Town of East Fremantle

Coastal Hazard Risk Management and Adaptation Plan (CHRMAP)

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Town of East Fremantle

Coastal Hazard Risk Management and Adaptation Plan (CHRMAP)

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Revision	Date	Status	Comments	Prepared	Reviewed	Approved
RevA	29/9/23	Draft	Issued for Stakeholder Review	JC	RW	JC
Rev0	30/11/23	Final	Issued for general release	JC	RW	JC
Rev1	16/2/24	Final	Issued Final	JC	RW	JC

Acknowledgement of Country

The Town of East Fremantle respectfully acknowledges the Whadjuk people of Nyoongar Nation, the traditional owners and custodians of this land, and we pay our respects to Elders past and present. The Town of East Fremantle is committed to building a deeper level of understanding and respect for all Aboriginal and Torres Strait Islander peoples as we continue on our journey of conciliation.

Executive Summary

The Town of East Fremantle (the Town) is undertaking a Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) project to develop a greater understanding of its river areas and support its future coastal management and planning decisions. The purpose of the CHRMAP is to identify coastal hazards (eg erosion and inundation) in the Town and to provide a framework for adaptation that can guide decision making in the short to medium term (next 10-20 years) and provide management and adaptation strategies to mitigate hazard in future planning periods (next 100 years).

The study area encompasses all of the East Fremantle foreshore area and is considered in three distinct shoreline management units (SMU) as shown in Figure E.1 termed:

1. Walled Zone – East Street to Niergarup Reserve (Leeuwin Boat Ramp)
2. Reclaimed Zone – Niergarup Reserve (Leeuwin Boat Ramp) to W Wayman Reserve eastern end
3. Natural Zone – W Wayman Reserve to Petra Street

The CHRMAP has been developed under WAPC (2019) guidelines with input from stakeholders and the local community. A Steering Group was appointed to review project milestones and technical deliverables with representatives from the Town, Department of Planning, Lands & Heritage (DPLH), Department of Transport (DoT), Department of Water and Environmental Regulation (DWER) and Department of Biodiversity, Conservation and Attractions (DBCA). A Community and Stakeholder Engagement Plan (CSEP) was prepared to guide the engagement process and ensure that the community and stakeholders were effectively and actively involved in the CHRMAP preparation. A range of engagement activities were delivered during the project including information sessions, workshops a survey and meetings with the Community and Business reference group (CBRG).

A Coastal Hazard Assessment (CHA) was completed for the study area (Baird 2023) in accordance with the requirements of the State Coastal Planning Policy, State Planning Policy 2.6 (SPP2.6). The CHA has provided mapping of coastal hazard to assess the impact of erosion and inundation on coastal assets in current and future planning periods in the CHRMAP. The planning timeframes examined in the hazard assessment 2025, 2035, 2050, 2075 and 2125 and these are carried into the CHRMAP. Sea level rise is incorporated into the hazard assessment. The sea level rise allowance is applied across the planning timeframes based on projection of +1.05m increase in sea level by the year 2125. Mapping of the coastal erosion hazard across the planning timeframes is presented with existing control structures maintained to their present function and with structures removed (Appendix B). Flood mapping associated with the SPP2.6 extreme 500-yr return period storm (S4) is shown in Appendix C.

Coastal asset types through the study area have been identified in the general categories of Social, Economic, Environmental and Heritage and Culture assets. Stakeholder views captured through the community engagement activities (Appendix A) have been used to define the coastal asset function, service and values.

The risk assessment framework for the project has been developed based on WAPC (2019) and considers the impact to coastal assets in the shoreline areas based on the projected coastal hazard in the present and future timeframes (2025, 2035, 2050, 2075 and 2125). The framework assesses likelihood and consequence of coastal hazard impacts and considers the adaptive capacity of the respective coastal assets.

The level of coastal hazard risk for the coastal assets through the study area is generally low for the present day, however this risk is projected to increase associated with sea level rise in future years.

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Figure E.1: Shoreline Management Units for the CHRMAP project. The Walled Zone, Reclaimed Zone and Natural Zone.

Residual risk and priority assets for risk treatment are presented in Section 11 of the report for each SMU, summarised as follows:

1. In the Walled Zone the continuous shoreline protection along the shoreline of the Walled Zone is assumed to be maintained in future years and assumed to continue to provide erosion protection afforded to the coastal assets presently. The Marine Education boatshed is rated as Highly vulnerable in 2035 and Extreme in the 2075 period. The risk from inundation for the Carpark at the Dome Café is rated as Highly vulnerable by 2050. Riverside Road is rated as Highly vulnerable by 2125.
2. In the Reclaimed Zone the areas of focus are the natural shorelines without any current erosion protection. This includes the beach at Niergarup Reserve, Norm Mckenzie and W Wayman Reserve foreshore reserves and coastal pathways which are all rated as Highly vulnerable to erosion in 2035. The 8 Knots Tavern is rated at Highly vulnerable to inundation in 2035 and Extreme in 2050. The buildings of the Navy cadets, Cool Beans café and Rowing Club are all rated as Highly Vulnerable to inundation in 2075. Riverside Road is rated as Highly vulnerable to inundation in 2075. There are six carparks around the area which are rated as Highly vulnerable from 2075 onwards. At the 2075 to 2125 planning timeframe the sea level rise projections of +0.5m to +1.05m lead to many assets becoming Highly vulnerable or Extremely vulnerable.
3. In the Natural Zone The foreshore, beach and stairs at the base of Jerrat Drive are rated as Highly vulnerable to erosion by 2035. For inundation the buildings at the Sea Scouts and East Fremantle Yacht Club and the lower carpark areas at the East Fremantle Yacht Club are rated Highly vulnerable in 2075

The Swan and Canning Rivers Management Act 2006 (SCRM Act) makes provision for the protection of the Swan and Canning Rivers to ensure ecological values and community benefits are maintained. Under the SCRM Act, the Swan Canning Development Control Area (DCA) has been established which covers the land and waters adjacent the Swan River in the study area. The DBCA, SRT, WAPC and State and local governments are responsible for the effective planning and management of land use and development within, abutting and affecting the waters and associated land within the DCA, at all stages of the planning process.

The DCA covers the majority of the shoreline area affected by coastal hazard in the study area, with the DBCA the key decision maker. A discussion with representatives from the DBCA regarding adaptation approaches was undertaken which provided the following guidance:

For the Walled Zone

- Maintaining shoreline revetments and riverwalls to ensure the protection of Riverside Road and raising the height at shoreline in response to future sea level rise needs to be done in balance with the viability of the road over the long term. In this CHRMAP, maintaining the current extent of river walls to provide protection to the foreshore and Riverside Road has been adopted.
- Under projected sea level rise the inundation hazard for Riverside Road will increase in extreme events in the future. At present the risk is manageable. At the time when sea level rise of approximately 0.5m to 1m above the present-day level is realised (projected to be in the 2075 to 2125 period) the risk management will be more difficult (expensive). The coastal hazard risk to Riverside Drive and the foreshore area will be reviewed in future revisions of the CHRMAP.

