications (property values).

Social – The social values are those elements that support the health, wellbeing, and quality of life of the community. This may include social benefits or services provided by infrastructure or environmental assets or land. Examples include car parking and local roads (public infrastructure) along the coast providing access (service) for the community to the coastal parks and recreation reserve.

Environmental – The environmental values are those elements that support ecosystems services, ecology and natural resources. Examples of environmental values ecosystem services provided by dune habitats include trapping of and storing sand, providing a source of sand to replenish beaches during erosion events and providing habitat for local flora and fauna.

Infrastructure assets – Infrastructure assets support economic, social and environmental values. Infrastructure includes physical assets, and land that provides infrastructure potential through various land uses. As some infrastructure supports a range of different values, infrastructure is discussed as an individual item. This also enables differentiation of assets that provide a public benefit, compared to private assets.

This plan typically focusses on values and assets that support public values, and provide public benefit, although it recognises that there may be private assets and values in the area that are important to community members.

3.2 Economic Values

There are a number of industries within the project area that support the local, regional and state economy.

Fremantle Port (Figure 3-2) is a significant infrastructure asset within the area that supports employment and the industrial industry. In the 2014-2015 financial year, Fremantle Port had an after-tax profit of $48.075 million (Fremantle Ports Annual Report, 2015). The annual report states that the Fremantle Port returned $68.369 million in tax equivalents and dividends to the Government and the people of Western Australia. The Fremantle Port has 322 full time employees as at 30 June 2015.

As a major gateway for freight, Fremantle Port has state significant economic value, and provides considerable benefit in the form of investment, import, export and employment for the community of Western Australia.

Other local industries in the area between Tydeman Road and Walter Place and also to the south of the study area at Rous Head are of economic significance to the local economy. These business generally have co-located in the area due to direct interactions with Fremantle Port, or due to businesses being coastally dependent e.g. Rottnest Express.

Figure 3-2 Fremantle Port is a major, state significant asset of economic value. It directly and indirectly supports investment and employment in the community of Western Australia.

In addition to the significant employment and industry generator of the port, there are a number of commercial businesses within the area including but not limited to:

- Bib and Tucker
- Leighton Beach Kiosk
- Coast Port Beach
- Light industrial businesses near Port Beach
- Transitory businesses including café vans and food vendors
- Montessori School

These local businesses provide employment opportunities and contribute to the local economy. Additionally, there is opportunity and current proposals for commercial uses such as those listed above to be developed in the future.

3.3 Social Values

Social values within Port, Leighton and Mosman Beaches have been identified by community members and users through a values survey.

Port, Leighton and Mosman Beaches support a range of social values, in particular access to:

- Coastal amenity
- Coastal recreation
- Community facilities
- Entertainment and socialising opportunities
- Employment and economic opportunities
- Private benefits

Based on survey data, the strongest social values provided by the area relate to the benefits of coastal amenity and recreation. Key values identified as important by the community include:

- Ability to access and enjoy a beach setting (coastal amenity)
- Ability to recreate in the ocean (recreational)
- Ability to enjoy coastal scenery and views (coastal amenity)
- Cleanliness of the beach (coastal amenity)
- Ability to exercise in the coastal environment (recreational)
- Universal access to the beach (community facilities)
- Coastal vegetation and habitat (coastal amenity)
- Ability to access change rooms, toilets, showers (community facilities)
- Ability to access bicycle and pedestrian facilities (recreational)
- Ability to access car parking and toilet facilities
- Ability to enjoy dining at cafes and restaurants in a coastal setting (entertaining and socialising)
- Ability to walk dogs on and along the beach (recreational)

Additional social values identified by community members within surveys include:

- The ability to volunteer, including on planting and revegetation programs
- The ability to enjoy shade trees
- The amenity of the open, coastal character of the area, compared to built up coastal settlements (such as Scarborough and Cottesloe)
- The ability to access the beach via the footbridge at Leighton Beach
- The quality of surf in the area

Private benefits – such as property values and living next to the beach – did not tend to be highly valued by the majority of survey respondents who may not live directly within the area. Beyond the direct beneficiaries of private benefits, the broader community places greater value on having open space available to everyone, not just those who live close by the beach.

Importance of social values in a particular place is measured by two key elements – the impact that a particular value or experience has on someone's quality or way of life, and their ability to access that value or experience. The social values enjoyed by local and regional communities cannot be easily or accurately measured based on area of beach frontage, reserve or other quantifiable metrics.

For many community members (based on survey responses, Appendix A), the loss of the strongest social values presented by the beaches would result in a significant impairment to their quality or way of life. The ability to access coastal amenity and recreation at Port, Leighton and Mosman Beaches – rather than at other coastal locations - is important to the community, with many survey respondents noting that they either cannot conveniently access these values elsewhere or prefer to access them at Port, Leighton and Mosman Beaches.

Figure 3-3 The ability for dogs to access Mosman and Leighton Beaches is viewed as a strong social value by many in the community.

The broader significance of the social values of Port, Leighton and Mosman Beaches can be indicated by how far community members travel to access these opportunities. Approximately 58 percent of survey respondents live within the City of Fremantle, and 11 percent within the Town of Mosman Park. Just over 30 percent of community

members that place importance on the beaches come from areas outside the local governments that manage the beach and foreshore reserves.

The majority of survey respondents lived within a 10-15 minute drive. The social values of Port, Leighton and Mosman Beaches are generally of local and district significance, although they also provide value at the regional scale.

Universal access to the beach and facilities was important to a substantial portion of survey respondents (70 percent), with many citing the footbridge from Leighton Beach across the railway lines as a significant facility that supported accessibility to the beach.

The social values of coastal amenity and recreation within Port, Leighton and Mosman Beaches have importance at the local, district and regional scale

Heritage is another key social value, in particular Aboriginal Heritage. The Port, Leighton and Mosman Beaches area does not include any registered Aboriginal sites. Irrespective of statutory heritage protection, it is an important part of the Swan Coastal Plain landscape that is significant to the culture and identify of the Whadjuk People, the traditional owners and custodians of this area.

3.4 Environmental Values

The study area supports a range of environmental values.

The coastal foreshore, which is reserved for parks and recreation, includes some stands of natural vegetation that provide habitat for coastal fauna. The habitat value of the area is continually being improved by revegetation works carried out by the City of Fremantle and Town of Mosman Park with support from Perth NRM Coastal and Marine Program.

Although located within a regional reserve, the habitat value of the Port, Leighton and Mosman Beaches has not been recognised as being regionally significant through Bush Forever (WAPC, 2000). However, Port and Leighton Beaches have been recognised as a locally significant natural area, and is identified in the City of Fremantle Green Plan 2020.

An artificial reef is located within the Mosman Beach area, providing both recreational and environmental value.

Just outside the Port, Leighton and Mosman Beaches study area – at Rous Head, is a nesting habitat for Fairy Terns. Fairy Terns are very particular about their nesting habitat, and this area is one of the few locations on the Western Australian coast that provides an ideal nesting ground. It is recognised that, while nearby, the nesting area is outside the area of the Port, Leighton and Mosman Beaches coastal plan, however care needs to be taken to ensure it is not impacted by decisions made upstream or downstream.

In addition to areas of environmental value, there are areas of environmental risk along the foreshore of Port and Leighton, due to contaminated sites associated with old industrial activities. There are four sites along the foreshore that are classified as ‘contaminated: remediation required’ and multiple site classified as ‘remediated for restricted use’, refer to Table 3-1 and Figure 3-4, and the remediation plans for these sites should consider the long-term coastal adaptation plan.

The coastal dunes of Port, Leighton and Mosman Beaches provide locally significant environmental value

Table 3-1 Site Contamination Summary within Study Area[1]

Lot	Classification	Nature and Extent of Contamination	Restrictions on Use
Lot 504 on plan 64772	20/06/2008 - Remediated for restricted use	No soil contamination remains on Site. Groundwater investigations show no evidence of groundwater contamination underlying the Site, however hydrocarbon contamination (such as diesel and oil) is present in groundwater to the southeast of the Site.	The abstraction and use of groundwater at this Site is not permitted in order to minimise the disturbance of groundwater contamination and remediation by Monitored Natural Attenuation (MNA) being carried on in Sub-Lots 3, 5 and 6.
Lot 500 on plan 52603	09/05/2017 - Remediated for restricted use	Hydrocarbon contamination (such as from petrol and diesel) is present in groundwater beneath the adjacent former fuel terminal as a plume which extends to the west to beneath the northern portion of this site. Perfluoroalkyl and polyfluoroalkyl substances (such as from fire-fighting foam) is present in groundwater below the south-eastern boundary of the site.	Due to the nature and extent of groundwater contamination identified to date, the abstraction of groundwater is not permitted.
Foreshore adjacent Lot 469 on plan 218635	30/11/2007 - Contaminated - remediation required	There is petroleum hydrocarbon contamination of the groundwater migrating to the west and northwest of the former North Fremantle and Golden Fleece facility areas under the adjacent foreshore and beach between the high and low watermark levels.	The land use of the Site is restricted to its current use as recreational foreshore, dunes and beach until further chemical testing of soil and groundwater and risk assessment is conducted.
Lot 505 on plan 68448	30/11/2007 - Contaminated - remediation required	There are residual deposits of petroleum hydrocarbons within soils and groundwater under the coastal dunes and pipeline corridor at the former North Fremantle facility area	

[1] Information was obtained from the Department of Water and Environment Regulation contaminated sites database – Accessed in August 2017.

Lot	Classification	Nature and Extent of Contamination	Restrictions on Use
Lot 520 on plan 400819		extending along 500m of foreshore, to the north of Rudderham Drive and west of Port Beach Road. There are residual deposits of petroleum hydrocarbons within soils and groundwater under the coastal dunes at the former Golden Fleece facility area extending along the foreshore between Walter Place and Tydeman Road and west of Port Beach Road	No groundwater may be abstracted from the Site without carrying out analysis in accordance with Department of Health guidelines to determine its suitability for use.
Lot 521 on plan 400819			

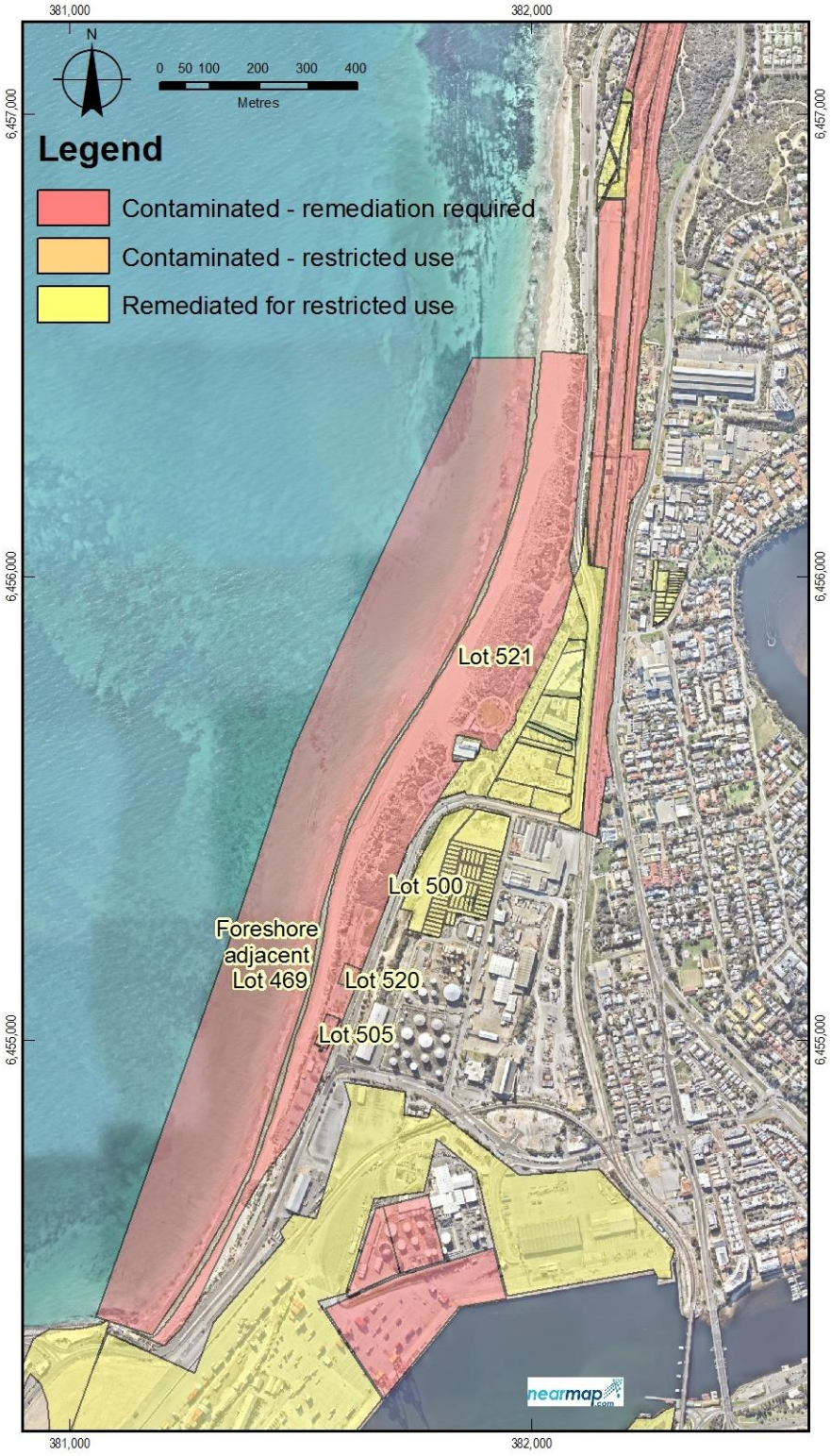

Figure 3-4 Contaminated sites in the study area

3.5 Infrastructure Assets

Port, Leighton and Mosman Beaches include a range of important infrastructure assets. This includes transport infrastructure, services infrastructure, community infrastructure and land availability. A register of infrastructure assets within Mosman, Leighton and Port Beaches is provided in Appendix B.

Transport infrastructure facilitates the movement of people and freight, which is vital for economic, cultural, and social exchange and activity. Key transport infrastructure within the area includes:

- Roads (e.g. Curtin Avenue, Stirling Highway) linking Fremantle to Perth
- Passenger railway line (Perth to Fremantle)
- Passenger rail station (North Fremantle train station)
- Fremantle Port, providing a state significant import and export gateway to the rest of the world
- Freight railway line, providing a freight connection into Fremantle Port
- Port Road, providing freight access to Fremantle Port and Rous Head

Service infrastructure provides essential services to land use and development. Key service infrastructure within the area includes:

- Water Corporation has two pressure mains within the site area, the Rous Head pressure main running parallel to the foreshore from the port northwards and Port Beach Rd pressure main running along Port Beach Road. Local pipelines also provide services to surrounding buildings.
- Major electricity utilities run along Port Beach Road and Curtin Avenue, with further services along Stirling Highway and Tydeman Road. Local electricity infrastructure is also provided within the study area.
- Underground fibre optic telecommunications cables for AARNet, Optus, Nextgen and NBN Co are located along Stirling Highway within the Mosman and Leighton Beach areas. They are of regional significance, with damage causing potentially significant disruption to communications in the areas serviced by these corridors.
- ATCO Gas medium pressured gas pipelines extend along the Port Beach Road Reserve and along the Leighton Beach Boulevard.
- Telstra lines are located along Port Beach Road from the Rous Head Extension in the south to Coast Port Beach café, through the industrial zone at north Port Beach to the Surf-Lifesaving Club and cafes at Leighton Beach and along the eastern side of sections of Curtin Avenue within the City of Fremantle and the Town of Mosman Park.

The zoning and release of land, whilst not a physical piece of infrastructure, provides for land use and development for community and economic purposes. Though privately owned, the state government is responsible for releasing land for urban and industrial purposes. The area surrounding Leighton Beach includes urban land that provides housing and commercial services to the local community. The area near Port Beach

includes industrial land, which supports business and employment. Land available within proximity to Mosman Beach supports urban residential development.

Community infrastructure is essential for community wellbeing and providing opportunities for community interaction. Within the Port, Leighton and Mosman Beaches there are areas of public purpose including the Beehive Montessori School, the Fremantle Surf Life Saving Club and foreshore infrastructure.

The coastal foreshore provides important community infrastructure including:

- Footpaths
- Street furniture
- Shaded pergolas
- Signage
- Coastal dune fencing
- Car parks
- Service infrastructure

Car parks on the coast are an important form of community infrastructure – providing access

3.6 Coastal Areas

The nature of coastal values – particularly in relation to land use – change across the Mosman, Leighton and Port Beaches area, although some key values occur across the entire area. The different values that various parts of the coast support and varied coastal processes, will result in different approaches to risk management and adaptation responses across the coast. To reflect this, the Mosman, Leighton and Port Beaches area was divided into three areas for the risk identification process.

Mosman Beach

3.6.1 Mosman Beach (Town of Mosman Park)

Mosman Beach area shown in Figure 3-5 includes a thin strip of coastal dunes. The Beehive Montessori school is also within this area. East of the coastal dunes is Curtin Avenue and the Fremantle passenger railway line.

Figure 3-5 Mosman Beach area

3.6.2 Leighton Beach (City of Fremantle)

Leighton Beach shown in Figure 3-6 includes Leighton Beach and some of the North Fremantle industrial area. There is also a new high density mixed use area adjacent to the North Fremantle passenger train station. There are areas of coastal dunes that extend along the coast.

Figure 3-6 Leighton Beach area

3.6.3 Port Beach (City of Fremantle)

Port Beach shown in Figure 3-7 includes Port Beach and Sand Tracks Beach. On the eastern side of Port Beach Road is the Fremantle Port and North Fremantle industrial area within the Port buffer area. There is a thin strip of coastal dunes that extends along the coast. The area also includes both the passenger railway line and the freight railway line.

Figure 3-7 Port Beach area

3.6.4 Coastal Management Units

For the adaptation planning process, these areas were further broken down into coastal management units shown in Figure 3-8 with common risk profiles.

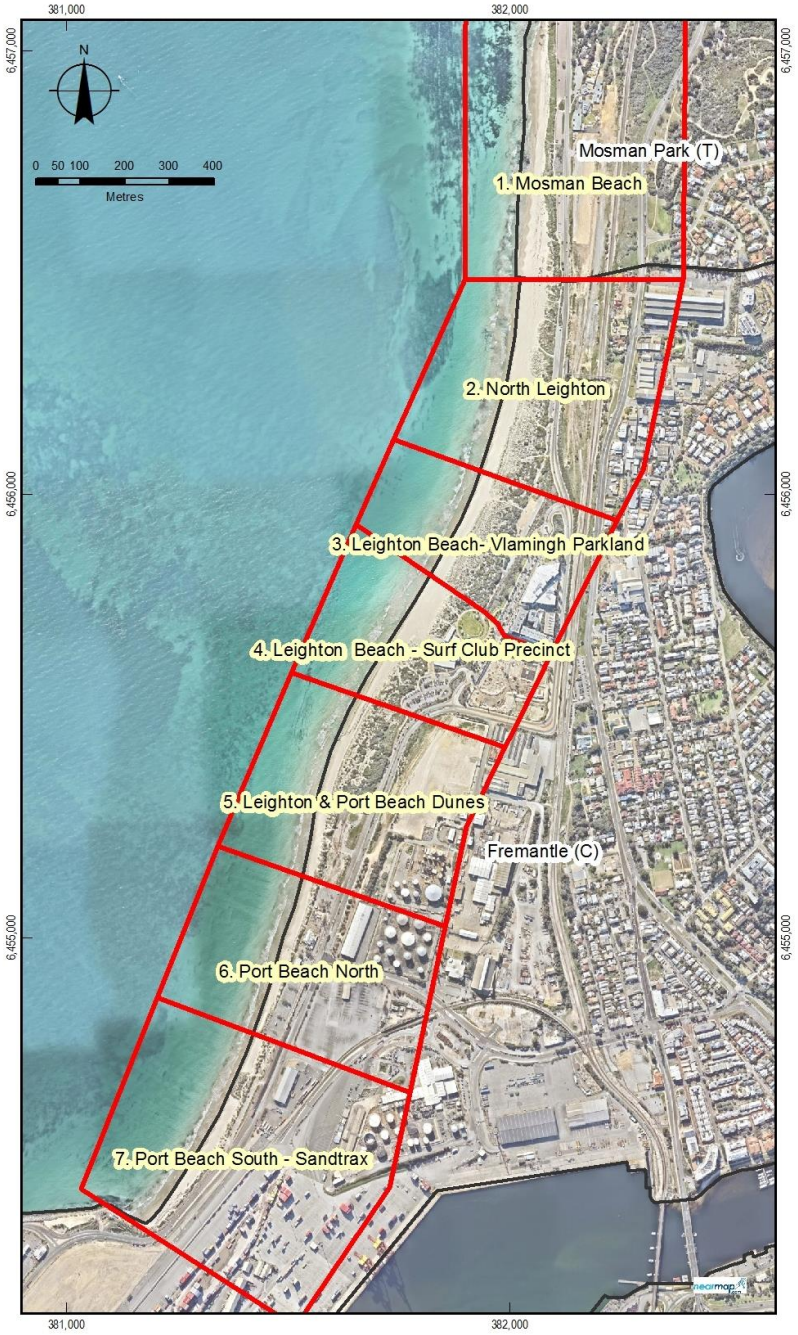

Figure 3-8 Coastal management units for adaptation planning.

3.7 An Evolving Coastline

The Port, Leighton and Mosman beaches are exposed and vulnerable to coastal processes, including erosion and inundation. Over time, the coast will become increasingly vulnerable to the impacts of sea level rise, storm surges and changes in sediment transport and natural sediment stores.

The coast has always been a dynamic, changing environment. As people have settled on the coast, continual changing of the coast line presents risk and impacts to coastal assets including social, environmental and economic assets and values. Adaptation planning is about being ready to manage the risks and impacts of changes to the coast line, by planning for the most appropriate decisions and options to implement over time.

3.7.1 Changing Beaches

The shape of the coastline is continuously changing in response to the forces acting on it: wind, currents, waves and the level of water. The coastline responds to these forces by changing shape, which can affect the way the forces act. For example, if a storm causes erosion and moves sediment offshore into a sand bar, the sand bar reduces the water depth and can cause waves approaching the beach to break before they reach the beach, reducing the size of the waves hitting the beach face.

Many of the forces acting on our beaches are driven by climate forces, so as the weather changes with seasons so do beaches. The climatic, weather and ocean forces also change at different time scales such as over many years due to cyclical changes such as El Nino/La Nina or due to longer term trends such as global warming. As a result, beaches are continually responding to these changes and consideration needs to be given to how these changes may influence the coastlines, interaction with coastlines and the current and ongoing value of the assets.

3.7.2 Inundation and Erosion

The two main processes which are considered hazards on sandy coastlines are erosion and inundation.

Erosion is the loss of sand. An eroding coastline refers to shoreline movement where the shoreline shifts landwards, potentially reducing the width of the coastal foreshore reserve or reducing the distance to fixed features on the land. Erosion is the result of sediment being moved either offshore or along the shore by waves and currents. Erosion can be a slow seasonal process, such as sand moving from one end of a beach to the other and back over a year as a result of change in seasonal wind and wave directions, or it can be sudden, resulting in sudden changes in the shape of the beach or vertical drops in the sand level such as after storm events. Erosion is a natural process, and is balanced by the opposite process of accretion, the accumulation of sand, which allows beaches to replenish and rebuild over time in some instances, dependent on the nature and severity of the erosive event.

Inundation is the flow of water onto previously dry land. It may either be permanent (for example due to sea level rise) or a temporary occurrence during a storm. Other than the regular short-term variations in water levels caused by tides, other temporary effects on water level include falling barometric pressure which allows water surfaces to rise (inverse barometric effect), the action of wind and waves that can cause water to pile up against the coastline (setup) and waves breaking and pushing water up the beach face (wave run-up).

3.7.3 Sediment Cells

Sediment transport events are ultimately linked, so when sand is removed from a beach by erosion, it is transported and deposited elsewhere, such as an offshore sand bar. Sediment transport is therefore often considered in the context of a sediment budget, similar to a bank account where if the amount of sand leaving the account is larger than the amount of sand coming into the account, then the beach will erode (or the bank account will reduce).

To assess the changes to the sand balance, it helps to define the geographical area to account for the sediment movement. These areas are called sediment cells and the boundaries of the cells are defined by features along the coast which may restrict sediment transport or indicate changes in sediment transport dynamics. Sediment cells are broken down at different scales with primary cells potentially being composed of secondary and tertiary cells depending on the coastline features. The location of the alongshore sediment cell boundaries on the beach and landside varies for primary, secondary and tertiary cells but in general occur:

- when rock structures restrict sediment transport,
- at specific geomorphic (landforms) features (e.g. headlands, tombolos),
- when adjacent cells have a different shoreline aspect which restricts sediment transport and
- at engineered structures (e.g. small harbours) or dredged channels (Stul 2015).

It is important that, when changes are made to the coastline, there is consideration of implications within a cell, such as causing accretion to occur at one location is ultimately going to result in erosion elsewhere. The application of sediment cells is a useful way to define a connected zone of influence on the coast and is therefore useful to align with planning boundaries when considering how changes to beaches may affect other locations. The extents of the secondary and tertiary sediment cell areas for the Fremantle and Perth coast are shown in Figure 3-9.

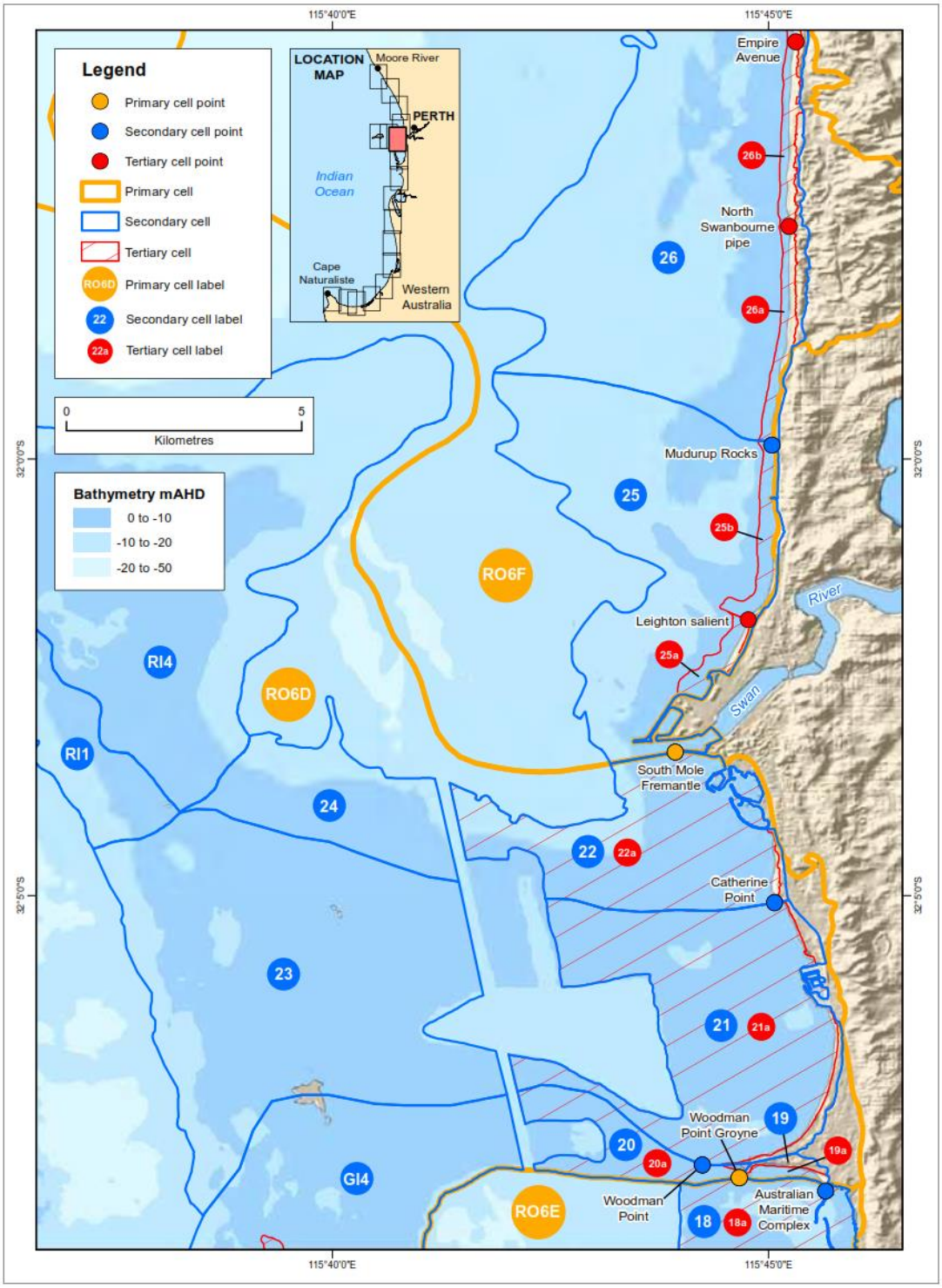

Figure 3-9 Secondary and tertiary sediment cells along the Perth coastline (Stul, 2015)

3.7.4 Constructed Changes on the Coast

The largest human constructed alterations to sediment transport and sediment supply along the Port, Leighton and Mosman beaches include:

- Flattening of the dunes along Port and Leighton Beaches between 1946 and 1972 to allow for new industrial development and new railway alignments
- Construction of the Rous Head Harbour from 1989 to 1991 (DPI 2004)
- Construction of the Rous Head Extension 1995 to 2004 (DPI 2004) including a groyne which acted as a sand trap.
- Extension of the Rous Head Seawall in 2009 to retain land reclamation for the expansion of the Rous Head industrial area, North Quay Rail terminal extension and truck marshalling area.
- Construction of a coastal protection rock nodes at the northern end of the Sandtrax carpark and carpark rock protection at the southern end of the South Beach carpark.
- Dredging and disposal of sediment from the Fremantle harbor channel.
- Use of the Mosman Park foreshore as a municipal tip from the early 20th century to 1950's. In 1959 the construction of the marshalling yards resulted in excavated material being located to Mosman Beach. This material is generally referred to as construction and non-industrial waste and there is up to 5m of overburden over the tip site from the marshalling yard material (GHD 2014).

The construction of these features have influenced and changed the forces acting on the beaches and the sediment transport pathways, resulting in changes to the shape of the beaches as the sediment budgets have been altered.

3.7.5 Coastal Hazard Likelihoods

In line with coastal hazard risk management and adaptation planning guidelines (WAPC 2014) an assessment of coastal hazards has been undertaken at different event likelihoods to reflect the probability of an event occurring within any given year. In the study, three hazard likelihoods of almost certain, possible and rare have been used to assess erosion and inundation. More detail on the information used, assumptions made and a full set of the coastal hazard maps can be found in Appendix C and the full report can be found in Appendix D – Coastal Hazard Assessment.

3.7.6 Mosman Beach

Erosion

Erosion in the short-term at Mosman Beach will be caused by sea level rise and a slow but consistent erosion of the dune/cliff base causing slope erosion. The erosion hazard risk area at Mosman Beach is significant because the width of the dune system and the elevation of the land behind mean that this section of the coast has a reduced capacity to buffer and repair from erosion events. The short-term erosion hazard at 2030 for Mosman Beach is shown in Figure 3-10 and shows that the extent of the erosion hazards increase to the southern end of Mosman Park due to the lack of information on the presence of any naturally occurring rock layers. In the medium and long-term, the trend is similar, with the hazard areas at the southern end of Mosman Beach extending into the carparks west of Curtin Avenue and Curtin Avenue itself.

Inundation

Due to the high elevation of the dunes at Mosman Beach, impacts of inundation is maintained within the beach area for all events for all of the short, medium and long-term timeframes. The risk of inundation to Mosman Beach by 2030, short-term, is shown in Figure 3-12.

Overall the hazard posed by inundation is likely to have a limited impact to the immediate beach and dune areas over the whole study time frame with the likelihood increasing slightly by the long-term timeframe. The inundation maps however only show the intersection with the current day topography. Further consideration needs to be given to the influence of increasing sea levels on saltwater intrusion into groundwater and increased risk of dune erosion due to higher water level.

3.7.7 Leighton Beach

Erosion

The Leighton Beach foreshore is an accreting foreshore so the processes contributing to the erosion hazards are storm erosion events and sea level rise. For all timeframes, the storm erosion component increases with the event likelihood. And as the risk of sea level rise increases with time so does the extent of erosion.

In the short-term, the almost certain erosion hazard for Leighton Beach is maintained within the dune system except near the northern extent of the City of Fremantle boundary. The possible and rare erosion hazard however do extend into the Leighton parklands and change rooms facilities as shown in Figure 3-10 and Figure 3-11.

In the medium and long-term, the extents of risk increase, impacting on Curtin Avenue in the north, the Leighton Park precinct and Surf Life Saving Club and by the long-term on Leighton Beach Boulevard.

Inundation

The effects of inundation at Leighton Beach in the short-term is contained within the beach width except for a rare inundation that may result in a small area of inundation just south of the Leighton Beach surf club carpark, see Figure 3-12 and Figure 3-13 for maps of the inundation risk to Leighton Beach by 2030. In the medium-term, inundation of the dune swales increases in area slightly as the likelihood shifts from rare to almost certain. In the long-term the influence of a rare event extends further in the swales but overall inundation is maintained within the beach area by the foredune.

3.7.8 Port Beach

Erosion

Coastal processes contributing to erosion at Port Beach include storm erosion, a long-term (23 year) trend of erosion and sea level rise. Hazards maps presented for Port Beach assume that the Port Beach Road sea wall does not contribute to beach protection to indicate the potential extents of erosion if this seawall is not included in future coastal adaptation solutions.