Within the Reclaimed Zone

- there is presently ‘hard engineering’ river walls and revetments that offer protection; however, it is not a given that this type of foreshore edge treatment will continue to be used in the future. As the infrastructure ages in the shoreline areas there will need to be consideration and discussion on what is appropriate in terms of replacement. The intention will be to deliver an outcome that satisfies the community need whilst being environmentally sensitive. For the Reclaimed Zone, using fill in the

foreshore areas to address inundation risk is not supported. There may be nature-based options or engineering alternatives that are yet to emerge that could provide the right solution.

- In future there may be a point where it becomes too difficult and expensive to provide protection to the shoreline areas from erosion and inundation hazard (with rising sea level) and planning the process of Managed Retreat may be required. A future scenario could be to retreat the foreshore areas back to Riverside Road and use this as the interface to the shoreline, due to the land levels being generally higher from this section landward.
- For the foreseeable future the Leeuwin Barracks site will remain under the ownership of the Department of Defence. Any changes to the use of the site with regard to residential development would need to consider the coastal hazard from the CHRMAP.

Within the Natural Zone

- For the Jerrat Drive escarpment section of foreshore, this is highly regarded as a key coastal asset for the Community as a site of recreation and environmental importance. Further understanding of the processes driving changes in this area is required – assessment of the present state of the foreshore (vegetation cover, habitat, drainage, underscoring at the shoreline and tree loss) and development and update to the existing foreshore management plan to guide future actions is considered a priority of the CHRMAP.

For areas outside of the DCA, the Town would be responsible for planning controls to manage coastal hazard risk. A detailed review of the planning controls applicable to land use and development within the Town was completed (Section 10.2). Based on the review, the use of Local Structure Plans, a Special Control Area (SCA) within the local planning scheme (LPS 3) and a CHRMAP Local Planning Policy (LPP) are recommended.

A multi-criteria analysis (MCA) of adaptation options and an economic analysis of assets in the reclaimed Zone was completed to support decision making. The MCA incorporates community and stakeholder feedback gained through the engagement process. The outcomes are used to inform selection of adaptation pathways in future planning periods for each of the SMU. The economic analysis in the Reclaimed Zone evaluates impacts from inundation hazard associated with projected sea level rise, using the value of assets to assist in understanding the economic costs of a Managed Retreat approach. The results provide a preliminary estimate of the magnitude of the economic cost of sea level rise and timing of asset loss within the Reclaimed Zone. The total undiscounted cost of sea level rise on the Reclaimed Zone is conservatively estimated at $46.2 million. The economic analysis has been used to inform selection of adaptation pathways in future planning periods for each of the SMU in Section 15. The pathways and triggers are summarised across the planning timeframes present to 2035, 2035 to 2050, 2050 to 2075 and 2075 to 2125.

The recommendations in this CHRMAP include:

- Avoid development on land within the erosion hazard area over the 100-year planning period.
- Accommodate coastal hazard risk from inundation to commercial and habitable buildings through improved building design and the use of planning controls (minimum floor levels).
- Accommodate coastal hazard risk to infrastructure in the foreshore areas until such time that a managed retreat pathway may be required, as a result of sea level rise.
- Protect foreshore area and assets landward in the Walled Zone from erosion through maintaining present riverwalls and revetments.
- Accommodate flood risk to Riverside Road through periodic incremental raising of the road level in accordance with the rate of sea level rise and general road upgrade / maintenance schedule.
- Implement nature-based solutions to provide resilience to shorelines including Niergarup Reserve, Jerrat Drive foreshore, John Tonkin Reserve, supported through grant funding and local volunteer groups.

- For the Reclaimed Zone, the short to medium term adaptation pathway is to maintain existing erosion protection along the foreshore areas through traditional 'hard engineering' methods currently in place - river walls, revetments and detached groynes. Examine alternative methods of protection that can be achieved through other 'soft engineering' methods (eg Nature Based Solutions) and look for opportunities to implement as part of the asset replacement lifecycle.
- For the Reclaimed Zone the long-term adaptation pathway is expected to require a managed retreat approach, triggered by the difficulty and cost of mitigating inundation hazard with projected sea level rise of 1.05m in the 100-yr planning period. This scenario is driven by future sea level rise where the current foreshore areas are inundated regularly in the general tides and it is too difficult and/or expensive to maintain the current extent of the foreshore. There is a general presumption against using fill in the foreshore areas to address inundation risk.
- A future scenario of Managed Retreat of the foreshore area and associated infrastructure along the Reclaimed Zone should consider retreat to the area landward of Riverside Road. This decision is contingent on the future of the Leeuwin Barracks site and potential for land being made available.
- If there is a future change in the land use at the Leeuwin Barracks site to redevelop the location for residential and commercial property, then this would need to address the risk from erosion and inundation across the 100-years planning timeframe through planning-based approaches.
- For the shoreline area at the base of the Jerrat Drive escarpment use of nature-based solutions to increase resilience of the shoreline area.
- Update foreshore management plans for the Town's foreshore areas. Foreshore management plans can be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities. They provide a strategy to deliver the recommendations of this CHRMAP for foreshore reserves throughout the Town.

Long term adaptation pathways for the key at risk assets identified in each of the SMU are summarised in Table E.1 for the Walled Zone, Table E.2 for the Reclaimed Zone and Table E.3 for the Natural Zone.

The colour legend in the table is based on the general adaptation categories in the table on the right. Sea level rise plays a key role in triggering actions on the adaptation pathways, and the projections associated with each planning period are noted at the top of the table.

Avoid
Planned or Managed Retreat
Accommodate
Protect
No Regrets
Do Nothing

Table E.1: Risk management pathway and triggers for the Walled Zone (SMU1)

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Sea Level Rise projection. End of period	0.1m	0.2m	0.5m	1.05m
Assets	**Foreshore Areas and All Assets Landward – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using Riverwalls and Revetments (Pr.4)			
Pathway	Protection Structure Audits (NR.4)			
Assets	**Carparks and Coastal Pathway – Inundation Hazard**			

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise level in step with SLR (AC3)			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent			T5: Damaged/ unsafe T6: Highly Vulnerable T7: Lack public support T9: Economic feasibility
Assets	**Riverside Road – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise surface level in step with SLR (AC3)			
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal inundation hazard extent			
Pathway	Develop emergency planning for use of Riverside Road in extreme events (NR.4)			
Assets	**Residential Properties (Riverside Road near Pier St and East St). Inundation Hazard**			
Pathway	Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion or inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development in the SCA that can address coastal hazard.			
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4,T10)			
Assets	**Dome Café and Marine Education Boatshed. Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise floor level in step with SLR (AC3)		Managed Retreat Remove and relocate the assets (MR1, MR2).	
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4)		T5: Damaged/ unsafe T6: Highly Vulnerable T9: Economic feasibility	
Assets	**Minor Infrastructure – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)		Managed Retreat	