In the short-term the almost certain erosion hazard for Port Beach extends across a significant portion of carpark and dune areas as well as across Port Beach Road at the southern end of the site as shown in Figure 3-11. In the medium-term this almost certain hazard extends further inland impacting on Fremantle Port land, seaward industrial lots and more of Port Beach Road. In the long-term the almost certain hazard impacts nearly all of Port Beach Road and more of the Port and industrial land.

Inundation

The effect of inundation at Port Beach in the short and medium-term is maintained within the beach width. In the long-term, inundation begins to affect the foredune and seaward areas of some car parking areas along Port Beach Road. The risk of inundation to Port Beach by 2030, short-term, is shown in Figure 3-13.

The coastal hazards of erosion and inundation have been quantified in this study and used to predict the potential levels of inundation and erosion on the coastline into the future. To review the mapping results for all timeframes, please see the complete coastal hazard map set in Appendix C. For information on the assumptions, methodology and results please see Appendix D.

Legend

- Almost Certain
- Rare
- Possible
- Coastal Management Units

Paper Size A4

0 25 50 100 150 200 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

City of Fremantle
Town of Mosman Park
Port, Leighton and Mosman Beaches
Coastal Adaptation Plan

Short Term Erosion Hazard

Job Number 61-34650
Revision A
Date 25 Oct 2017

Figure 3.10

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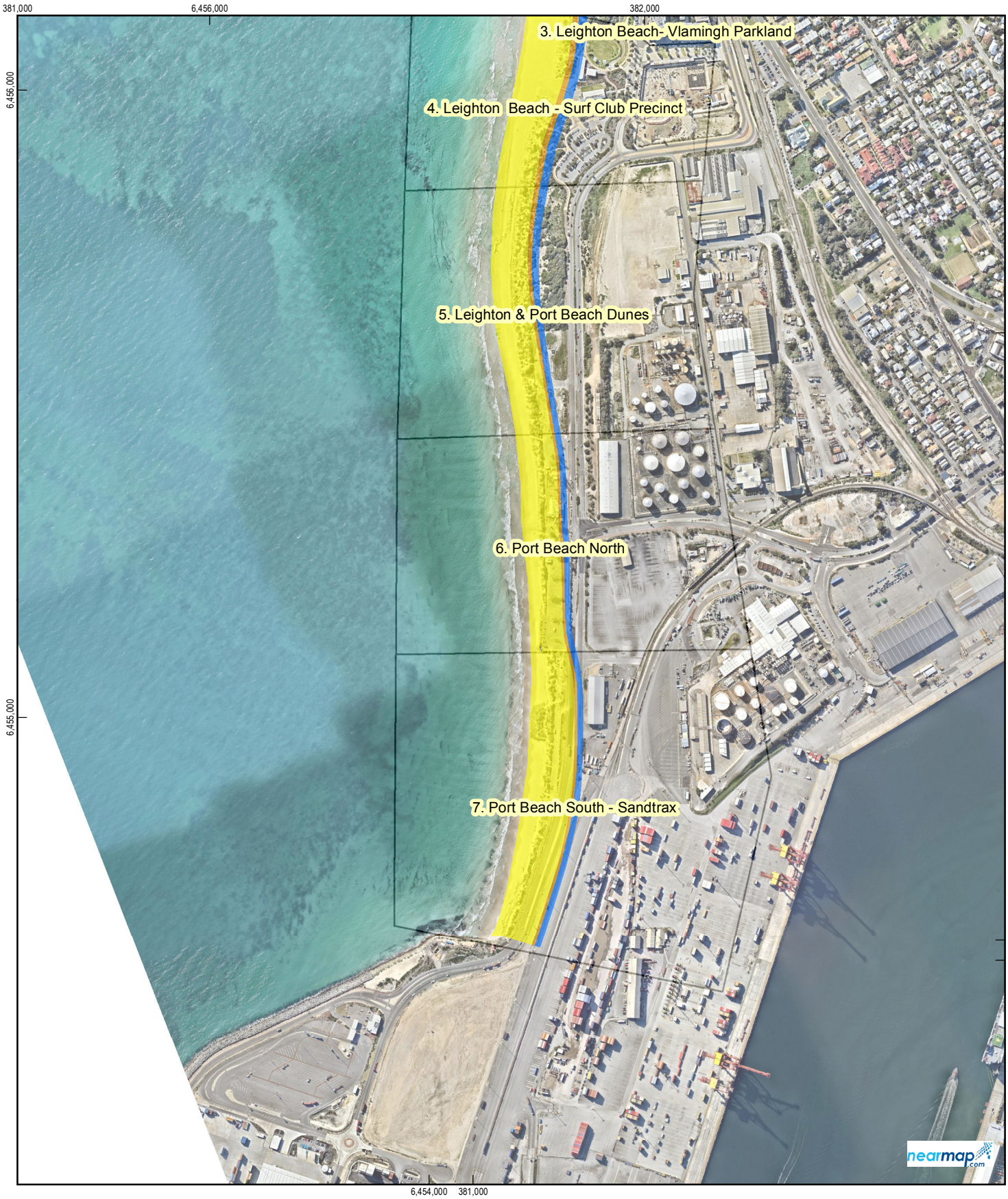
Data source: Nearmap: Imagery 12th July 2016 - 20160802; Landgate: Local Government Boundary; GHD: Erosion Hazard - 20160802. Created by:gcbertrand



Legend

- Almost Certain
- Rare
- Possible
- Coastal Management Units

Paper Size A4

0 25 50 100 150 200 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

City of Fremantle
Town of Mosman Park
Port, Leighton and Mosman Beaches
Coastal Adaptation Plan

Short Term Erosion Hazard

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Figure 3.11

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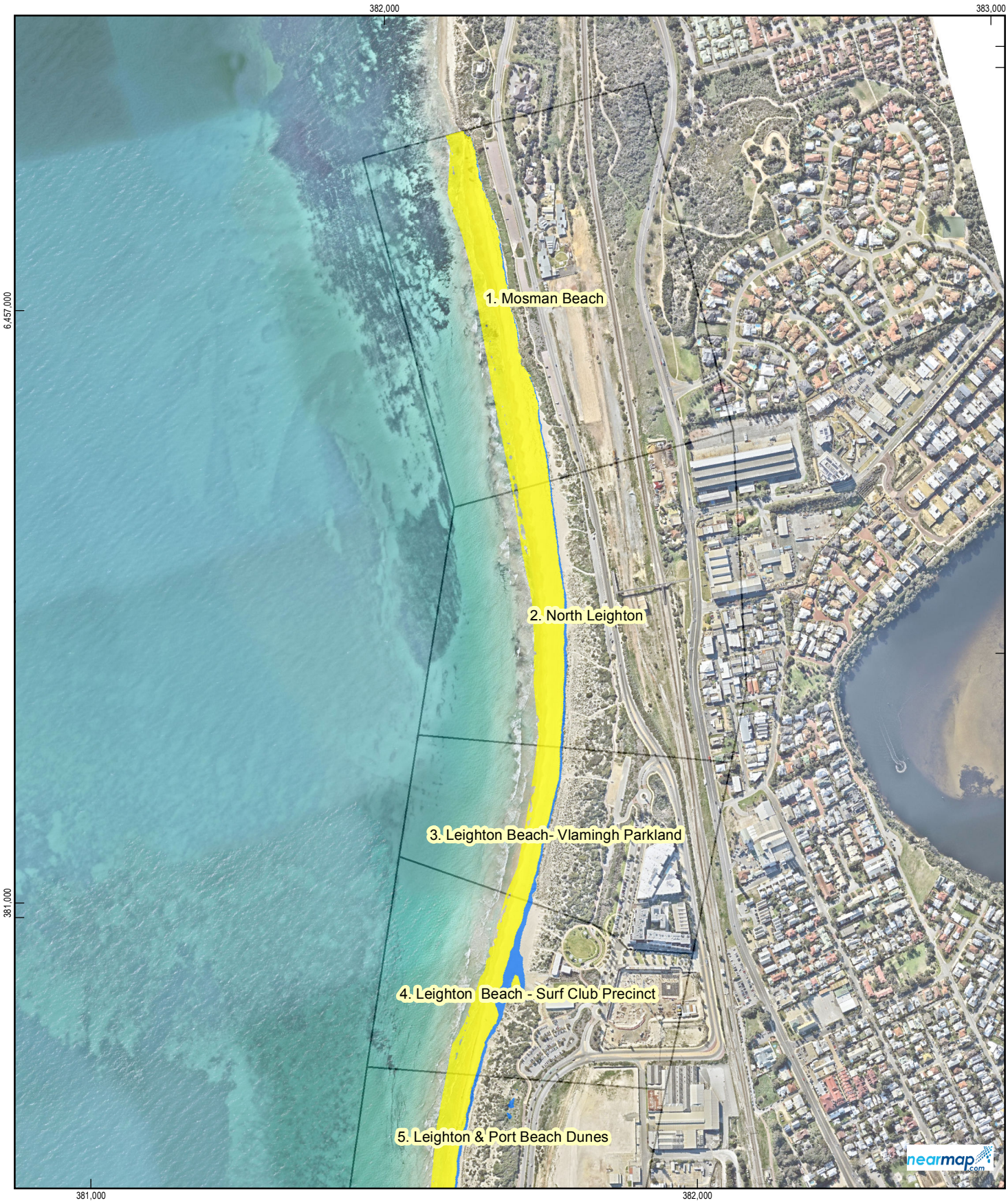
Data source: Nearmap: Imagery 12th July 2016 - 20160802; Landgate: Local Government Boundary; GHD: Erosion Hazard - 20160802. Created by:gcbertrand



Legend

- Almost Certain
- Rare
- Possible
- Coastal Management Units

Paper Size A4

0 25 50 100 150 200 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

City of Fremantle
Town of Mosman Park
Port, Leighton and Mosman Beaches
Coastal Adaptation Plan

Short Term Inunation Hazard

Figure 3.12

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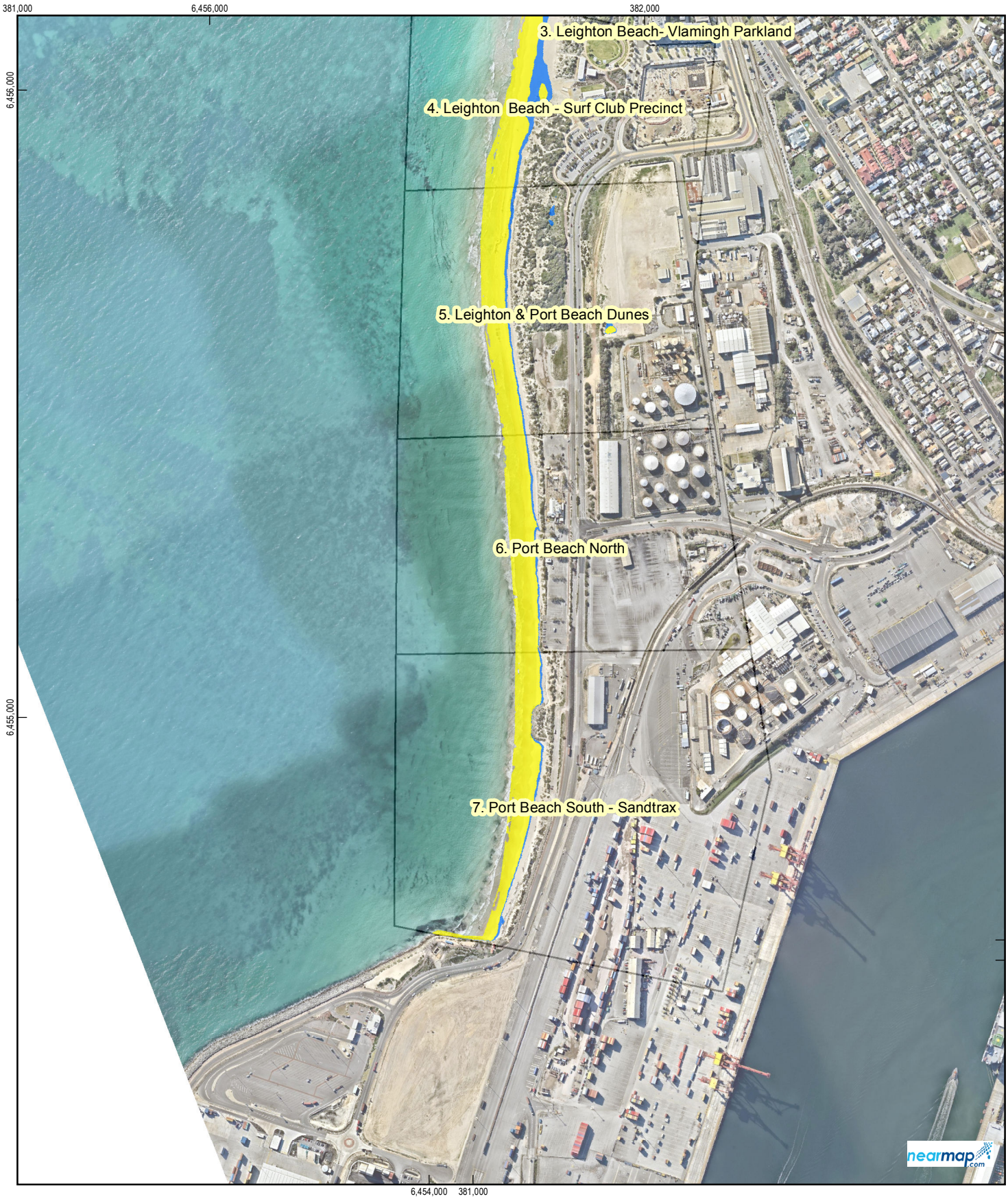
\\ghdnet\ghd\AU\Perth\Projects\61\34650\GIS\Maps\MXD\6134650-011 Rev A - Short Term Inundation A4 Figure.mxd

Data source: Nearmap: Imagery 12th July 2016 - 20160802; Landgate: Local Government Boundary; GHD: Inundation Hazard - 20160802. Created by:gcbertrand



Legend

- Almost Certain
- Rare
- Possible
- Coastal Management Units

Paper Size A4

0 25 50 100 150 200 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

City of Fremantle
Town of Mosman Park
Port, Leighton and Mosman Beaches
Coastal Adaptation Plan

Short Term Inunation Hazard

Figure 3.13

Job Number	61-34650
Revision	A
Date	25 Oct 2017

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Data source: Nearmap: Imagery 12th July 2016 - 20160802; Landgate: Local Government Boundary; GHD: Inundation Hazard - 20160802. Created by:gcbertrand

3.8 Risks of a Changing Coast

A risk assessment was undertaken to determine the level of risk of coastal hazards impacting assets and values within the Port, Leighton and Mosman Beach zones. The risk assessment was undertaken in line with the framework outlined in the WAPC 2014 Coastal Hazard Risk Mapping and Adaptation Guidelines (CHRMAP Guidelines).

Coastal risk is assessed by combining the likelihood of a coastal hazard impacting an asset or value with the consequence of that impact.

3.8.1 Likelihood

Likelihood is defined as the chance of a coastal hazard occurring and how often it may impact an asset. The hazard likelihood for erosion is based on the technical inputs developed by the Coastal Hazards Assessment. Further information on how the likelihood scale was established is detailed in Appendix D – Coastal Hazard Assessment.

Analysis of the coastal hazards found inundation to pose an insignificant risk to assets within the three zones of Port, Leighton and Mosman Beach. As a result, the risk assessment is significantly influenced on the likelihood and consequence of erosion on existing assets and land uses. The likelihood scale for erosion and inundation was determined in the Coastal Hazard Risk Assessment, in Appendix D

3.8.2 Consequence

Consequence is the impact of coastal hazards on assets and their values. Consequences relate not only to the direct impact or damage to an asset but also the effect on related social, economic and environment values (WAPC 2014). The scale identifies the levels of consequence, from insignificant to catastrophic, across a range of categories depending on the defined impact of a coastal hazard to an asset. Where an asset related to more than one category, the category with the highest scale of consequence was selected. Community values, as outlined in the survey summary (see Appendix A) and the Values Register (see Appendix B) have been taken into consideration when defining the level of consequence the coastal hazard will have on social values.

Consequence scales, shown in Table 3-2, were developed for each of the categories of social, environmental, economic, infrastructure and safety. The scale of consequence for the different categories were selected to represent the range of potential consequences relevant to the context of the study area. For example, the social consequence scale ranges from local to regional as both local residents and people across the Perth metropolitan area use and value social services and experiences unique to the area. Setting the consequence levels to cover the expected scale of potential impacts is important as it assists decision makers to prioritise risks requiring

mitigation. Use of state-wide or national scales for some categories, would not allow identification of risks appropriate to the scale of this project.

The social consequence scale was developed based on the results of the community values survey undertaken in Phase 1 of the project for the Port, Leighton and Mosman Beach sites. The economic consequence scales have been adapted from consequence scale from the South Fremantle Coast – Coastal Adaptation Plan and is in line with the scale of costs for direct impact costs per management area.

The environmental scale has been based on the potential damage to the local environment, the ability for the environment to recover, for damage to be of offset and identification of alternate habitat areas. For example erosion of a small area of foredune vegetation in an area with a wide dune habitat is not going to impact on all of the dune habitat and through natural processes dune vegetation has the ability to recover from small amounts of damage so consequence is less critical than if it could not recover.