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
			Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).	
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent		T5: Damaged/ unsafe T6: Highly Vulnerable Next 10-yrs T9: Economic feasibility	

Table E.2 Risk management pathway and triggers for the Reclaimed Zone (SMU2)

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Sea Level Rise projection. End of period	**0.1m**	**0.2m**	**0.5m**	**1.05m**
Assets	**Foreshore Areas and All Assets Landward – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using offshore detached groyne field, riverwalls and revetments (Pr.4) where currently in use. Apply Nature based solutions (Pr.2) to areas that are currently unprotected			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Pathway	Protection Structure Audits (NR.4)			T9: Economic feasibility
Assets	**Carparks and Coastal Pathway – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise level in step with SLR (AC3)			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent			T5: Damaged/ unsafe T6: Highly Vulnerable T7: Lack public support T9: Economic feasibility

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Assets	**Riverside Road – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise surface level in step with SLR (AC3)			
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal inundation hazard extent			
Pathway	Develop emergency planning for use of Riverside Road in extreme events (NR.4)			
Assets	**Commercial Properties - Inundation Hazard**			
Pathway	Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion of inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development that can address coastal hazard.			
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4,T10)			
Assets	**Minor Infrastructure – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)		Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).	
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent		T5: Damaged/ unsafe T6: Highly Vulnerable Next 10-yrs T9: Economic feasibility	

Table E.3: Risk management pathway and triggers for the Natural Zone (SMU3)

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Sea Level Rise projection. End of period	0.1m	0.2m	0.5m	1.05m
Assets	**Foreshore Areas - East Fremantle Yacht Club and Sea Scouts – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using Riverwalls and Revetments (Pr.4)			
Pathway	Protection Structure Audits (NR.4)			
Assets	**Jerrat Drive Escarpment Foreshore Area – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using Nature Based Solutions (Pr.2)			
Pathway	Shoreline Monitoring (NR.1)			
Assets	**Carparks and Coastal Pathway adjacent East Fremantle Yacht Club – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise level in step with SLR (AC3)			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent			T5: Damaged/ unsafe T6: Highly Vulnerable T7: Lack public support T9: Economic feasibility
Assets	**Sea Scouts Building and East Fremantle Yacht Club Building - Inundation**			
Pathway	Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion of inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development in the SCA that can address coastal hazard.			

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4,T10)			
Assets	**Minor Infrastructure – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)		Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).	
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent		T5: Damaged/ unsafe T6: Highly Vulnerable Next 10-yrs T9: Economic feasibility	

In Section 17 of the report the short-term implementation actions over the period to 2035 are presented which include recommendations for:

1. Planning Actions;
2. Annual Monitoring Program;
3. Additional Technical Studies; and
4. Adaptation Actions in Shoreline Areas.

It is recommended that an annual monitoring program commence following the adoption of the CHRMAP. This will be used to support the CHRMAP and to further develop the understanding of the shoreline dynamics in the key locations where the risk from erosion and / or inundation has been identified. The annual monitoring report will combine desktop analysis with collection of locally captured data from:

- Photo Monitoring.
- Capture of survey and aerial oblique photos using unmanned aerial vehicle (UAV).

The monitoring program would be used to target key locations in the Town's shoreline areas to improve understanding of coastal erosion and inundation impacts in the coming years. It will also provide the mechanism to assess where established triggers are being approached, to provide early indication of a change in management.

The cost for the monitoring activities is estimated at approximately $15,500 (ex GST) annually, with a five-year total of $77,500 ex GST. Co-funding of up to 50% of the cost of the program could be made available if the Town is successful in grant funding opportunities outlined in Section 19.

In conjunction with annual monitoring activities, a general review of the CHRMAP approximately every 5-years would be used to implement the findings from the monitoring program and address updates to the CHRMAP recommendations where required.

The following technical studies and planning based studies are recommended over the short term (by 2035):

- Jerrat Drive escarpment foreshore stability study.
- Catchment based flooding study based on the existing stormwater network.
- Study to determine appropriate Nature Based Solutions for target shoreline areas.

- Update and implement actions in the Foreshore Management Plan.
- Update to Emergency Response and Evacuation Plan.

Adaptation options for implementation of nature-based solutions are recommended over the next 10-years to improve the resilience of the natural shoreline areas through the Reclaimed Zone and the Natural Zone. The selection of nature-based solutions is supported by the outcomes of the MCA, discussion with DBCA and the community engagement.

Budget estimates for the short-term implementation actions for the period over the first 5-years 2024 to 2028 inclusive is estimated at $427,500. This is comprised annual monitoring, technical studies and planning studies and funding for nature-based adaptation approaches.

The implementation budget over the 12-year short-term period from 2024 to 2035 is estimated at approximately $596,000. This will cover the cost of annual monitoring, complete the additional technical / planning studies recommended including two reviews of the CHRMAP (2028, 2033) and undertake nature-based work in the shoreline areas. All figures quoted are order of magnitude estimates and are excluding GST.

The grant funding options that can support the funding of coastal management activities is summarised in Section 18. These funding mechanisms generally require a co-funded approach whereby 50% of the funding which is matched.

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1. Introduction

1.1 Introduction

The Town is developing a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the shoreline areas along the edge of the Swan River. The CHRMAP is being prepared based upon the understanding of coastal hazard risk (eg inundation and erosion) over the next 100-year planning timeframe and the coastal values held by the community for both natural and built assets along the foreshore area.

The objectives of the CHRMAP are to:

- improve understanding of coastal and riverine features, processes and hazards in the study area;
- identify significant vulnerability trigger points and respective timeframes to mark the need for immediate or medium-term risk management measures;
- identify assets (natural and man-made) and the services and functions they provide situated in the coastal zone;
- gain an understanding of asset vulnerability;
- identify the value of the assets that are vulnerable to adverse impacts from coastal hazards;
- determine the consequence and likelihood of coastal hazards on the assets, and assign a level of risk;
- identify possible (effective) risk management measures (or 'actions') and how these can be incorporated into short and longer-term decision-making; and
- engage stakeholders and the community in the planning and decision-making process.

The Western Australian Government has accepted that climate change and sea level rise are issues that will affect the State in the coming century and an allowance for sea level rise must be adopted for coastal planning purposes. For the current study, an allowance of +1.05m over the next 100-yrs has been adopted. The projected sea level rise in the coming century is expected to increase the vulnerability of assets in the Town to coastal hazards such as inundation and erosion.