The infrastructure impact scale was developed based on the proportion of infrastructure impacted, whether the asset was sensitive to gradual versus a threshold response to coastal hazards and its adaptive capacity, in line with the Coastal hazard risk management and adaptation planning guidelines (WAPC 2014).

When considering coastal hazard likelihoods in the present planning period, existing erosion controls such as the seawalls along Port Beach Road were not considered due to varying engineered quality of the implemented structures. Risk levels of existing erosion structures quality and expected design life were taken into consideration in the adaptation planning phase.

The seawall along Port Beach Road has not been included in the risk assessment (which focuses on unmitigated risk), however is taken into consideration in adaptation planning

Table 3-2 Scale of Consequence

		Category				
		Social	Economic	Environment	Infrastructure	Safety
5	Catastrophic	Loss of social or heritage values of regional significance; no alternative exists	Damage to local economy, public infrastructure or loss of land value greater than $20 million	Irreversible damage to local environmental asset that would compromise its viability, no alternate habitats exist.	Damage to majority or all of infrastructure (Greater than 75%). Asset with step change sensitivity and no adaptive capacity.	Loss of life or serious injury
4	Major	Loss of social services and experiences that would significantly impair quality of life of the local community; no convenient alternative exists	Damage to local economy, public infrastructure or loss of land value $5 million to $20 million	Irreversible damage to local environmental asset that would compromise its viability, local alternate habitat exists.	Damage to significant portion of infrastructure (50% - 75%) or asset with step change sensitivity. Asset with step change sensitivity and some adaptive capacity.	Serious injury
3	Moderate	Loss of social services and experiences that would somewhat impair quality of life of the local community; no convenient alternative exists	Damage to local economy, public infrastructure or loss of land value $500,000 to $5 million	Environmental damage to local environmental asset that could be reversed or offset, no alternate habitats exist.	Damage to no more than half of the infrastructure (25% - 50%). Asset with step change sensitivity with adaptive capacity.	Minor injury
2	Minor	Loss of social services and experiences that would somewhat impair quality of life of the local community; alternative sites exist	Damage to local economy, public infrastructure or loss of land value $50,000 to $500,000	Environmental damage to local environmental asset that could be reversed or offset, local alternate habitat exists.	Minor damage to infrastructure (10% - 25%)	No injury
1	Insignificant	Loss of social services and experiences that would have limited impact on quality of life; many alternative sites exist	Damage to local economy, public infrastructure or loss of land value less than $50,000	Minimal damage to local environmental assets; recovery may take less than six months	Little or no damage to infrastructure (Less than 10%)	No injury

3.8.3 Risk Evaluation

Risk levels enable decision-makers to prioritise actions based on the likelihood and consequence of a hazard on existing assets. Four risk levels were identified for the assessment and follow the scale set out in the CHRMAP Guidelines:

- Extreme – risks are unacceptable/intolerable, requiring immediate management and adaptation action.
- High – risks are the most severe that can be tolerated and need monitoring in the short-term as management and adaptation action is likely to be needed in the short-term.
- Medium – risk can be tolerated and need monitoring in the short to medium-term.
- Low – risk can be accepted; no actions will be required in the short to medium-term.

The matrix in Table 3-3 defines the risk level based on “likelihood” x “consequence”.

Table 3-3 Risk Evaluation Matrix

Likelihood	Risk Level				
A Almost certain	Medium	High	High	Extreme	Extreme
C Possible	Low	Medium	High	High	Extreme
E Rare	Low	Low	Medium	High	High
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
	Consequence				

The results of the risk assessment identified a risk level for each asset in the short, medium and long-term (refer Table 9 in Appendix E – Risk Assessment).

3.8.4 Tolerance Level

The varying levels of risk must be defined in terms of their acceptability that is the expected need and timeframe for adaptation. The 'As Low As Reasonably Practicable' (ALARP) Framework identifies required actions based on whether a risk is acceptable, tolerable or intolerable/unacceptable (CSCA 2014).

Table 3-4 presents the tolerance for each risk level and the corresponding required actions.

Table 3-4 Tolerance Level Matrix

Risk Level	Action Required	Tolerance
Extreme	Risk treatment required	Intolerable/ Unacceptable
High	Eliminate or reduce the risk or accept the risk provided residual risk level is understood	Tolerable
Medium	Reduce the risk or accept the risk provided residual risk level is understood	Tolerable
Low	Accept the risk and manage through existing risk management systems	Acceptable

The following sections present for each coastal management unit, the highest risk levels within each planning period and the asset values triggering the risks. This information identifies when trigger points are reached for each coastal management unit. Risk maps are presented in Figure 3-14.

3.8.5 Coastal Management Unit 1- Mosman Beach

Short to medium term extreme risks at Mosman Beach indicate that coastal paths and beach access points have an extreme risk of erosion. Due to the difference in elevation between shore parallel coastal paths and the beach, beach access ways such as piled timber framed stairs are less adaptable to changes in beach levels over the long-term when compared to sandy or paved pathways through dunes. In the long-term, off the street parking at Mosman Beach also becomes exposed to extreme risk.

The values impacted by these risks are predominantly social, with the potential to impact on the community's ability to access and enjoy beach settings and use beach areas for a variety of active recreation and passive uses.

Table 3-5 Management Unit 1 -Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short	Extreme	Beach Access Points	Social
Medium	Extreme	Beach Access Points, Coastal Path	Social
Long	Extreme	Beach Access Points, Coastal Path, Off Street Parking	Social

3.8.6 Coastal Management Unit 2 – North Leighton

Short to medium-term risk levels at North Leighton are high, due to potential for social impacts from loss of the beach and dune areas, affecting social values of the area. In the long-term, the risk increases to extreme due to the potential for coastal erosion to impact on the Curtin Avenue Reserve, impacting social and infrastructure values.

The social values impacted by these risks are people's ability to access and enjoy beach settings, use beach areas for a variety of active recreation and passive uses as well as access to car parking and facilities near the beach.

Table 3-6 Management Unit 2 -Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short	High	Leighton Beach Reserve, Vlamingh Parkland	Social
Medium	High	Leighton Beach Reserve, Vlamingh Parkland, Curtin Ave Reserve, Curtin Ave off street parking	Social
Long	Extreme	Curtin Avenue Reserve	Social

3.8.7 Coastal Management Unit 3 – Leighton Beach – Vlamingh Parkland

The short and medium term risk profiles for this area of Leighton Beach are high due to impacts on the beach reserve and Vlamingh Parklands. This risk increases to extreme in the long-term due to impacts on coastal paths and off street parking.

Environmental values affected by the risk in the short and medium-term are the result of loss of coastal dunes, vegetation and habitat – which provide a supply of sand to the beach during storm events, provide a natural buffer zone to coastal processes and supports ecology. Social values at risk in the long-term include the ability to access and enjoy beach areas which may further impinge on people's ability to undertake a variety of passive and active recreation and other social values.

Table 3-7 Management Unit 3 - Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short	High	Leighton Beach Reserve, Vlamingh Parklands	Environment
Medium	High	Leighton Beach Reserve, Vlamingh Parklands	Environment
Long	Extreme	Coastal path, off street parking	Social

3.8.8 Coastal Management Unit 4 -Leighton Beach – Surf Club Precinct

In the short-term, the risk level at Leighton Beach is high due to risks to environmental and social values. In the medium-term, a number of assets including the Fremantle Surf Life Saving Club and the Leighton Beach Change room facilities are at extreme risk of erosion. In the long-term, there is an extreme risk of erosion to the off street car parking area and coastal paths.

Environmental values at risk in the short-term are the result of loss of coastal dunes, vegetation and habitat – which provide a supply of sand to the beach during storm events, provide a natural buffer zone to coastal processes and supports ecology. In the medium term, social values at risk are access to public toilet facilities near the beach and park, and having a safe surf-lifesaving patrolled beach. In the long-term, social values at risk also include access to car parking which may impinge on the community's access to the beach for a variety of passive and active recreation and other social values.

Table 3-8 Management Unit 4 - Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short	High	Leighton Beach Reserve, Vlamingh Parklands, Leighton Beach Changerooms	Environment, Social
Medium	Extreme	Leighton Beach Changerooms, Fremantle Surf Life Saving Club	Social
Long	Extreme	Leighton Beach Changerooms, Fremantle Surf Life Saving Club, Curtin Ave Reserve, coastal path, off street parking	Social

3.8.9 Coastal Management Unit 5 - Leighton and Port Beach dunes

In the short-term the risk level at Leighton and Beach dunes is high due to risks to environmental and social values of the Port Beach Reserve. In the medium to long-term, there are extreme risks to coastal paths and the Port Beach Road reserve, affecting social values.

Environmental values at risk in the short-term are the result of loss of coastal dunes, vegetation and habitat – which provides a supply of sand to the beach during storm events, provide a natural buffer zone to coastal processes and supports ecology. In the medium to long-term, social risks relate to the potential impacts on accessing the foreshore reserve by road or coastal paths due to risk to the road reserve.

Table 3-9 Management Unit 5 -Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short	High	Port Beach Reserve	Environment
Medium	Extreme	Port Beach Road Reserve	Social
Long	Extreme	Port Beach Road Reserve	Social

3.8.10 Coastal Management Unit 6 – Port Beach North

The risk profile for Port Beach North is extreme across all time periods due to the impact to economic, social and infrastructure values from erosion hazards to assets identified in Table 3-10. These risks represent a substantial economic cost due to the potential impacts to the Fremantle Port, ability to run a small coastal business, and industry related businesses east of Port Beach Road.

The social values impacted by erosion include impact on the community's ability to access and enjoy beach settings, use beach areas for a variety of active recreation and passive uses, access public toilet facilities near the beach and park, have a safe surf-lifesaving patrolled beach and access the region by road.

Table 3-10 Management Unit 6 -Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short	Extreme	Port Beach Road Reserve, Fremantle Port Land, Beach access points, coastal paths, off street parking, Public Coastal Facilities – Kiosk and Change Rooms	Economic, Social, Infrastructure
Medium	Extreme	Port Beach Road Reserve, Tydeman Road Reserve, Fremantle Port Land, Freight Rail, Beach access points, coastal paths, off street parking, Public Coastal Facilities – Kiosk and Change Rooms	Economic, Social, Infrastructure
Long	Extreme	Port Beach Road Reserve, Tydeman Road Reserve, Fremantle Port Land, Freight Rail, Beach access points, coastal paths, off street parking, Public Coastal Facilities – Kiosk and Change Rooms	Economic, Social, Infrastructure

3.8.11 Coastal Management Unit 7 – Port Beach South – Sandtrax

The risk profile for Port Beach South is extreme across all planning periods (Table 3-11) due to potential impact to social assets including parking, beach access, coastal paths, kiosks and infrastructure assets including the North Quay Rail Terminal and Port Beach Road Reserve. These risks represent a substantial economic cost within the area due to the potential impacts to the Fremantle Port and businesses associated with the Rous Head precinct. This is due to potential risks to the Port Beach Road Reserve and the Freight Rail line impacting access and services.

Table 3-11 Management Unit 7 - Risk Profile Summary

Timeframe	Risk Level	Asset Triggering Risk	Value Triggering Risk Level
Short[2]	Extreme	Port Beach Road Reserve, Fremantle Port Land, Beach access points, coastal paths, off street parking	Economic, Social, Infrastructure
Medium	Extreme	Port Beach Road Reserve, Fremantle Port Land, Freight Rail, Beach access points, coastal paths, off street parking	Economic, Social, Infrastructure
Long	Extreme	Port Beach Road Reserve, Fremantle Port Land, Freight Rail, Beach access points, coastal paths, off street parking	Economic, Social, Infrastructure

[2] . Note, risk levels presented for Port Beach assume that the Port Beach Road seawalls do not contribute to beach protection. Protection provided by the existing seawalls were considered in the implementation plan.

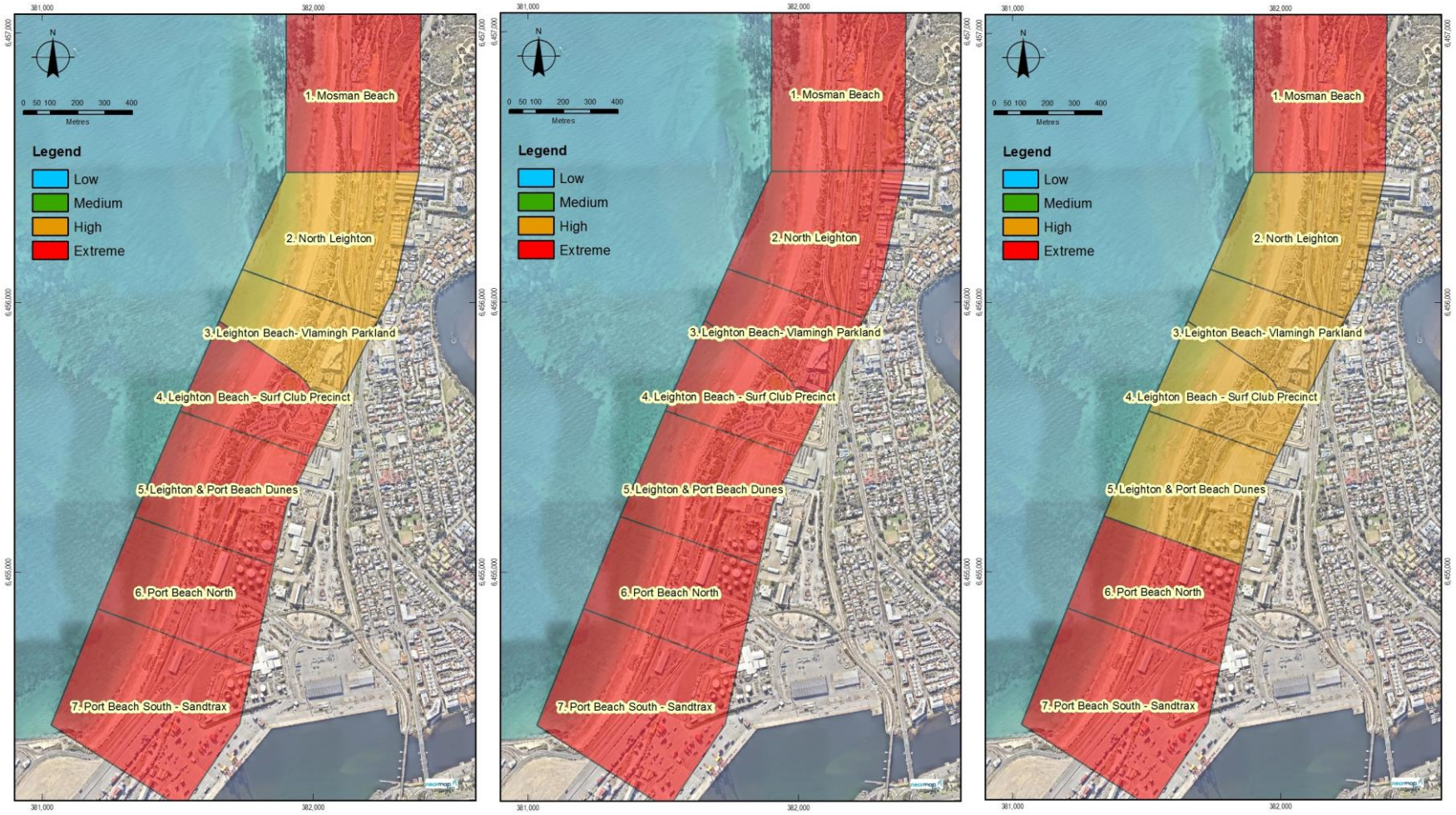


Figure 3-14 Short, medium and long-term coastal risk

4 Adaptation Principles and Pathways

4.1 Adaptation Principles

In developing a pathway to adapt to changing coastal processes, and to guide decisions that are appropriate for the community, the following principles should underpin the adaptation planning process.

Principle 1 Adaptation planning in the current planning horizon does not impede the ability of future generations to respond to increasing risk beyond current planning horizons.

The preparation of erosion and inundation risk mapping to inform this plan considers possible scenarios for sea level rise to 2110. These hazard risks include projections for sea level rise that are dependent on the global action taken to mitigate climate change impacts through greenhouse gas emission reductions. The modelled scenarios considered by the Intergovernmental Panel on Climate Change (IPCC) give rise to a range of predictions of sea level rise, which show increasing variability in sea level estimates with increasing time into the future.

Therefore the implementation of adaptation solutions should, where possible, not be tied to specific time frames, but tied to trigger points in coastal hazard risks due to uncertainty about the timing of when and if risks may be realised. And the implementation of short and medium-term coastal adaptation measures should not adversely impact upon coastal adaptation measures implemented in the medium and long-term.

Principle 2 Adaptation requires a decision-making framework that enables the right decision to be made at the right time, in line with the values and circumstances of the time.

The dynamic nature of community needs and values requires a flexible approach when considering adaptation options. The effects of climate change on the coast, and changes to our beaches from erosion and engineered changes have been identified as potential concerns for some in the community. The interest and values of the community will change over time as more information becomes available, and impacts of climate change become more apparent. Our approach to coastal adaptation will likely evolve as new technology and information opens up new approaches to manage risk.

Making decisions based on community values that are likely to change may potentially prevent achieving the best possible outcome when considering short, medium and long-term measures to adapt to changing coastal processes. Adaptation planning should provide opportunity for future action to utilise new technologies and reflect community values at the time of the decision.

Principle 3 Adaptation planning reflects the public's interest in the social, environmental, and economic value of the coast.

Western Australia is renowned for its extensive coastline and beaches. Social and recreational use of these features form an integral part of Western Australian culture. Continued public access to the coast and beaches is an iconic part of Western Australia's lifestyle, contributing to the high quality of public spaces enjoyed by the community. Our economy and quality of life is supported by coastally dependent infrastructure and industries. In addition the coast might support future projects critical to the development of the Western Australian economy. The coast also provides important environmental values, with a unique ecology that includes marine, intertidal, and dune habitats.

Adaptation planning should respect the inherent value of the coast that is ingrained in the state's social, environmental and economic interests.

Principle 4 Alternative adaptation measures should consider the full range of land uses and values.

The objectives of State Planning Policy (SPP) 2.6 include the retention of coastal areas for a range of public and private uses including economic uses, coastal foreshore access and social and environmental uses and values, including:

- Housing, tourism, recreation, ocean access, maritime industry, commercial and other activities;
- Public coastal foreshore reserves and access to them; and
- Landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

Principle 5 The full life-cycle benefits, costs and impacts of coastal interim protection works should be evaluated when considering adaptation options.

Coastal engineering works have the potential to provide protection to nearshore coastal assets over their design life, dependent on the rate of future sea level rise. There are two broad categories of protection with potential for use along the Port, Leighton and Mosman Beaches. These are:

- Engineering (hard) measures: seawalls, revetments, levees, groynes/breakwaters
- Regenerative (soft) measures: beach (sand) replenishment and dune restoration

Seawalls and revetments, if implemented in response to persistent erosion but without ongoing beach (sand) replenishment, will eventually lead to a loss of beach and coastal habitat seaward of the structures, particularly as sea levels rise. Replenished/nourished beaches require ongoing maintenance to offset sediment losses incurred from storm-

related erosion events and sea level rise. Coastal protection measures taken in a specific location may also influence adjacent coastal cells.

Interim protection measures also bring cost impacts. Engineering works can have a high capital cost, and require ongoing investment in maintenance. The cost impact of coastal engineering works should also consider decommissioning costs. Engineering options are designed to mitigate against a particular level of risk and have a discrete design life. However, the presence of protection works can set expectations for asset owners, and can potentially limit future decision-making flexibility.

SPP 2.6 includes a presumption against coastal protection measures unless “all other options … have been fully explored”.

Adaptation principles recognise that the most appropriate adaptation decision may differ based on the specific site and the values to be protected. As illustrated in Figure 4-1**Error! Reference source not found.**, land protection measures (seawalls) can exacerbate erosion and severely affect beach amenity compared to retreat or natural recession.

Figure 4-1 Restricted amenity of a protected beach vs a natural beach.

4.2 Adaptation Pathways

In line with adaptation principles, the most appropriate adaptation pathway is one that enables decision-making on adaptation measures to be made at the right time, in line with the values of that time.

4.2.1 Triggers

Decisions must be made as the risk to assets increases from tolerable to intolerable. The points in time when decisions are required become trigger points for adaptation planning and are summarised in Table 4-1 .

Table 4-1 Trigger and decision points.

Trigger	Decision	Implication/action
Trigger 1: Assets or values in coastal zone reach high risk level	Risk is tolerable - avoid and monitor	Avoid through strategic planning measures Ongoing monitoring
Trigger 2: Assets or values in coastal zone will reach extreme risk level in next planning period	Increasing likelihood of intolerable risk - accommodate and monitor	Accommodate through asset or area specific activities Ongoing monitoring
Trigger 3: Assets or values in coastal zone reach extreme risk level	Intolerable risk – interim protection may viable - retreat or protect	Evaluate whether interim protection is justifiable on social, environmental, and economic grounds. Where interim protection is justifiable, determine the nature of the works based on social, environmental and economic grounds.
Trigger 4: Assets or values in coastal zone continue to be extreme	Intolerable risk - protection is not viable - retreat	Actively plan for retreat in a coordinated manner.

In order to make appropriate decisions it is important to identify the trigger points that separate the options available to decision makers. It is recommended that the above trigger points become the basis of those decisions, using the combination of factors, hazard likelihood and consequence, level of tolerability accepted and appropriate adaptation options.

4.2.2 What Does Successful Adaptation Look Like?

The Coastal Hazard Risk Management and Adaptation Planning Guidelines (WAPC, 2014) set out coastal adaptation options available when making decisions about managing coastal risk (Figure 4-2). The options shown in Figure 4-2 should be considered as a hierarchy – the further down the hierarchy, the less flexibility there is to consider alternative adaptation measures. Effectively, these options become decisions for government and the community to make when planning for the future of coastal assets and land.

Figure 4-2 Hierarchy of risk management and adaptation options (WAPC, 2014)

A successful adaptation pathway is achieved when decisions made now, in 20 years or in 50 years do not prevent other courses of action being chosen later, retaining ongoing flexibility in decision-making consistent with the hierarchy of options. For example, at the end of the life cycle of interim protection structures, the hierarchy of adaptation options should be reassessed and the adaptation measure most appropriate for that point in time progressed. There may be a point when the viability of less flexible measures (such as interim protection) is compromised due to social or economic costs. This requires ongoing strategic planning to retain the full flexibility of adaptation options for future decisions, even when other options are employed in the shorter-term.

Flexible Adaptation: we prepare our governance and planning frameworks to maintain flexibility in available adaptation options, so that the right decisions can be made at the right time.

The recommended flexible adaptation pathway combines decision-making at trigger points on specific adaptation measures (avoid, retreat, accommodate, interim protection) with an ongoing strategic planning process that plans for, and therefore maintains, all adaptation options for subsequent trigger points over time. In this way, by choosing to accommodate or protect in early horizons, future communities are not bound to the long-term cost of that decision beyond the design life of the infrastructure or asset. The pathway and decision points are illustrated in Figure 4-3.

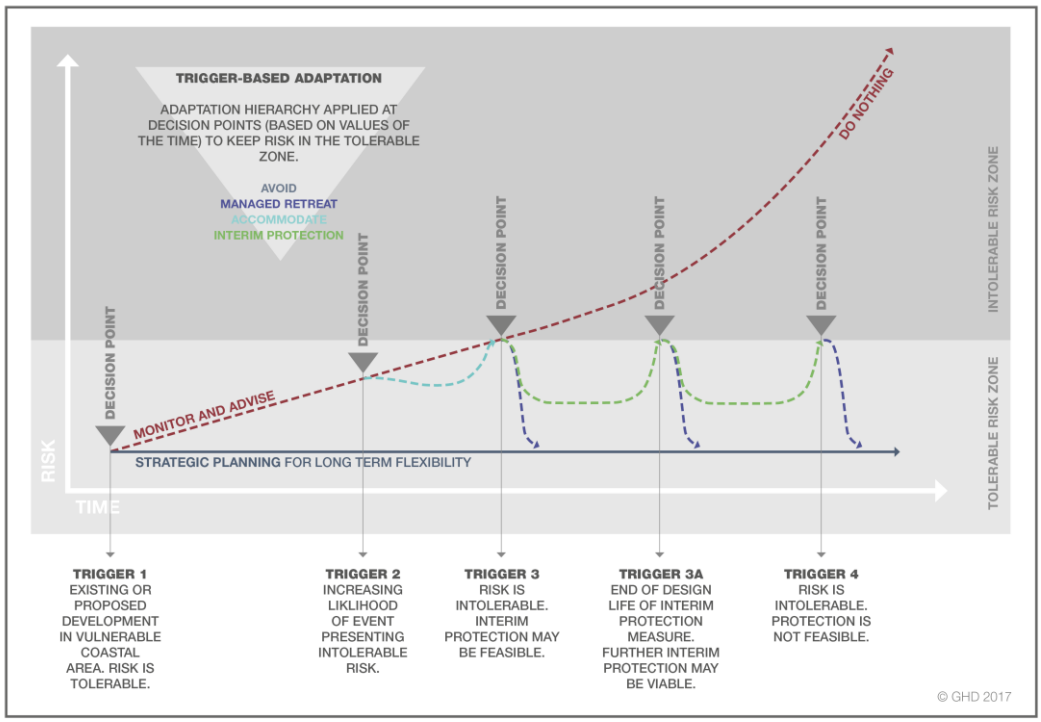


Figure 4-3 Flexible adaptation pathway

The flexible pathway provides a framework to enable retreat measures on the most vulnerable coastal land in the long-term. The pathway also facilitates responsible interim adaptation measures that continue land uses where those measures are justified on social, economic and environmental grounds.

4.2.3 Planning Horizons

For the medium and long-term planning horizons, strategic planning should focus on maintaining the ability of community and stakeholders to choose from the most appropriate adaptation measures at future decision points. This includes provision in planning tools to enable avoid and retreat measures, even if these measures are not put into action in the short-term.

In the short-term planning horizon, any decision points that will arise from increasing risk in that timeframe should be identified. Community values should be confirmed to understand the social, environmental, and economic influences on the decision. Using the values of the time, the decision on the most appropriate adaptation measure (avoid, retreat, accommodate, or interim protection) should be made and acted upon. This delivers a no-regrets adaptation decision, reserving the right to review investment and protection strategies over time. 15-years is sufficient to implement necessary planning controls in local planning schemes if retreat is required, and to commence budgeting for required adaptation measures.

In line with the adaptation pathway, this adaptation plan focusses on the two strategic areas of adaptation actions:

1. Implement appropriate adaptation actions in response to specific triggers

2. Develop strategic planning frameworks for flexibility in the medium and long-term.

This adaptation plan presents strategic planning measures to incorporate a flexible pathway into the medium and long-term planning horizons in the City of Fremantle and Town of Mosman Park. The plan recommends adaptation measures for the short-term (to 2030) planning horizon, and identifies possible measures for decision points that would occur beyond that. Provisional adaptation measures for planning horizons beyond 2030 should be subject to ongoing review and testing with the community, in line with the recommended long-term strategic planning approach.

Erosion in the area following storms in 2016

5 Appropriate Adaptation Actions

To recommend appropriate adaptation measures for the short, medium and long-term planning horizons, this plan has developed, assessed, and prioritised appropriate adaptation options. Adaptation measures were tested for short-term suitability on an individual coastal management unit scale to develop a list of preferred measures, which were then considered at the whole of coast scale using a trigger based approach to risk management.

The coastal hazard risk levels and tolerability ratings from the risk assessment in Appendix E of the Coastal Adaptation Plan has been used to establish the tolerance profile and trigger point for each coastal management unit in the short, medium and long-term and is shown below in Table 5-1.

Table 5-1 Summary of coastal hazard risk tolerance levels and trigger points per CMU.

Management Unit	Short	Medium	Long
1. Mosman Beach	Intolerable Trigger 3	Intolerable Trigger 3A	Intolerable Trigger 3A
2. North Leighton	Tolerable Trigger 1	Tolerable Trigger 2	Intolerable Trigger 3
3. Leighton Beach-Vlamingh Parkland	Tolerable Trigger 1	Tolerable Trigger 2	Intolerable Trigger 3
4. Leighton Beach - Surf Club Precinct	Tolerable Trigger 2	Intolerable Trigger 3	Intolerable Trigger 3A
5. Leighton & Port Beach Dunes	Tolerable Trigger 2	Intolerable Trigger 3	Intolerable Trigger 3A
6. Port Beach North	Intolerable Trigger 3A	Intolerable Trigger 3A	Intolerable Trigger 3A
7. Port Beach South - Sandtrax	Intolerable Trigger 3A	Intolerable Trigger 3A	Intolerable Trigger 3A

Intolerable risk levels (representing a trigger point 3) are expected to be reached in coastal management units 1, 6 and 7 in the short-term. At these locations an immediate decision between retreat and interim protection is required. For CMUs 4 and 5, the risk level is tolerable but expected to rise in the medium-term (representing a trigger point 2). For CMUs 2 and 3, the risk is expected to remain tolerable over the short and medium-term (representing a trigger point 1 and 2).

5.1 Assessing the available adaptation measures

The adaptation measures identified in Appendix G – Adaptation Options Compendium as suitable for evaluation are summarised below:

- Retreat
- Dune stabilisation, revegetation and sand replenishment or engineered cliff stabilisation with revegetation and sand replenishment
- Offshore breakwaters and sand replenishment
- Groynes and sand replenishment or
- Seawall and sand replenishment or buried seawall and sand replenishment

To assess the suitability of the adaptation measures for each coastal management unit a technique known as multi-criteria decision analysis was used to compare the adaptation measures on the basis of impacts or benefits to the following social, environmental and economic criteria:

- Beach area
- Dune vegetation area
- Length of road
- Area of carpark
- Number of non-residential lots
- Residual risk to assets and values
- Cost of implementation

A score was calculated for each adaptation measure within each coastal management unit accounting for the impact or benefit towards the above criteria. In a workshop, the steering committee and project team weighted the scoring for each of the criteria based on consideration of community and stakeholder values. The total scores were calculated for each measure based on the criteria scores and criteria weightings and the adaptation measures were then ranked in order of lowest to highest score. Sensitivity testing was undertaken to identify how sensitive the top ranked solution was to changes in criteria weighting. From the sensitivity testing one or two recommended adaptation measures were made per coastal management unit. Further details on the multi-criteria decision analysis including assumptions and results and sensitivity testing are set out in Appendix F.

5.2 Adaptation Pathway

The current state coastal planning policy supports maintaining flexibility of options and accepting some level of risk as it only allows for protection when all other options for a section of a coast have been explored. Using the outcomes of the adaptation measures evaluation, measures were matched to the coastal management unit trigger points requiring risk mitigation for each planning period. The whole of coast plan was developed to consider only complementary adaptation measures between coastal management units. The recommended adaptation measures for implementation in the trigger based flexible adaptation pathway which manages the risk at a tolerable level is shown in Table 5-2.

Table 5-2 Flexible adaptation pathway for Port, Leighton and Mosman Beaches

CMU	Short		Medium		Long	
	Present	2030	2050	2070	2090	2110
1. Mosman Beach	Engineered dune stabilisation with revegetation and replenishment			Interim Protection or Retreat	Interim Protection or Retreat	
2. North Leighton	Beach monitoring and dune stabilisation		Beach monitoring and dune stabilisation		Interim Protection or Retreat	
3. Leighton Beach-Vlamingh Parkland	Beach monitoring and dune stabilisation		Beach monitoring and dune stabilisation		Interim Protection or Retreat	
4. Leighton Beach - Surf Club Precinct	Beach monitoring and dune stabilisation		Interim Protection or Retreat		Interim Protection or Retreat	
5. Leighton & Port Beach Dunes	Beach monitoring and dune stabilisation		Interim Protection or Retreat		Interim Protection or Retreat	
6. Port Beach North	1 Seawall and replenishment or 2. Dune stabilisation, revegetation & replenishment			Interim Protection or Retreat	Interim Protection or Retreat	
7. Port Beach South - Sandtrax	1. Seawall and replenishment or 2. Dune stabilisation, revegetation & replenishment			Interim Protection or Retreat	Interim Protection or Retreat	

The flexible adaptation pathway in the short and medium-term uses a combination interim protection and accommodation measures to maintain risks at a tolerable level. In the medium to long-term the decision should be made closer to the time of the trigger point, in line with the flexible, trigger-based adaptation approach. This will enable a decision based on the values at the time the trigger point is reached.

Further details on the interim protection measures are provided in the Adaptation Options Compendium in Appendix G and further details on the analysis and scoring of the adaptation measures is provided in the Adaptation Options Evaluation Report in Appendix H.

Interim protection, through engineered dune stablisation, is an appropriate adaptation action to manage short-term risk at Mosman Beach

5.3 Implementation of Interim Protection

State Planning Policy 2.6 State Coastal Planning Policy (SPP2.6) sets clear policy expectations for the use of coastal protection works. First and foremost, coastal protection works are to be considered only as all other options have been explored through a coastal hazard risk management process. This adaptation plan serves as that process for the short-term triggers within coastal management units 1, 6 and 7.

Prior to the construction of coastal engineering protection structures, there are several steps that should be undertaken to develop the basis of design and confirm that the proposed interim protection methods are the most suitable approach from a performance and financial viability perspective.

The following steps (as a minimum) are proposed:

1. Develop a data register and acquire long-term information on the Port, Leighton and Mosman Park Beaches including: erosion and accretion patterns, wave climate, water levels, sediment processes, bathymetric data and shoreline area surface levels.
2. Review the data register to identify gaps in information required to inform design works.
3. Undertake the required investigations to fill any gaps in the data. This may require installation of data recording devices, survey work and modelling.
4. Develop a basis of design with available information.
5. Develop several concept designs based on the preferred approach to be optimised to confirm the most suitable design.
6. Obtain environmental approvals for the preferred design.
7. Once a final design option has been selected, detailed design and documentation can then be prepared.