In accordance with Western Australia's State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6), coastal areas (including tidally influenced riverine areas) identified as being at risk of coastal hazard require coastal hazard risk management and adaptation planning (CHRMAP). The CHRMAP process is a risk-based approach to ensure that the coastal hazard is factored into decision-making for future planning requirements and has been established in Western Australia for the past decade, with guidelines published by the Department of Planning, Lands and Heritage (DPLH, WAPC 2019). Ultimately, the CHRMAP will provide strategic guidance for coordinated, integrated and sustainable land use planning and management decision-making by the Town. The CHRMAP will also guide necessary changes to the Local Planning Strategy, Local Planning Scheme No. 3 and other relevant strategies and local planning policies.

1.2 Study Location

The subject site is located on Whadjuk Nyoongar land with the focus of the study on a section of the Swan River approximately 3.5km in length, that lies between Petra Street to the north-east and East Street to the south (Figure 1.1). Bordered by the residential suburb of East Fremantle, the subject site has interactions with many landmarks and recreational features including the John Tonkin Reserve, Swan Yacht Club, East Fremantle Yacht Club, several outdoor sporting grounds, hospitality venues and several boat moorings and jetties. The significant Leeuwin Barracks site (closed to the general public) is a nearby land area

Figure 1.1: Study Area for the Town of East Fremantle CHRMAP project

currently undergoing consideration for a divestment process by Department of Defence, should the land no longer be required for Defence purposes.

1.3 Project Delivery

The CHRMAP project has been developed in consultation with the Town, the local community and a range of stakeholders, and is delivered in accordance with local and national guidelines and standards (WAPC 2019, AS5334-2013).

The CHRMAP examines erosion and inundation within the study area to understand coastal hazard risk presently affecting the river shoreline areas, and the impacts forecast over the next 100 years (to 2125) under projected sea level rise.

A coastal hazard study to determine coastal erosion and coastal inundation hazard informs the CHRMAP and was completed in accordance with SPP2.6 requirements (Baird 2022). A range of planning timeframes are considered over future planning periods (2025, 2035, 2050, 2075, 2125) with erosion and inundation outcomes presented based on these timeframes.

Community Engagement activities have supported the project delivery, with the aim of developing the understanding of the project within the community and fostering local input to the CHRMAP process. The process with stakeholders and community sought engagement on:

- Potential risks arising from hazards in the river shoreline areas;
- Key shoreline infrastructure and assets at risk within these areas;
- Community and cultural values within these areas; and
- Adaptation pathways and management options that the Town and other stakeholders can pursue to address the risks from coastal hazard over time.

The CHRMAP has been developed in a manner consistent with the views of the stakeholders and community. Identification of adaptation pathways and management options were guided by an economic assessment of alternatives, with the options presented to the community and stakeholders for discussion and approval.

1.4 Project Team

The Town is the key Client, with a project team appointed to work with the multi-disciplinary consultant team composed of:

- Baird Australia (Coastal Hazard Risk and Adaptation Planning, Lead Consultant);
- element (Statutory and Strategic Planning, Stakeholder and Community Engagement); and
- Rhelm (Economic Analysis).

A ‘Steering Group’ was appointed to review project milestones and technical deliverables and includes representatives from:

- Town of East Fremantle (ToEF);
- Department of Planning, Lands & Heritage (DPLH);
- Department of Transport (DoT);
- Department of Water and Environmental Regulation (DWER); and
- Department of Biodiversity, Conservation and Attractions (DBCA).

A Community and Business Reference Group (CBRG) was appointed following an Expressions of Interest (EoI) that was advertised in July 2022.

Meetings with the Steering Group and the CBRG have been scheduled as part of the project delivery at key stages.

1.5 Coastal Management Framework in Western Australia

The key documents that guide coastal hazard assessment and coastal planning in Western Australia are:

1. State Planning Policy No. 2.6, State Coastal Planning Policy (SPP2.6, WAPC 2013).
2. Coastal Hazard Risk Management and Adaptation Planning Guidelines (CHRMAP guidelines, WAPC 2019).
3. State Coastal Planning Guidelines (WAPC 2020).

The purpose of these documents and their application in this project is discussed briefly in this section.

1.5.1 State Coastal Planning Policy (SPP2.6)

SPP2.6 draws on and is supported by several WAPC state planning policies, development control policies and guidelines relevant to the coastal zone. For coastal matters, SPP2.6 is the prevailing policy.

The stated purpose of SPP2.6 is to provide guidance for decision-making within the coastal zone including managing development and land use change, establishment of foreshore reserves, and to protect, conserve and enhance coastal values. This policy recognises and responds to regional diversity in coastal types, requires that coastal hazard risk management and adaptation is appropriately planned for, and encourages innovative approaches to managing coastal hazard risk and provides public ownership of coastal foreshore reserves.

Schedule one of SPP2.6 provides guidance for calculating the component of the coastal foreshore reserve required to allow for coastal processes. The component of the coastal foreshore reserve to allow for coastal processes should be sufficient to mitigate the impacts of coastal hazards (including erosion and inundation). An appropriate coastal foreshore reserve will include a component to allow for coastal processes and be of an appropriate width to ensure a coastal foreshore reserve continues to provide the values, functions and uses prescribed to it should the adverse impact of coastal processes be realised over the planning timeframe.

It is recognised that development may need to occur within an area identified to be potentially impacted by physical coastal processes within the planning time frame. Such development should always be considered within a coastal hazard risk management and adaptation planning process (CHRMAP).

1.5.2 Coastal Hazard Risk Management and Adaptation Planning Guidelines

Coastal areas identified as at risk of being affected by coastal hazards require a CHRMAP to address this coastal hazard. A CHRMAP provides a risk management approach to decision making in the coastal zone, which assesses the risk to assets in the coastal zone for current and future planning periods, through consideration of the likelihood and consequence of coastal hazard impact.

The CHRMAP process is developed in consultation with community members and a range of stakeholders and in accordance with SPP2.6 requirements, WAPC guidelines and relevant Australian Standards (AS5334-2013). It is not a one-off linear process, but a continual cyclical process. Ongoing review is essential to ensure that the management plan remains relevant. Factors that may affect the likelihood and consequences of an outcome may change, as may the factors that affect the suitability or cost of the treatment options. It is therefore necessary to repeat the risk management cycle regularly.

1.5.3 State Coastal Planning Guidelines

These guidelines assist the interpretation and practical application of SPP 2.6 and provide information for decision-making authorities, planners, landowners, proponents, and referral agencies to achieve the SPP 2.6 objectives and implement the SPP 2.6 measures.

These guidelines provide detail on how land use and development is to be addressed when planning, designing and assessing a proposal in the coastal zone.

1.6 Scope – Project Stages

The seven stages that make up the CHRMAP project are shown in Figure 1.2 and the tasks within each of the stages outlined in Table 1.1. After each stage, a Chapter Report was issued for review by the steering committee and key findings shared with the CBRG.