The earlier that steps 1 to 3 can be undertaken in advance of any construction works the better informed the design work will be. In addition to the above design elements, to be compliant with the SPP, the planning of coastal protection works will need to demonstrate adequate funding for construction and maintenance.

5.4 Ocean and Shoreline Monitoring

Management of the Port, Leighton and Mosman Beaches would benefit from an extension to the current annual monitoring being undertaken for Port Beach. A list of monitoring and data acquisition/analysis that would be beneficial for coastal management of Port, Leighton and Mosman Beach is summarized below.

- The Department of Transport and other state agencies currently undertake monitoring and data collection in Perth Coastal Waters. Long-term historic wave and water levels are publically available, as well as coastal surveys, vegetation line mapping, and ongoing scientific studies. Regular review of these data by the City of Fremantle and Town of Mosman Park is recommended to allow for trends that may be affecting the coastline to be identified and to ensure that the information required for the design of coastal structures is readily available.
- Installation of nearshore hydrodynamic instrumentation to collect wave and water level conditions at locations where interim protection is expected to be implemented will enable better calibration and validation of any modelling required.
- Photo monitoring should be undertaken biannually (winter/summer) and during/post significant storm events, in accordance with the methodology recommended by Department of Transport (DaSilva 2012). Visual comparison of site photos provides context for interpretation of the measured profile, vegetation line and bathymetric changes. Opportunities for citizen participation in science may be used to undertake photo monitoring.
- LIDAR survey and aerial photography of the coastline should be repeated on a regular basis (~5 to 10 years). When undertaken, it should be compared with previous datasets to identity coastal trends and interpret coastal management pressures.
- Local tidal stations should be established to record storm water level extremes and monthly mean sea level, to help interpret coastal management pressures, along with annual means (and exceedance levels). A local and global understanding of recorded sea level rise and future projections should also be maintained to inform future studies.

Working with and sharing relevant coastal data between the Town of Cottesloe, Town of Mosman Park and City of Fremantle would allow for resources to be pooled and trends across LGA boundaries to be identified within the secondary sediment cell.

5.5 Funding Coastal Adaptation

Funding will be a key issue for the implementation of adaptation planning. The responsibility for paying for coastal adaptation lies with the beneficiaries of those actions. This includes land and asset owners that benefit from protection strategies, and coastal users that benefit from coastal management approaches. Where public funds are used for coastal adaptation works, there should be a direct public benefit as a result of that investment. Ongoing cooperation between local and state government and key asset owners will be required to consider and address these funding issues and responsibilities.

Some options for managing and covering the costs of coastal adaptation options include:

- Funding through state government budgets
- Funding through local government budgets
- Funding through federal government budgets
- Special area rates within the coastal risk area
- Developer contributions plans to recoup costs where the need and obligation is clearly defined
- Metropolitan Region Improvement Fund (MRIF) for the coastal foreshore reserve
- Coastal Adaptation and Protection grants through the Department of Transport
- Coastal Management Plan Assistance Program through the Department of Planning
- Ceding of private land for the coastal foreshore reserve
- Inclusion of coastal management/protection levy within lease agreements within the coastal reserve

The appropriate funding option for coastal adaptation options will depend on the beneficiaries of the measures taken, and the values being protected. Direct beneficiaries should directly contribute to coastal management and adaptation costs. Indirect beneficiaries also contribute through public funding investment (contribution through rates and taxes into public funds). Table 5-3 presents the most likely direct and indirect beneficiaries of the short-term coastal measures proposed in this coastal adaptation plan.

Table 5-3 Beneficiaries of short-term adaptation measures in Port, Leighton and Mosman Beaches

CMU	Short-term adaptation measure	Short-term Direct Beneficiaries	Short-term Indirect Beneficiaries
1. Mosman Beach	Engineered dune stabilisation with revegetation and replenishment	Public users of Mosman Beach	Public infrastructure providers
2. North Leighton	Beach monitoring and dune stabilisation	Public users of North Leighton Beach	Public infrastructure providers
3. Leighton Beach- Vlamingh Parkland	Beach monitoring and dune stabilisation	Public users of Leighton Beach	Public infrastructure providers
4. Leighton Beach - Surf Club Precinct	Beach monitoring and dune stabilisation	Public users of Leighton Beach Fremantle Surf Life Saving Club Leighton Beach Kiosk Bib and Tucker	Private residents tenants and landowners at Leighton Beach Public infrastructure providers
5. Leighton & Port Beach Dunes	Beach monitoring and dune stabilisation	Public users of Leighton Beach	Public infrastructure providers Industrial landowners at Leighton Beach
6. Port Beach North	Seawall and replenishment or Dune stabilisation, revegetation & replenishment	Public users of Port Beach Coast Port Beach (Café/Restaurant) Fremantle Ports	Public infrastructure providers
7. Port Beach South - Sandtracks	Seawall and replenishment or Dune stabilisation, revegetation & replenishment	Public users of Port Beach Fremantle Ports	Public infrastructure providers Rous Head businesses

Funding options that seek to raise funds from immediate coastal landowners (such as special area rates for coastal areas and developer contributions plans) are suitable when coastal management works provide protection of privately owned landward assets. In the current planning horizon, coastal hazards do not generally influence private land. Consultation outcomes show that the users of Port, Leighton and Mosman Beaches do not only reside in the immediate coastal area. Therefore there is insufficient need and association to use special area rates or developer contributions in this area. It is recognised that coastal residents and developers indirectly benefit from a functioning coastal foreshore reserve in this location (based on retention of social and environmental values) therefore indirectly contribute to the cost of coastal management through contributing to public funds.

It is noted that any future development in this area should require ceding of additional foreshore reserve where necessary to meet the requirements of SPP2.6 (including the physical processes allowance plus additional land to meet social and environmental values). This is another way in which private developers in the area will contribute to long-term coastal adaptation in the area. If a suitable reserve is not provided during redevelopment planning, therefore requiring coastal management or interim protection works to maintain social coastal values in an insufficient reserve area, developer contributions may be appropriate.

In the short-term, the direct beneficiary for the majority of coastal adaptation works is the community, whom benefit from the retention of the values associated with the beaches and parks and recreation reserves. Fremantle Port receives direct benefit from protection of the port access road. Local businesses within the coastal foreshore reserve at Leighton and Port Beaches also benefit from proposed coastal adaptation works.

The wider public who enjoy the social and environmental values visit Port, Leighton and Mosman Beaches from a range of local and regional suburbs. Therefore regional rather than local public funding (aligned with the regional beneficiaries), through state and federal government funding options, are appropriate funding source to support coastal management and adaptation in the area.

Where local businesses and commercial development within the coastal foreshore reserve benefit from coastal management works to manage coastal hazards, it may be appropriate to include a coastal management levy into new leases and lease renewals. This provides an opportunity for commercial tenants to contribute directly to the necessary coastal management works to maintain their coastal assets.

6 Developing Strategic Planning Frameworks for Flexibility

6.1 Development and Planning Control in the Coastal Zone

Developing a strategic planning framework that will adequately respond to coastal vulnerability over time needs to consider how planning and development decisions are made in relation to the coast, and who makes them. This depends on who owns the land that the development is on and the policies and strategies that govern land use and development, as shown in Figure 6-1.

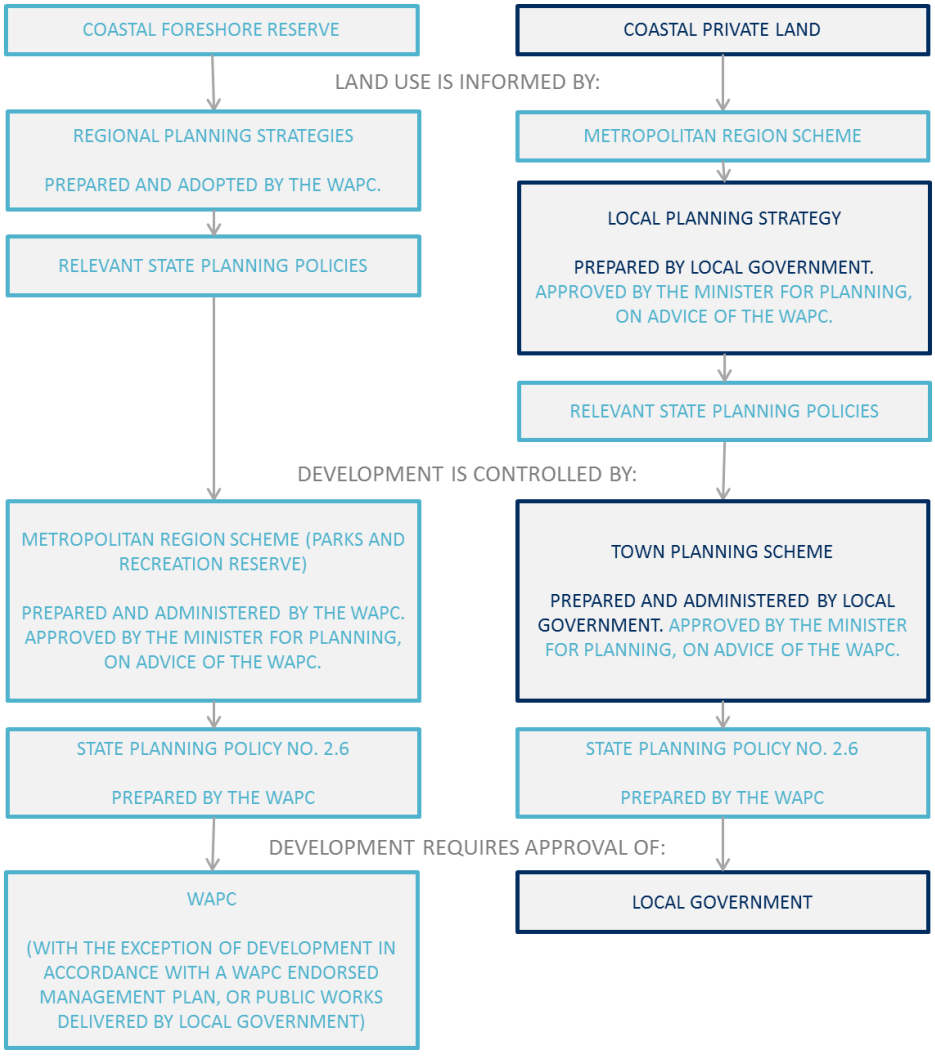


Figure 6-1 Overview of the statutory planning framework that applies to coastal development.

As shown in Figure 6-1, much of the planning authority in Western Australia is centralised at the state government level. Whilst the City of Fremantle and Town of Mosman Park are responsible for preparing their local planning schemes and strategies, these documents must be consistent with higher level state planning documents, and must be approved by the state government. Therefore, strategic decisions regarding land use change and coastal reserves are ultimately confirmed by the state government, and not the City of Fremantle or Town of Mosman Park.

The two types of schemes that control development (and therefore will be the mechanisms for land use change over time in response to coastal processes) are:

- The Metropolitan Region Scheme, developed and administered by the Western Australian Planning Commission (WAPC) and
- Local schemes, developed and administered by local government, and approved by the Minister for Planning.

The region scheme plans for regional infrastructure and reserves (including the coastal foreshore reserve). Local schemes plan for local infrastructure and reserves.

The Western Australian Planning Commission (WAPC) is responsible for much of the relevant planning and decision-making on coastal land. The WAPC is responsible for determining applications within the Parks and Recreation Reserve in the Metropolitan Region Scheme (which is the formal reservation of the coastal foreshore). Public works undertaken by local government within the coastal reserve do not require the approval of the WAPC, however all other development does. In addition, the WAPC makes recommendations to the Minister for Planning on the acceptability of land use change proposed by local government outside that coastal reserve through the approval of local planning strategies and schemes.

The City of Fremantle and Town of Mosman Park have responsibility for development on zoned land and therefore can use their planning system to influence development on private land near the coast. The City of Fremantle and Town of Mosman Park can also actively engage with the WAPC to encourage the state and regional planning framework to respond to long-term coastal vulnerability.

This section of the document provides an overview of the key state and local government planning documents which play an important role in coastal planning and how these documents can be used to respond to the changing nature of the coast. Changes to the planning framework are required to achieve two key adaptation outcomes:

1. Build resilience and flexibility into coastal planning frameworks to enable long-term retreat; and
2. Facilitate land use change to implement retreat when required

A broad summary of the existing planning documents in place in the study area is provided in Appendix F.

6.2 Planning recommendation 1

Review City of Fremantle Local Planning Strategy and Scheme to include investigation of appropriate planning responses and mechanisms for the Port and Leighton coastal areas

The City of Fremantle Local Planning Strategy was adopted in 2001. The City of Fremantle Town Planning Scheme No. 4 was gazetted in 2007. These planning documents are scheduled for review. The review of these documents should incorporate the requisite planning framework to adapt to coastal risks in the immediate (15-year) and longer (100-year) term.

Local planning strategies and schemes are developed by local government and approved by the WAPC/Minister for Planning. Therefore, local planning strategies and schemes represent a congruence of state, regional and local planning decisions, and are a very effective tool to deliver the land use elements of the CHRMAP. Local governments can also use policy in their local planning strategy as a means to lobby and call for changes and updates in the regional and state planning framework.

The purpose of local planning strategies is to set out the local government's objectives for future planning and development and includes a broad framework by which to pursue those objectives. The strategy is therefore the appropriate document to clearly enunciate the longer-term nature of the challenges arising from sea level rise and its associated effects on the coastline, and the City of Fremantle's response to those challenges. As the primary land use policy of the City, the local planning strategy is the key document within which to articulate policy positions and deliver the necessary (local) planning activities to prepare for, and later implement, retreat of land use from the vulnerable coastal area.

Inclusion of planning measures in the strategy will be the precursor to the introduction over time of statutory measures in the local planning scheme, which provides the statutory framework and local implementation measure for land use change on and near the coast.

Local planning strategies and schemes are required to be consistent with regional plans, strategies, and the Metropolitan Region Scheme, therefore it is important that the regional and state planning framework responds to local decisions regarding land use change on the coast (see earlier recommendations).

Planning action – incorporate a special control area for vulnerable coastal area

The local planning strategy review should incorporate a clear local coastal planning strategy in accordance with SPP 2.6. A key planning mechanism to deliver the local coastal planning strategy is a special control area applied to the vulnerable coastal area, which provides additional planning controls for a specific area.

In developing a special control area for the vulnerable coastal area, the following elements should be considered in the local planning strategy review:

- Determination of an appropriate special control area that encompasses land that would be both impacted and influenced by future land use change in response to coastal processes. This includes:
    - The physical processes allowance for a 100-year planning horizon in accordance with SPP 2.6 using best available information – this would include the coastal vulnerability mapping undertaken in this adaptation plan
    - Additional land that would fulfil functions of a coastal foreshore reserve (for a 100-year planning horizon), including social and environmental elements. These are defined in Section 8 of the State Coastal Planning Policy Guidelines
- A presumption that the special control area will expand landwards over time as sea levels rise
- Investigation of necessary development controls for the special control area, and the timing or trigger points for inclusion of those controls in the scheme. This would include consideration of:
    - Notifications on title for properties within the special control area which are reviewed and updated over time
    - Policy provisions requiring all new development and redevelopment within the special control area to be setback behind the physical processes allowance, which would facilitate incremental and opportunistic relocation (retreat) of private development over time

The local planning strategy should clearly identify at what point the scheme should incorporate controls on development or redevelopment in vulnerable areas.

The local planning scheme, informed by the strategy, should incorporate the special control area to advise land owners and planners that the area is in a vulnerable coastal area for the long-term (100 year) planning horizon. The extent of development controls included should reflect whether or not intolerable risk will be experienced in the short-term (15-year). Currently, intolerable risk does not affect private land therefore development controls may not be necessary. In future, as risk becomes intolerable, then controls should be introduced.

The local planning strategy will be a key consultation and communication tool that will engage the community in decision-making, and communicate triggers and timeframes for additional controls of coastal land use to manage coastal risks.

Planning action – develop local policy to manage coastal settlement planning

The local planning strategy should provide clear expectations to manage development in the coastal area, and avoid proliferation of high value development in the vulnerable coastal zone which would considerably increase the cost of future retreat to the community.

Whilst SPP 2.6 requires that infill development consider the adaptation planning hierarchy, some infill development may not be subject to the same requirement for the physical processes allowance and ceding of foreshore reserves as new development and settlements, particularly where it is not contiguous with the current foreshore reserve. The local planning strategy review should consider the long-term implications of this, and investigate policy measures to provide a consistent approach to new and infill development.

In particular, the local planning strategy review should investigate:

- Introduction of policy measures that require infill development and proposals to increase density to be assessed against SPP2.6 as if it were new development.
- Policy expectation that all new development in the area provides/cedes sufficient coastal foreshore, considering the physical processes allowance and additional area as required to fulfil all functions identified within the State Coastal Planning Policy Guidelines.
- Planning for infrastructure provision in a way that avoids placing future infrastructure within or immediately adjacent to the physical processes allowance, and avoids permanent linear servicing infrastructure (including roads) parallel to the coast, therefore potentially becoming a threatened asset in longer-term planning horizons.

The settlement recommendations identified in the local planning strategy review should be incorporated into the local planning scheme at the appropriate time.

Planning action – use the local planning strategy as a tool to lobby the WAPC to expand the Coastal Foreshore Reserve to support long-term retreat from coastal land

The current CHRMAP for Port, Leighton and Mosman Beaches does not recommend retreat of land use and development from immediate short-term risk areas at Mosman and Port Beaches. However, medium term and longer term risks may trigger a decision for retreat; setting up the key retreat planning responses can assist in preparing for these decisions, and manage the long-term cost of retreat.

A primary planning response to enable retreat from the vulnerable coastal area is through expansion of the coastal foreshore reserve. The current foreshore reserve in Port Beach and areas of Leighton Beach is insufficient in width to maintain the social and environmental functions of the reserve once physical processes have been allowed for. Retreat cannot occur in the locality without impacting on land use outside the current foreshore reserve.

The coastal foreshore reserve is a formal reserve under the MRS, therefore the expansion of the reserve cannot be implemented by the City of Fremantle. However, the local planning strategy can assist the City to direct the WAPC to expand the reserve by undertaking a review of the coastal foreshore reserve in accordance with Section 8 of the State Coastal Planning Policy Guidelines. This would confirm the physical processes allowance plus the additional reserve area necessary to continue to provide for the social and environmental functions of the Port and Leighton foreshore reserves. The local planning strategy should identify the preferred foreshore reserve, and instruct/lobby the WAPC to amend the MRS to achieve it.

Sufficient coastal foreshore reserve is necessary to support social functions, in addition to protecting private land from coastal processes

The expansion of the coastal foreshore reserve will be required when a decision to retreat is made; reservation is not essential (although in some cases may be beneficial) prior to that trigger/decision.

Reservation of private land does not preclude the ongoing use of that land for private purposes and existing approved land use (through non-conforming use rights). However, it does enable the WAPC to control and restrict future land use to ensure that any future development proposals do not impede on the future use of the land for a coastal foreshore reserve. Compensation for injurious affection of land values as a result of reservation is payable at the time a development application for use or development is refused on the basis of the reservation, or when the land is first sold following reservation. Over time, to implement retreat, reserved land would be acquired using public funds.

6.3 Planning recommendation 2

Review Town of Mosman Park Local Planning Strategy to recommend appropriate regional planning responses for the Mosman Beach coastal area

The Town of Mosman Park Local Planning Strategy has been prepared as part of the review of Town Planning Scheme No. 2. The strategy was prepared within the last five years, therefore is not due for review, however will be in the next few years. As part of the review, consideration should be given to the short, medium and long-term strategies for coastal planning.

Planning action – use the local planning strategy as a tool to lobby the WAPC for greater resilience in the regional planning framework that applies to the area.

The entirety of the Mosman Beach locality within the Town of Mosman Park is reserved land under the MRS. This predominantly includes the parks and recreation reserve, with other regional reserves applied for the public railway, primary regional roads, water infrastructure, and special uses. The local planning strategy, therefore, will not have any jurisdiction to consider local planning mechanisms in relation to coastal land. It should, however, recommend necessary changes to the regional planning framework – as described in subsequent sections – as a tool to lobby the WAPC to build resilience into coastal planning in the locality.

6.4 Planning recommendation 3

Prepare new foreshore management plans to provide additional guidance regarding adaptation planning for Port, Leighton and Mosman Beaches for endorsement by WAPC

The City of Fremantle and Town of Mosman Park both have management plans for coastal foreshore areas:

- City of Fremantle Port and Leighton Beaches Management Plan (October 2001)
- Town of Mosman Park Mosman Beach Management Plan

Management plans are formal planning documents prepared for areas of parks and recreation reserve under the MRS. These plans provide additional land use controls regarding appropriate development within the reserve, and also provide a tool to prioritise management activities.

The foreshore management plans will be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities.

Foreshore management plans provide important guidance and control of development within the reserve

Planning action – develop foreshore management plans that include comprehensive policy guidance for temporary development and land use within the coastal foreshore reserve

Updated management plans should include:

- Identification, prioritisation, and funding of natural coastal and dune management techniques to enhance the ability of the natural system to buffer coastal processes;
- Consideration of sea level rise and coastal risk, defining any relevant trigger points for the reserve and whether there is a need for the relocation or decommissioning of existing assets as required;
- Identification of appropriate, impermanent community facilities to meet demand for coastal infrastructure in the short-term;
- Development of new policy requirements for development in the reserve, including:
    - Design life for assets to reflect risk timeframes
    - Architectural and construction requirements for development to portray a temporary aesthetic – communicating to the community the impermanent nature of facilities
- Coastal interim protection works required in the short-term planning horizon, where recommended by this adaptation plan, including:
    - a plan detailing the location of protective structures
    - estimated costs, maintenance responsibility, and impacts on the reserve and
    - consideration of the requirements of SPP 2.6, in particular clause 5.7 regarding coastal protection works
- A long-term plan for the relocation of impermanent structures
- Recommended lease conditions for private use and development that:
    - Define lease duration in relation to risk levels and likely timeframe of triggers
    - Clarify that lease renewals will be contingent on adaptation decisions at future triggers
    - Require decommissioning of private assets at the expiry of a lease

Planning action – liaise with the WAPC to attain endorsement of foreshore management plans

Under clause 16 of the MRS, there is the ability to prepare a management plan for the parks and recreation reserve, that, if endorsed by the WAPC, may enable certain development to be undertaken without the need for development approval. Neither of the existing management plans are endorsed by WAPC, therefore there is opportunity to review the plans to respond to this adaptation plan and obtain WAPC endorsement. This would facilitate the development of the recommended interim protection option without the need for development approval, if located within the parks and recreation reserve. This option will be most applicable for the dune stabilisation revegetation and replenishment option for Mosman Beach (CMU1) and seawalls and replenishment for the Port Beach North (CMU6) and Port Beach South – Sandtrax (CMU7).

Foreshore management plans should be reviewed on a five year cycle and updated to reflect changing values and adaptation options in line with future iterations of the adaptation plan.

Beach access point

6.5 Planning Recommendation 4

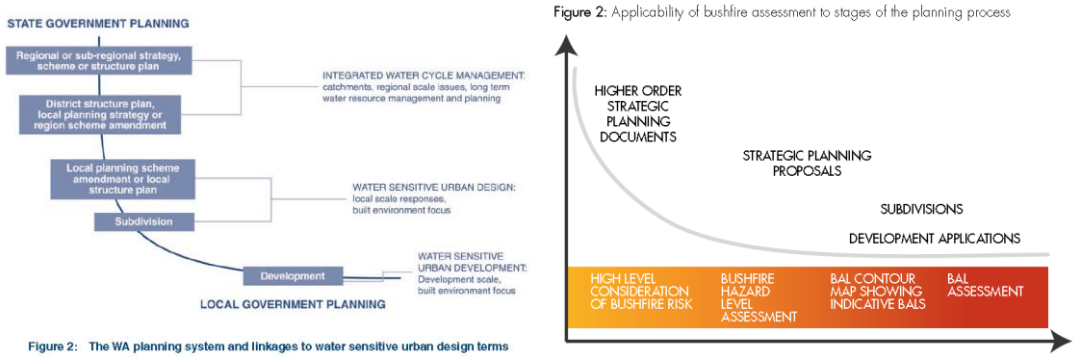
Review the State Coastal Planning Policy Guidelines to align adaptation recommendations with planning processes and decisions

The preceding recommendations for local planning responses would be more effective if delivered across the entire metropolitan region to provide a consistent approach to integration of coastal adaptation and risk management into local planning decisions.

SPP2.6 provides a range of policy measures that require planning authorities to consider the long-term nature of coastal processes into decision-making, and sets a framework for coastal adaptation and risk management to inform decision-making. The State Coastal Planning Policy Guidelines (the guidelines) provide explanation on how the principles should be delivered by planning authorities and in planning decisions. However, the guidelines could provide a clearer framework to assist local governments do this within their local planning frameworks.

Section 4.4 (Adaptation) of the State Coastal Planning Policy Guidelines provides a list of planning responses that can be considered for each of the overarching adaptation options – avoid, planned or managed retreat, accommodate and protect. However, how these can be achieved in different planning decisions (local planning strategies, schemes, policies, local structure plans, subdivisions, and development applications) is not well articulated.

The guidelines would strongly benefit from a review that tailors/applies the current Section 4.4 to specific planning stages. Other state planning policy guidelines – such as SPP 2.9 Water Resources and SPP 3.7 Planning in Bushfire Prone Areas – provide clear expectations and guidance for how local government can demonstrate integration of water management/bushfire risk as appropriate to the planning decision being made.



Planning guidelines that support the state water management (left) and bushfire (right) planning policies provide tailored frameworks to integrate water management/bushfire risk into specific planning proposals.

A similar framework for coastal planning would give local planners greater guidance on how they can build flexibility and resilience into local planning frameworks. For example, the guidelines might articulate the key planning stages, and list the avoid, retreat, and accommodate strategies most relevant to each. This would set a clear expectation of what the WAPC expects local governments to consider at each stage of the planning process.

Additional examples of guidance (existing policy gaps) that could be considered in a review include:

- Definition of “coastally dependent and easily relocatable development”, to manage pressure for high value assets and long-term land uses (such as commercial developments and hotels) within the vulnerable coastal area
- Guidance for how to apply coastal hazard risk management and adaptation to infill and existing development – such as a recommendation for local planning strategies to review the existing foreshore reserve and avoid density increases in coastal areas with an insufficient foreshore reserve
- Planning and spatial criteria for coastal nodes, to ensure future coastal nodes are located with a discrete planning purpose and avoid unnecessary proliferation of coastal nodes
- Policy principles to avoid high construction value of coastal dependant and temporary development (such as surf clubs) which creates community expectation of permanence in the coastal vulnerable area
- Consideration of the need for development contributions to support decommissioning or longer-term interim protection costs. Whilst SPP2.6 includes a reference to state policy regarding developer contributions, it does not clearly articulate a policy expectation that, where private development will require or benefit from coastal management or interim protection works, developer contributions are appropriate and should be sought to manage these costs in the future.
- Consideration of impermanent land tenure (such as release of leasehold land) for coastal development (in particular residential development associated with coastal nodes or marinas on urban zoned land) to avoid future need for acquisition or compensation of private land where required for retreat

Such policy guidance will help future communities – beyond the current long-term planning horizon – retain flexibility in the adaptation pathways available for coastal settlements, and do not bear unreasonable costs of protection, land acquisition or decommissioning.

Planning action – City of Fremantle and Town of Mosman Park should liaise with the WAPC to request review of the State Coastal Planning Guidelines

A review of the guidelines requires action by the Department of Planning, Lands and Heritage. The City of Fremantle and Town of Mosman Park should lobby the state government, including relevant senior staff and Ministers, to undertake this review.

It is noted that the Department of Planning, Lands and Heritage is currently preparing planning guidelines for retreat decisions. This will be a welcome form of guidance for local governments to assist in delivering retreat at the time of retreat triggers/decisions.

6.6 Planning Recommendation 5

Review regional planning strategies to build flexibility into the regional planning framework and facilitate long-term managed retreat

Perth and Peel at 3.5 Million – Central Sub-regional Strategy (draft) is the current strategic planning document prepared by the Western Australian Planning Commission (WAPC) to guide the future planning for Perth and the Peel region with a population of 3.5 million. The strategy makes recommendations on the spatial distribution of land uses and provides the broad mechanisms for managing growth.

Draft Perth and Peel at 3.5 Million acknowledges Perth's enviable coastline however there is an opportunity for the strategy to provide greater guidance on the suggested mechanisms for how we can continue to manage risks associated with coastal processes. Through appropriate planning mechanisms there is an opportunity to further maintain our 'enviable coastline' for future enjoyment.

Regional plans identify future urban and industrial development areas, strategic infill areas, and regional infrastructure locations. These plans form the strategic basis for the Metropolitan Region Scheme (MRS), which zones and reserves land for development and public purposes. These planning documents identify reserves and locations for key public infrastructure. Key infrastructure within the Port, Leighton and Mosman Beaches locality planned for in regional planning documents includes:

- Fremantle Port
- Fremantle passenger rail line
- Stirling Highway
- Curtin Avenue (including a road reserve adjacent to the railway reserve, providing for future realignment)
- Public reserves for water infrastructure
- Port, Leighton and Mosman Coastal Foreshore Reserve.

Future iterations of Perth and Peel @ 3.5 million should consider infrastructure, reservations and zoned land in the coastal vulnerable area, and include strategic planning projects to identify new locations and reservations for infrastructure outside areas of coastal risk, building in long-term resilience to regional planning. For example, the current primary regional road reservation that provides for realignment of Curtain Avenue away from the coast (and areas of risk) should be retained in all future plans and the MRS. Whilst relocation of assets may not be required in the immediate term, planning for future relocation of strategic infrastructure is essential to enable retreat at future triggers/decisions.

Planning action – City of Fremantle and Town of Mosman Park should liaise with the WAPC to review regional plans and strategies

The WAPC should review regional planning documents including strategic land use and infrastructure plans to provide the necessary land use framework to support the flexible adaptation pathway.

The City of Fremantle and Town of Mosman Park should lobby the state government, including relevant senior staff and Ministers, to include coastal hazard risk management and adaptation into regional plans. When drafts are advertised, local governments should provide written submissions that comment on the appropriateness of the regional plans in relation to coastal hazard risk management and adaptation.

6.7 Planning Recommendation 6

Update and amend the Metropolitan Region Scheme to deliver retreat strategies where required by local decision CHRMAPs

The MRS is the overarching statutory planning framework for land uses within the Perth metropolitan area. The MRS identifies areas of reserved and zoned land and provides the framework for how the land is to be used.

In the short-term, the adaptation options for seawalls and replenishment do not require amendments to the MRS in order to be implemented as they can occur within the existing parks and recreation reserve. Offshore breakwaters are likely to be developed in the MRS waterways reserve. A development application may be required or consideration could be given to amending the MRS to extend the land area into the ocean to capture those sites identified for offshore breakwaters.

Consideration could also be given to the inclusion of a special control area (SCA) in the MRS in the short to medium-term. Whilst this mechanism is currently unavailable in the MRS, an amendment could be undertaken to enable this. The SCA would be used to identify areas of coastal vulnerability and alert land owners of the longer term impacts on their land. In the shorter term, the SCA could be high level and provide objectives for

planning decisions. In the long-term, the MRS could be amended to include development provisions and agency referral requirements to manage increasing risks.

The MRS will require amendments to be consistent with future iterations of regional plans and strategies, and to support local decisions to retreat. The MRS will be the key land use mechanism in the implementation of retreat. It is not possible for the City of Fremantle or Town of Mosman Park to implement managed retreat, as they are not responsible for application or expansion of the parks and recreation reserve. Longer term amendments to the MRS to facilitate long-term retreat decisions may include:

- Expansion of the parks and recreation (coastal foreshore) as the risks move landwards;
- Relocation of major infrastructure resulting in new locations for public purpose reserves (as required by servicing agencies); and
- Relocation of major road and rail reservations (as required by transport agencies).

Planning action – City of Fremantle and Town of Mosman Park should request changes to the MRS where needed to support adaptation decisions and deliver retreat strategies

The City of Fremantle and Town of Mosman Park should request state government to review the MRS in response to local requirements for infrastructure reserves and expansion of the coastal foreshore reserve.

6.8 Planning recommendation 7

Develop and deliver a community awareness campaign regarding coastal risks and impacts, and the adaptation plan.

Our community places a great deal of value on the coastal foreshore and environment, and many community members have high expectations for quality assets and experiences in the foreshore reserve. Facilities and development within the vulnerable coastal area are not permanent. The adaptation plan recognises that the coastal environment will change considerably into the future, just as the area of the coastal vulnerable area will change over time. It is important to engage the community in regards to the dynamic nature of the coast and manage expectations for future coastal development and use.

A key component of ongoing coastal adaptation planning is to consider and test the core values of the community in relation to the coast, and the implications of the impacts of sea level rise. The trigger-based adaptation pathway articulates the need to do this frequently as trigger points are reached, to ensure the right decision is made. Over time, as sea level rise occurs and we see changes in the Western Australian coast, it is likely that the community's values and how the community prioritises different values will change. Ongoing community engagement is important to inform future decision-making.

A longer term awareness drive and community dialogue – engaging with media – would be a beneficial way in which to engage the community and engage them in testing values over time. Greater levels of awareness will bring together broader views on the issue, and enable a more informed discourse of the, often competing, values of the coast and coastal land. Alongside general awareness of coastal planning and values, it will be important to inform the community of the coastal adaptation plan and its recommendations.