Table 1.1: CHRMAP Project Stages and Tasks

Stage	Tasks
Stage 1 – Establish the Context	• Task 1 – Establish the Context Report Chapter • Task 2 – Develop Stakeholder and Community Engagement Plan • Task 3 – Undertake Coastal Values Assessment
Stage 2 – Risk Identification	• Task 4 – Coastal Hazard Assessment • Task 5 – Asset Identification
Stage 3 – Vulnerability Analysis	• Task 6 – Develop Likelihood and Consequence Scales • Task 7 – Develop Level of Risk Matrix and Risk Tolerance Scale • Task 8 – Adaptive Capacity and Asset Vulnerability
Stage 4 – Risk Evaluation	• Task 9 – Existing Controls • Task 10 – Priorities for Risk Treatment
Stage 5 – Risk Treatment	• Task 11 – Identify Risk Treatment Options • Task 12 – Multi-Criteria Analysis • Task 13 – Cost Benefit Analysis • Task 14 – Benefit Distribution Analysis • Task 15 – Identification of Long-Term Adaptation Pathways
Stage 6 – Implementation Plan	• Task 16 – Short Term Implementation Plan • Task 17 – Medium and Long-term Implementation Plan • Task 18 – Land Use Planning, Local Laws and other relevant Instruments • Task 19 – Funding

Stage	Tasks
Stage 7 – Monitoring Reporting and Review	• Task 20 – Monitoring and Reporting Plan
Final CHRMAP	• Task 21 – Draft CHRMAP • Task 22 – Review of draft CHRMAP • Task 23 – Preparation of Final Draft CHRMAP and Public Comment • Task 24 – Finalisation of CHRMAP

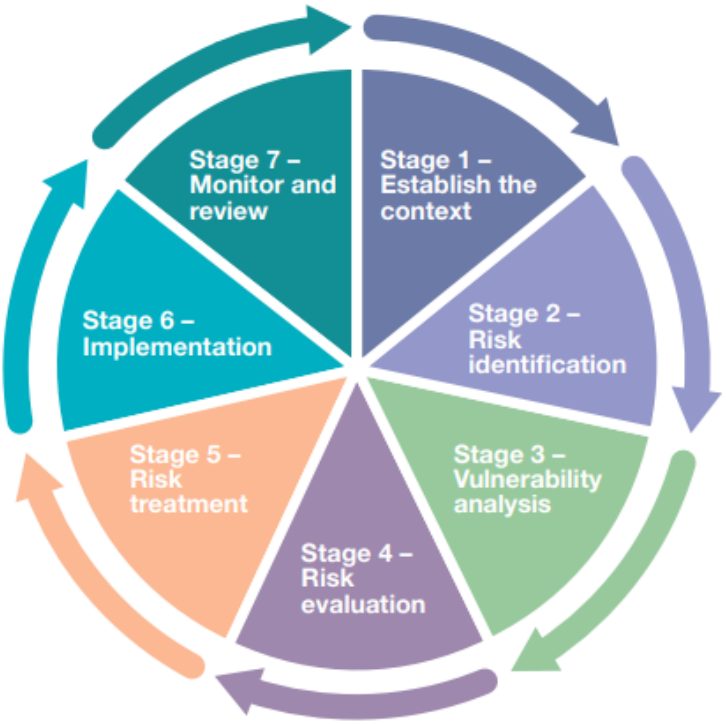

Figure 1.2: CHRMAP Stages (WAPC 2019)

2. Establish the Context

2.1 Background

The Town has a population of approximately 8,000 people and is bounded to the north and west by the Swan River. The river shorelines host a variety of uses including hospitality venues, sporting clubs, parks and recreational facilities and are highly valued by the local community and visitors alike.

Through its recently endorsed *Climate Emergency Action Plan 2023-2033*, the Town has acknowledged that we are living in a time of a Climate Emergency and need to urgently reduce or limit emissions to avoid potentially irreversible warming and environmental damage. Climate change, including rising sea levels, is predicted to increase the level of erosion of sandy coastlines and inundation (flooding) of low-lying areas, including the East Fremantle Foreshore.

In recent years the foreshore has experienced an increase in flood events and inundation within the study area, further highlighting the need for the Town, alongside the community, to consider how to mitigate these hazards. These coastal assets, including recreational spaces, businesses and environmental assets, will face increased pressure in the future from the effects of human and environmental events. Governments at all levels and private parties (individuals, businesses and the community) each have important, complementary and differentiated roles in managing risk arising from coastal hazards.

2.2 Purpose

The purpose of the CHRMAP is to identify coastal hazards in the Town and to provide a framework for adaptation that can guide decision making in the short to medium term (next 10-20 years) and provide management and adaptation strategies to mitigate hazard in future planning periods (next 100 years).

2.3 Objectives

The objectives of the CHRMAP are to:

- improve understanding of shoreline features, natural processes and hazards in the study area;
- identify significant vulnerability trigger points and respective timeframes to mark the need for immediate or medium-term risk management measures;
- identify assets (natural and man-made) and the services and functions they provide situated in the river shorelines;
- gain an understanding of asset vulnerability;
- identify the value of the assets that are vulnerable to adverse impacts from hazards;
- determine the consequence and likelihood of hazards on the assets, and assign a level of risk;
- identify possible (effective) risk management measures (or ‘actions’) and how these can be incorporated into short and longer-term decision-making; and
- engage stakeholders and the community in the planning and decision-making process.

The project objectives are consistent with SPP2.6 and the Western Australian Planning Commission (WAPC) CHRMAP Guidelines (WAPC 2019).

2.4 Study Area – Shoreline Management Units

The study area is considered in three distinct shoreline management units (SMU), as shown in Figure 2.1. These are consistent with the zones identified in the Town’s Foreshore Master Plan (Ecoscape 2016) termed:

1. Walled Zone – East Street to Niergarup Reserve (Leeuwin Boat Ramp).
2. Reclaimed Zone – Niergarup Reserve (Leeuwin Boat Ramp) to W Wayman Reserve eastern end.
3. Natural Zone – W Wayman Reserve to Petra Street.

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Figure 2.1: Shoreline Management Units for the CHRMAP project (SMU). Walled Zone, Reclaimed Zone and Natural Zone.

3. Community and Stakeholder Engagement

A Community and Stakeholder Engagement Plan (CSEP) was prepared to guide the engagement process and ensure that the community and stakeholders were effectively and actively involved in the CHRMAP preparation process (element 2022a).

3.1 Level of Engagement

The CSEP outlines how the community and stakeholder participation, and engagement process aligns within the inform, consult, involve and collaborate levels of IAP2 Public Participation Spectrum. The goals of each level of engagement are described in Table 3.1.

Table 3.1: Levels of Engagement for the Project (based on IAP2 Public Participation Spectrum)

Level	Inform	Consult	Involve	Collaborate	Empower
Goal	To provide balanced and objective information in a timely manner.	To obtain feedback on analysis, issues, alternatives, and decisions.	To work with the public to make sure that concerns and aspirations are considered and understood.	To partner with the public in each aspect of the decision making	To place final decision-making in the hands of the public.
Promise	We will keep you informed.	We will listen to and acknowledge your concerns.	We will work with you to ensure your concerns and aspirations are directly reflected in the decisions made.	We will look to you for advice and innovation and incorporate this in decisions as much as possible.	We will implement what you decide.

The engagement objectives and the engagement tools are summarised in the sections that follow based on the information in the CSEP.

3.2 Engagement objectives

The CSEP details the key stages of the project and guides stakeholders and the wider community on the CHRMAP process and their involvement in the determination of the final outcomes. The engagement objectives are to:

- Utilise reliable communication channels to ensure information is shared with interested stakeholders.
- Identify stakeholders and understand the nature of their interest and potential to contribute towards success of the project or otherwise.
- Establish early in the project opportunities to have authentic conversations with people. Particularly those most affected by potential change from future coastal adaptation measures.
- Inform key community member and stakeholders to develop understanding and alignment with the goals of coastal hazard risk assessment within the East Fremantle community.
- Ensure adjacent neighbours (residents and businesses) to the project site are kept informed and are invited to undertake targeted engagement as required, giving sufficient notice to do so.
- Inform, consult and involve the community in identifying suitable adaptation options.

- Collect and collate the community and stakeholders' coastal values and aspirations for the long term.
- Understand the level of tolerance of specific risks within the community for specific assets, or groups of assets.
- Develop a shared vision between the Town, landowners and surrounding community for the future CHRMAP recommendations.

3.3 Engagement Tools

The key engagement methods and activities used during the engagement process outlined in the CSEP are discussed in this section.

Engagement methods included:

- Project Website.
- Project Posters, flyers.
- Project emails.
- Local Media Advertising.

The engagement Activities involved:

- Council / Town staff briefings.
- CBRG meetings.
- Coastal Values Survey.
- Popup Information sessions.
- Community Workshop as part of the George Street Festival 2022.

3.3.1 Online engagement tool – Project Webpage

The project webpage (Figure 3.1) hosted information about the CHRMAP process and project, an up-to-date timeline of project milestones.

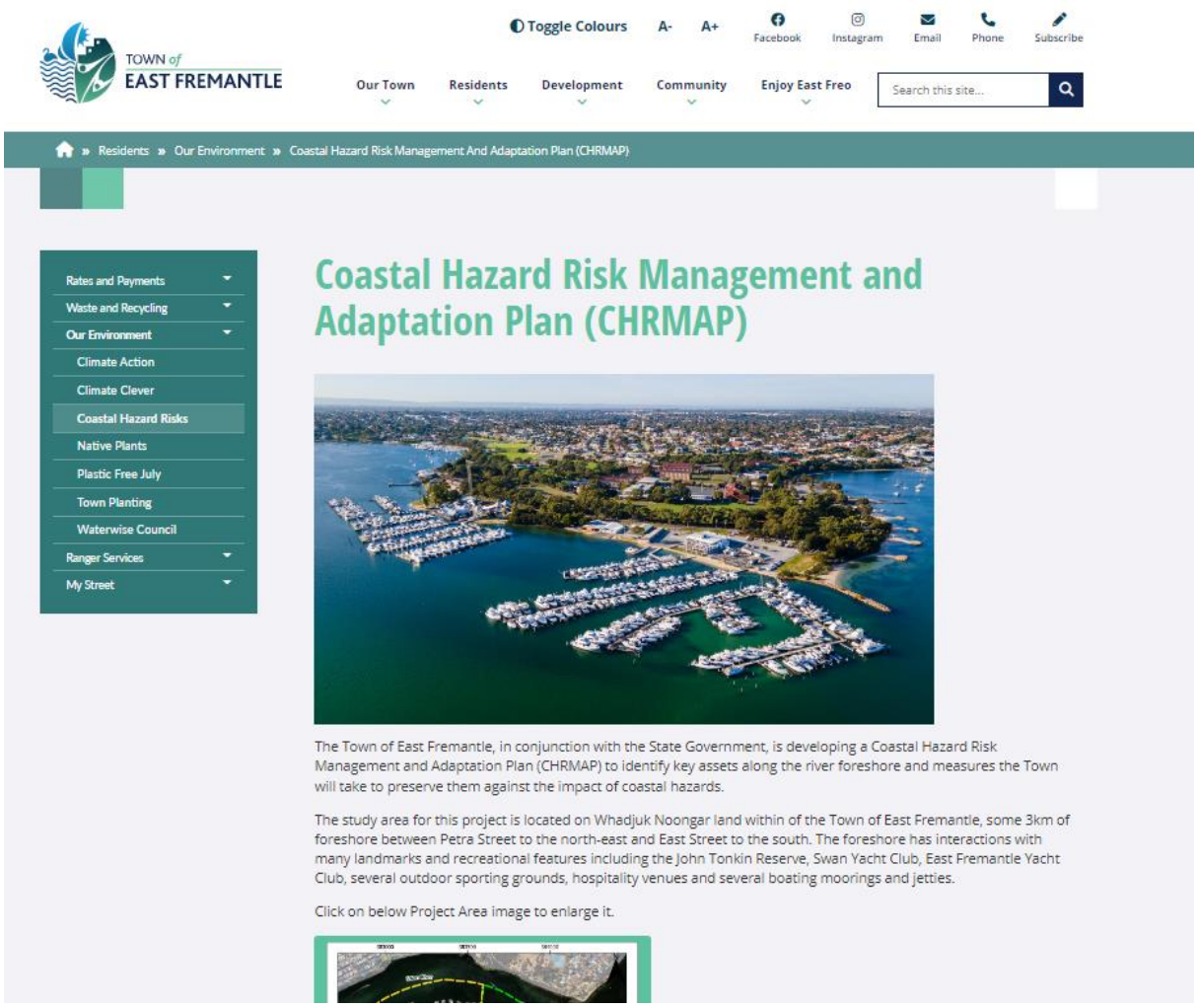

Figure 3.1: Project webpage

3.3.2 Community and Business Reference Group

A Community and Business Reference Group (CBRG) was established to meet periodically through the delivery of the CHRMAP. By engaging the local knowledge and insights of the CBRG, the project demonstrates a greater level of transparency, collaboration and willingness to take on board concerns, values and ideas of local businesses and the community, via selected representatives. The CBRG members were selected via an Expression of Interest process which aimed to ensure a diverse mix of local business and community members.

3.3.3 Pop-Up Information Sessions

Two pop-up information sessions were held to introduce the CHRMAP process and provide information about the project including;

- Why does a CHRMAP need to be prepared.
- Outline of foreshore zones to be included in the study.
- Identification of coastal assets.
- Explanation of coastal hazards.