Planning action – City of Fremantle and Town of Mosman Park should continue to engage with the community on coastal hazard risk management and adaptation

It is recommended that the City of Fremantle and Town of Mosman Park continue with awareness raising via a number of methods, including specific information on the website, fact sheets and through an ongoing interaction with the broader community. Incorporation of community education and awareness into future projects, such as foreshore management plan reviews, and coastal projects – such as interpretive signage – provides an excellent opportunity to continue the conversation with the community that this project has started. The ongoing engagement strategy needs to be a process of regular and repeated opportunities to inform and engage with the community so that the values of the community can be properly assessed. This will be important for long-term decision-making, which will need to test the values of the community in relation to the coast at each decision-making point.

Signage is one component of ongoing community engagement about coastal processes and adaptation

7 Implementation Plan

A trigger based flexible adaptation pathway is recommended to manage coastal risk to tolerable levels within Port, Leighton and Mosman Beaches. This pathway is shown in Table 7-1 below.

Table 7-1 Flexible adaptation pathway for Port, Leighton and Mosman Beaches

CMU	Short		Medium		Long	
	Present	2030	2050	2070	2090	2110
1. Mosman Beach	Engineered dune stabilisation with revegetation and replenishment			Interim Protection or Retreat	Interim Protection or Retreat	
2. North Leighton	Beach monitoring and dune stabilisation		Beach monitoring and dune stabilisation		Interim Protection or Retreat	
3. Leighton Beach-Vlamingh Parkland	Beach monitoring and dune stabilisation		Beach monitoring and dune stabilisation		Interim Protection or Retreat	
4. Leighton Beach - Surf Club Precinct	Beach monitoring and dune stabilisation		Interim Protection or Retreat		Interim Protection or Retreat	
5. Leighton & Port Beach Dunes	Beach monitoring and dune stabilisation		Interim Protection or Retreat		Interim Protection or Retreat	
6. Port Beach North	1 Seawall and replenishment or 2. Dune stabilisation, revegetation & replenishment			Interim Protection or Retreat	Interim Protection or Retreat	
7. Port Beach South - Sandtrax	1. Seawall and replenishment or 2. Dune stabilisation, revegetation & replenishment			Interim Protection or Retreat	Interim Protection or Retreat	

To deliver the trigger based pathway, a range of specific implementation actions will be required over time, in relation to the two strategic areas of adaptation actions:

1. Implement appropriate adaptation actions in response to triggers

2. Develop strategic planning frameworks for flexibility in the medium and long-term.

Table 7-7 provides a consolidated list of all recommendations and required actions from across this adaptation plan to achieve these strategic recommendations.

The adaptation plan identifies focus areas/actions for implementation by state government, particularly in relation to policy, expansion of the foreshore reserve (where necessary in the longer term), and major infrastructure. This plan does not bind state government or other stakeholders to the actions, however recognises that long-term adaptation requires the support of these key stakeholders. The City of Fremantle, alongside the Town of Mosman Park, will work closely with the state government and other key stakeholders to deliver the actions necessary to achieve adaptation principles.

7.1 Implementation Costs

7.1.1 General

The following sections provide a summary of the interim protection measures and their order of magnitude cost/budget estimates. The estimates include capital, maintenance and decommissioning costs. Decommissioning costs will be applicable if in the long-term a retreat strategy is selected. The decommissioning costs would be incurred at the end of the medium-term planning period.

The budget estimates provided in this section are indicative only. The estimates are based on average typical cross sections and do not consider specific physical conditions of each site. As a result, further investigation could show that costs vary significantly from values shown in this section. These estimates were initially prepared for reference in the multi criteria decision making process and are not produced specifically for this implementation plan and budgeting purposes.

7.1.2 Coastal Management Unit 1- Mosman Beach

Table 7-2 provides a summary of the likely costs for the preferred adaptation options for Mosman Beach in the short and medium-terms.

Table 7-2 Summary of interim protection measures and order of magnitude budget estimate for Mosman Beach

	Description	Capital Costs ($M)	Maintenance Costs ($M)	Decommissioning Costs ($M)
Short term (to 2030)	Construction of engineered dune stabilisation to 450m of weathered Tamala limestone dune foundations, dune revegetation and replenishment to 620m of foreshore, beach monitoring.	3.7	0.5	
Medium term (2031 to 2070)	Ongoing maintenance replenishment, engineered stabilisation maintenance and beach monitoring.	n/a	1.1	0.4

7.1.3 Coastal Management Unit 6- Port Beach North

Table 7-3 provides a summary of the likely costs for the preferred adaptation options for Port Beach North in the short and medium-terms.

Table 7-3 Summary of interim protection measures and order of magnitude budget estimate for Port Beach North

	Description	Capital Costs ($M)	Maintenance Costs ($M)	Decommissioning Costs ($M)
Short term (to 2030)	Construction of a seawall and beach replenishment to 380m of foreshore. Ongoing maintenance and beach monitoring.	5.8	1.3	
Medium term (2031 to 2070)	Ongoing seawall and replenishment maintenance and beach monitoring.	n/a	3.0	0.6

7.1.4 Coastal Management Unit 7- Port Beach South – Sandtrax

Table 7-4 provides a summary of the likely costs for the preferred adaptation options for Port Beach South in the short and medium-terms.

Table 7-4 Summary of interim protection measures and order of magnitude budget estimate for Port Beach South

	Description	Capital Costs ($M)	Maintenance Costs ($M)	Decommissioning Costs ($M)
Short and medium-term, to 2050	Maintain 240m of buried seawall, construction of 280m seawall, beach replenishment to maintain beach area to 520m of foreshore. Ongoing maintenance and beach monitoring	4.5	4.3	
Medium-term (2050 to 2070)	Upgrade or reconstruction of 240m, maintenance to 280m seawall, beach replenishment to maintain beach area to 520m of foreshore and beach monitoring.	2.0	1.7	0.8

7.1.5 Accommodate Costs

Likely costing for implementation and maintenance of accommodation measures to be implemented to the remainder of the coast, between coastal management unit 2 - North Leighton to coastal management unit 5 - Leighton and Port Beach Dunes have are summarised below in Table 7-5.

Table 7-5 Summary of accommodation short and medium-term order of magnitude budget estimate.

	Description	Capital Costs ($M)	Maintenance Costs ($M)
Short term (to 2030)	Dune revegetation, maintenance beach replenishment and beach monitoring to 1.5km of coast.	2.0	0.6

Medium term (2031 to 2070)	Dune revegetation maintenance, maintenance beach replenishment and beach monitoring to 1.5km of coast.	n/a	1.3

7.1.6 Total Costs

The summary of the order of magnitude for the entire planning period and for each coastal management unit is shown in Table 7-6.

Table 7-6 Estimated total order of magnitude budget estimate to 2070 per CMU.

Coastal Management Unit	Adaptation Option	Whole of Life Estimated Discounted Cash Flow Budget Estimate to 2070 ($M)
1.0 Mosman Beach	Engineered Cliff Stabilisation & Revegetation	
	- capital costs	3.7
	- operating costs	1.6
	- decommissioning costs	0.4
	Total costs	**5.7**
2.0 North Leighton /Vlamingh	Dune Stabilisation + Revegetation	
	- capital costs	0.7
	- operating costs	0.6
	- decommissioning costs	0.0
	Total costs	**1.3**
3.0 Leighton - Vlamingh Parkland	Dune Stabilisation + Revegetation	
	- capital costs	0.4
	- operating costs	0.4
	- decommissioning costs	0.0
	Total costs	**0.8**

4.0 Leighton - Surf Club Precinct	Dune Stabilisation + Revegetation	
	- capital costs	0.4
	- operating costs	0.5
	- decommissioning costs	0.0
	Total costs	**0.9**
5.0 Leighton/ Port Parkland	Dune Stabilisation + Revegetation	
	- capital costs	0.6
	- operating costs	0.5
	- decommissioning costs	0.0
	Total costs	**1.1**
6.0 Port Beach North	Hard Passive Protection and Replenishment	
	- capital costs	5.8
	- operating costs	4.3
	- decommissioning costs	0.6
	Total costs	**10.7**
7.0 Port Beach South - Sandtrax	Hard Passive Protection and Replenishment	
	- capital costs	6.5
	- operating costs	6.0
	- decommissioning costs	0.8
	Total costs	**13.3**
Total Costs	**Mosman Park Total**	**5.7**
	City of Fremantle Total	**28.1**
	Grand Total	**33.8**

Table 7-7 Implementation Plan

Action	Timing	Responsible Agency	Supporting Stakeholders
Implement appropriate adaptation actions in response to triggers			
Monitor risk levels to land and infrastructure	Immediately after events	Town of Mosman Park, City of Fremantle	
Undertake geotechnical investigations (geophysical survey) to understand extents of Tamala Limestone across Mosman to Leighton Beach (CMU 1 to CMU 5).	Immediate	Town of Mosman Park, City of Fremantle	
Undertake annual beach monitoring of Port, Leighton and Mosman Beach	Ongoing	Town of Mosman Park, City of Fremantle	Fremantle Ports
Undertake engineering feasibility studies for short-term interim protection at Mosman Beach (CMU 1) and Port Beach North and South (CMU 6 and 7)	Immediate	Town of Mosman Park, City of Fremantle	Department of Transport (information, data and technical advice)
Provide information to land owners in vulnerable areas regarding increasing coastal risk	Immediate	Town of Mosman Park, City of Fremantle	
Undertake responsive beach replenishment at Port and Mosman Beaches.	As required	Town of Mosman Park, City of Fremantle	
Undertake a regular program of dune management and revegetation for Mosman and Leighton Beach (CMU 1 to CMU 5)	Immediate	Town of Mosman Park, City of Fremantle	

Action	Timing	Responsible Agency	Supporting Stakeholders
City of Fremantle and Town of Mosman Park should identify and apply for funding for coastal adaptation, based on the beneficiaries of adaptation actions	As needed basis	Town of Mosman Park, City of Fremantle	Department of Planning Department of Transport (Coastal Adaptation and Protection grants scheme) Fremantle Ports
Develop strategic planning frameworks for flexibility in the medium and long-term			
Review City of Fremantle Local Planning Strategy and Scheme to include investigation of appropriate planning responses and mechanisms for the Port and Leighton coastal areas Specific planning actions: • incorporate a special control area for vulnerable coastal area • include local policy to manage coastal settlement planning • use the local planning strategy as a tool to lobby the WAPC to expand the coastal foreshore reserve to support long-term retreat from coastal land	During next scheduled review of the Local Planning Strategy and Local Planning Scheme	City of Fremantle	Department of Planning Western Australian Planning Commission Land owners and managers
Review the Town of Mosman Park Local Planning Strategy to recommend appropriate regional planning responses for the Mosman Beach coastal area Specific planning action: • use the local planning strategy as a tool to lobby the WAPC for greater resilience in the regional planning framework that applies to the area.	During next scheduled review of the Local Planning Strategy and Local Planning Scheme	Town of Mosman Park	Department of Planning Western Australian Planning Commission

Action	Timing	Responsible Agency	Supporting Stakeholders
Prepare new foreshore management plans to provide additional guidance regarding adaptation planning for Port, Leighton and Mosman Beaches for endorsement by WAPC Specific planning action: • develop foreshore management plans that include comprehensive policy guidance for temporary development and land use within the coastal foreshore reserve • liaise with the WAPC to attain endorsement of foreshore management plans	As soon as possible	Town of Mosman Park City of Fremantle	Department of Planning Western Australian Planning Commission
Review the State Coastal Planning Policy Guidelines to align adaptation recommendations with planning processes and decisions Specific local planning action: • City of Fremantle and Town of Mosman Park should liaise with the WAPC to request review of the State Coastal Planning Guidelines	Immediate	Department of Planning Western Australian Planning Commission	Town of Mosman Park City of Fremantle
Review regional planning strategies to build flexibility into the regional planning framework and facilitate long-term managed retreat Specific local planning action: • City of Fremantle and Town of Mosman Park should liaise with the WAPC to review regional plans and strategies	During next scheduled review	Department of Planning Western Australian Planning Commission	Town of Mosman Park City of Fremantle

Action	Timing	Responsible Agency	Supporting Stakeholders
Update and amend the Metropolitan Region Scheme to deliver retreat strategies where required by local decision CHRMAPs Specific local planning action: • City of Fremantle and Town of Mosman Park should request changes to the MRS where needed to support adaptation decisions and deliver retreat strategies	As required	Department of Planning Western Australian Planning Commission	Town of Mosman Park City of Fremantle
Develop and deliver a community awareness campaign regarding coastal risks and impacts, and the adaptation plan.	Immediate	Town of Mosman Park City of Fremantle	Department of Planning Western Australian Planning Commission
CHRMAP Review			
Review the CHRMAP alongside reviews of strategic plans and local planning strategies.	Next scheduled review	Town of Mosman Park City of Fremantle	Department of Planning Department of Transport (information, data and technical advice) Fremantle Ports
Review erosion and inundation hazard assessment following the release of the next IPCC assessment report which is expected in 2020/21.	Issue of the next IPCC assessment report.	Town of Mosman Park City of Fremantle	Department of Planning Department of Transport (information, data and technical advice)

8 Review Framework

8.1 Adaptation Plan Review

This plan should be reviewed regularly, alongside the ten-yearly review of the City of Fremantle and Town of Mosman Park strategic plans and/or five-yearly reviews of local planning strategies.

Review processes should include targeted community and industry consultation to update values and views about coastal development and assets that will be at risk both within a 15-year planning horizon and beyond. Revised values and new learnings should be used to test recommendations of this adaptation plan, and determine whether adaptation strategies for the 15-year planning horizon require modification as a result of changing values.

The regular testing of values and adaptation measures will involve the following actions incorporated into the review of future strategic plans, for land and assets identified as being at risk within 15-years of the strategic plan review:

- Identification of any new or alternative adaptation options based on greater information and new technology;
- Review of criteria used in the multi-criteria assessment;
- Community, stakeholder and industry consultation on the weighting of criteria;
- Review of the weighted scoring of adaptation options;
- Confirmation of adaptation options for a 15-year planning horizon.

8.2 Future Hazard Assessment

It will be necessary to update the hazard mapping from time to time to reflect actual sea level rise, updated projections of future sea level rise and the response of the coast to changing conditions. These updates should occur as new information becomes available.

It is recommended that the erosion and inundation hazard assessment is updated following the release of the next IPCC assessment report which is expected in 2020/21.

9 References

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Limitations

This report: has been prepared by GHD for the City of Fremantle and may only be used and relied on by City of Fremantle for the purpose agreed between GHD and the City of Fremantle.

GHD otherwise disclaims responsibility to any person other than City of Fremantle arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report . GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by the City of Fremantle and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The purpose of estimating the coastal hazards of erosion and inundation in this study is to assess the risks to coastal assets and values to assist in the analysis of coastal adaptation solutions and is not to be used for the purpose of determining coastal setback distances for new development.

Climate change is a significant current and future issue and effects, such as sea level rise, are at this stage difficult to quantify to a high degree of certainty. The following assumptions have been made during the preparation of this report:

- *The sole purpose of the reports are for evaluating coastal hazard risks and developing adaptation plans associated with coastal hazards and sea level rise for the City of Fremantle and Town of Mosman Park.*
- *The reports are produced for use by the City of Fremantle and Town of Mosman Park, and are not for use by any third party person or organisation. The information and recommendations are to be read and considered holistically, and content is not to be used selectively for purposes other than coastal hazard risk management (e.g. design) as this may misrepresent the data and processes herein and provide erroneous project or decision outcomes.*
- *The data and processes herein are to be used for coastal hazard risk assessment and adaptation planning purposes, approved by the City of Fremantle and Town of Mosman Park, and based on Australian and state government guidelines:*
    - *Western Australian Planning Commission and Department of Planning (2014). Coastal hazard risk management and adaptation planning guidelines, Perth, Australia.*
    - *Western Australian Planning Commission (2013). State Planning Policy No. 2.6 State Coastal Planning Policy.*
    - *Western Australian Planning Commission (2013), State Coastal Planning Policy Guidelines.*

  These guidelines have been considered as per the requirements of the brief. This information has not been independently verified. Assumptions and recommendations that need further testing are noted in the text of the report.
- *The establishment of the sea level rise aspects of the project uses data and scenarios based on publicly available information by the International Panel on Climate Change, summarised by the Western Australian Department of Transport:*
    - *Bicknell (2010). Sea Level Change in Western Australia: Application to Coastal Planning, prepared by the Department of Transport, Fremantle, WA.*
- *Climate change and coastal hazard assessment by its nature is a dynamic and ongoing process. As the sea level rise projections used are uncertain by nature, it is possible that the effects that actually occur may not be as assumed and stated in this exercise. Therefore, it is recommended that City of Fremantle and Town of Mosman Park routinely incorporate the latest climate change science and sea level rise cause and effect knowledge into all future planning.*

GHD has prepared the indicative order of magnitude costs set out in sections 7.1 of this report using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD based on capital and maintenance costs of similar foreshore stabilisation projects in Western Australia.

The Cost Estimate has been prepared for the purpose of comparing the feasibility of the different adaptation options in the Multi Criteria Decision Analysis and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

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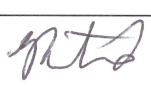
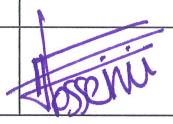
0	Colleen Thompson	Gemma Bertrand		Shahab Hosseini		25.10.2017