- Overview of management options.

The information sessions were held on Wednesday 31 September 2022 from 5pm to 7pm and 2 October 2022 from 10am to 12pm at the East Fremantle town Hall. The 2 sessions were visited by 14 people who came to view the information and chat to the project team to gather more information about the project.

3.3.4 Coastal values Survey

The Foreshore Values survey was composed of 21 questions and considered the East Fremantle foreshore as three separate zones; the Walled Zone, the Reclaimed Zone and the Natural Zone (refer Figure 2.1). The survey was hosted online via the Town's webpage and was open from 1 August to 6 September 2022. A total of 152 respondents undertook the Foreshore Values survey.

An outline of the questions in the Coastal Values survey is shown in Table 3.2 with results presented in Section 4.

Table 3.2: Foreshore Values Survey - Questions

Number	Question
	About you – Respondent Demographic Information
1	Please tell us your current residential suburb
2	What is your connection to the East Fremantle foreshore project area (between Petra Street and East Street)?
3	Are you of Aboriginal and/or Torres Strait Islander descent?
	CHRMAP Awareness and Interactions with the Foreshore
4	Before taking this survey, how familiar are you with the CHRMAP project currently being undertaken by the Town of East Fremantle?
5	Thinking about your interactions and experiences with the East Fremantle Foreshore (between Petra Street and East Street) what are three words that come to mind?
	Values and Activities
6	Below is a list of values that can apply to a variety of coastline and foreshore environments. Please tell us how important each value is to you in the context of the East Fremantle foreshore.
7	Roughly how close do you live to the East Fremantle Foreshore project area?
8	Please indicate below whether you personally undertake any of these activities and where you undertake them.
	Activities in the Walled Zone
9	How often do you participate in these activities in the Walled Zone?
10	Why do you choose to undertake these activities in the Walled Zone as opposed to other areas? (You may select more than one option)
	Activities in the reclaimed Zone
11	How often do you participate in these activities in the Reclaimed Zone?

Number	Question
12	Why do you choose to undertake these activities in the Reclaimed Zone as opposed to other areas? (You may select more than one option)
	Activities in the Natural Zone
13	How often do you participate in these activities in the Natural Zone?
14	Why do you choose to undertake these activities in the Natural Zone as opposed to other areas? (You may select more than one option)
	Impact of Hazards
15	If you were unable to do these activities along the East Fremantle foreshore, how much would this impact your life?
16	From your experience, within the project area have you noticed any areas along the foreshore that may be affected by, or increasingly impacted by, inundation and/or erosion hazards over the past 5 years. Please tell us more below, including the location/s of concern
	Other demographics and comments
17	Please tell us how you heard about this survey
18	How young are you?
19	What is your gender?
20	Would you like to receive project updates via email?
21	Please let us know if you had any further questions or comments about the project for the CHRMAP Team here:'

4. Coastal Values Assessment

4.1 Coastal Foreshore Survey – Overview of Responses

The foreshore values survey was used to determine the coastal values assessment for the CHRMAP. An overview of the key findings from the survey is presented here.

Respondent summary:

- The majority of respondents were residents from within the Town of East Fremantle (n=101) whilst most of the remaining respondents were from nearby suburbs, particularly Bicton. A smaller number of respondents were from a variety of other metropolitan suburbs.
- Approximately 7% owned property in East Fremantle but did not live in the area, whilst 14.5% worked in East Fremantle. A significant amount attended a sporting or community group (35%) while 65% used the area for recreational purposes.
- Well over half (58%) lived within 1km of the site, while a further (31.5%) lived up to 5km away. The remaining (10.5%) lived more than 5km away.
- The majority of respondents (60%) were over 55 years of age, with 27% aged 35-54 and 10% 34 years or below. Most respondents were male (56%).

When asked about what three words they associated with the East Fremantle foreshore based on their experiences and interactions the survey responses reflected the natural setting, community aspects and recreation activities as captured in word cloud form in Figure 4.1. In summary:

- Almost a quarter of respondents (22%) described the foreshore using beautiful (or beauty). Peaceful/tranquil/serene (15%) and nature/natural (13%) were mentioned often, along with recreation (9%), walking (9%) and relaxing (8%).

Figure 4.1: Perceptions of the foreshore area – word cloud of survey responses

The values and importance question in the survey is summarised in Figure 4.2.

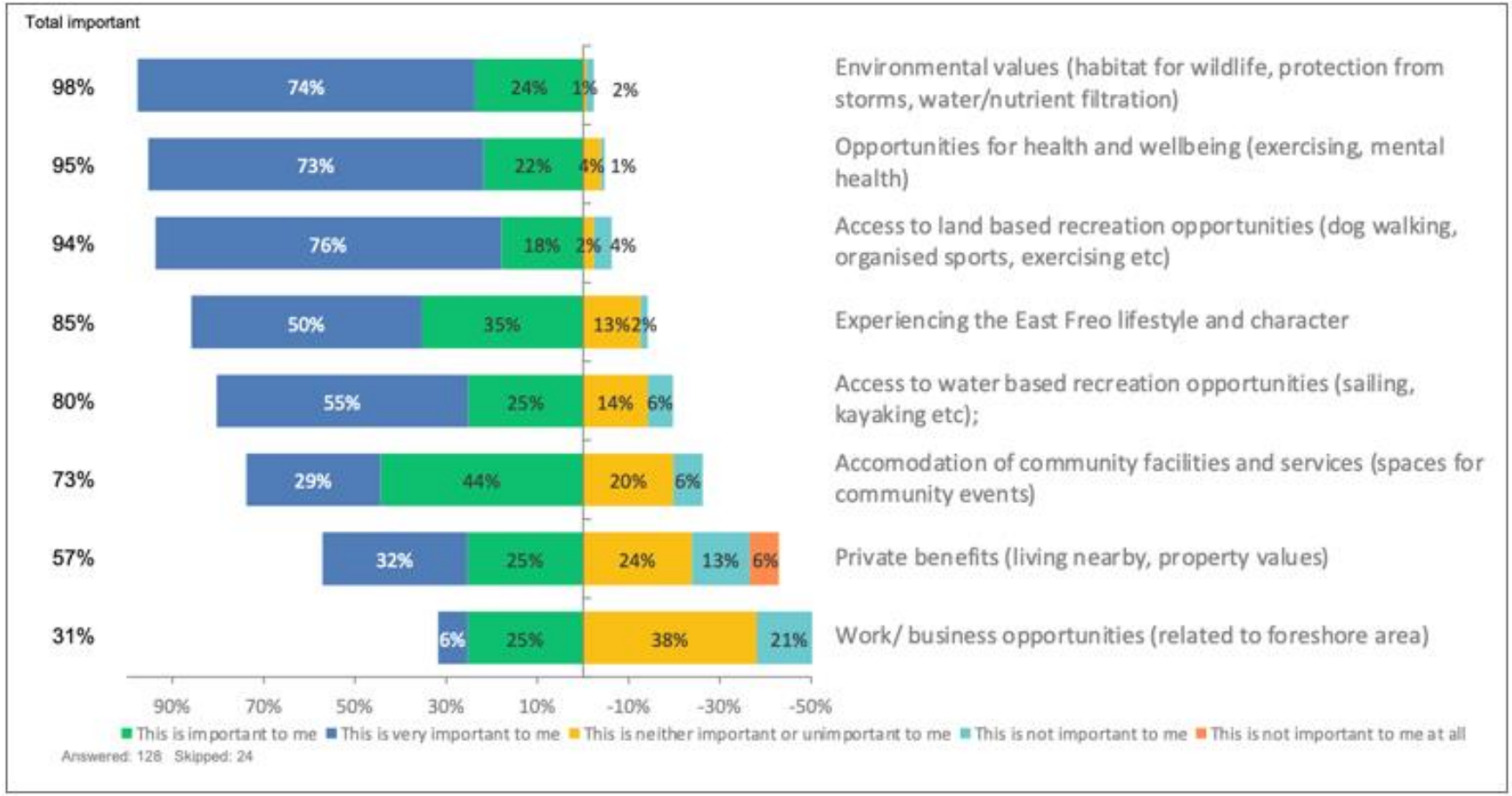

Figure 4.2: Survey Outcomes – Importance and Values

The responses in Figure 4.2 show:

- the Environment as the most highly rated (98% combined importance). Other high rating aspects were 'Opportunities for health & well-being' (95% combined importance) and 'Access to Land-based recreation opportunities' (94% combined importance).
- 'Work/ business opportunities were seen as the least important value (31% overall importance).

The highest ranked types of activities that were cited by respondents using the East Fremantle foreshore were walking, visiting a restaurant or café, being in nature and outdoor socialising/picnics.

There were some differences noted between the zones:

- Outdoor socialising/picnics were more likely to occur in the Reclaimed Zone than other zones (67% vs 48% and 47% for the Reclaimed and Walled Zones)
- Sporting or community group activities were more likely to occur in the Natural Zone than other zones (40% vs 26% and 16% for the Natural and Walled Zones)
- Visiting a restaurant or café were least likely occur in the Natural zone (37% vs 72% and 73% for the Reclaimed and Walled Zones)

The use of the foreshore for activities and the frequency of the usage for various activities indicates the high use of the foreshore for activities such as walking, running, cycling, community activities at least once a week.

For most activities across the zones the most common reasons were 'I live nearby so it is more convenient for me' and 'Proximity to an attractive, natural setting'.

Detailed presentations of the foreshore usage are presented in the Engagement Summary (Appendix A).

A total of 46 responses were received to the question on whether respondents have noticed any areas along the foreshore that may be affected by, or increasingly impacted by, inundation and/or erosion hazards over the past 5 years. Areas most cited in the responses included the walking paths, EFYC, river walls, rowing club foreshore, Zephyrs foreshore and the area near the Dome (carpark).

In summary, the coastal values survey confirms there is a strong connection from the community to the river's foreshore areas. The community value the environment and natural setting very highly and regularly use the foreshore areas for recreation activities, social gatherings and access to the restaurants and cafés.

4.2 Community Workshop – George Street Festival

The annual George Street Festival offered a good opportunity to canvas a broader and greater amount of community members due to good attendance numbers. The George Street Festival is an outdoor event that incorporates the length of George Street. It is a free event that features a range of stalls, music and activities.

The event occurred on the 4 December, 2022 from 11am – 6pm. An East Fremantle CHRMAP stall was set up for the day and a total of 92 people attended the CHRMAP stall. The purpose of the stall was to share information about the CHRMAP and to encourage attendees to participate in activities to identify important community assets, prioritise these assets and understand the preferred adaptation options for them. This also allowed information sharing to occur with community members who were not already aware of the East Fremantle CHRMAP (Figure 4.3).

The utilisation of the George Street Festival to obtain feedback meant that the number of community members exposed to the information and involved in the process was maximised. However, the stall format also meant that the time available to explain the CHRMAP concept and obtain feedback was

reduced in comparison to a workshop. To accommodate this, the tasks that participants undertook were split into two sessions for the day.

The format for activities was tested with the CBRG and the feedback from the group helped to refine the final activities that were undertaken with the community at the 2022 George Street Festival.

Two structured sessions were delivered during the course of the day at the Festival. Display Boards were utilised during the day to provide information about the CHRMAP, outline the instructions for the activities and gather feedback from the community.

Session One: Coastal Assets Identification and Prioritisation

- The tasks that occurred during session one were undertaken between 11am – 2.30pm. These tasks required participants to identify the assets along the foreshore that were of importance to them by placing 3 dots on the maps displayed to indicate their top 3 assets. (Participants from session 2 of the day were also asked to provide input for this). Participants from session one were also required to state why these assets were important to them.

Session Two: Coastal Asset Adaptation Options

- Session two was undertaken between 2.30pm – 6.00pm. Similarly to session one, participants were required participants to identify the assets along the coast that were of importance to them by placing 3 dots on the maps. Participants were then also asked to decide on the preferred adaptation option for each of their priority assets. Relevant adaptation approaches and examples were shown on Display Boards and each participant had the adaptation options explained to them individually. They then wrote their top three assets on a piece of paper and allocated them to an adaptation option by placing them in the appropriately labelled container. Additional descriptions of the adaptation options were next to the containers for each of the options.

Figure 4.3: Workshop sessions presented as part of the George Street Festival 2022

4.3 Success Criteria

The engagement activities were used to determine the success criteria. Success criteria determine if the objectives of the CHRMAP are achievable and sustainable. The success of the CHRMAP will be determined by the coastal asset(s) continuing to provide their present function, service and values in future.

Based on the coastal values discussed in the previous section the following success criteria have been defined:

1. Ensure the natural environment is protected and sustained in its current condition or an improved condition.
2. Preserve the function and opportunity for land-based health & well-being and recreation activities along the foreshore and access to water-based activities such as walking (the dog), sailing and kayaking.
3. Preserve the existing hospitality and recreation venues along the coastline and access to them.
4. Maintain services that maximise community benefit for all.
5. Consider management and protection of foreshore areas that have current inundation and erosion issues.
6. Develop solutions to riverine processes that are sustainable (financially, socially and built form) and locally responsive.
7. Revisit regularly with community and key stakeholders their values in relation to development adjacent the foreshore.

5. Coastal Hazard Assessment

5.1 Coastal Planning Policy Overview

In accordance with SPP2.6 coastal areas (including tidally influenced riverine areas) identified as being at risk of coastal hazard require a CHRMAP.

A coastal hazard assessment (CHA) was completed for the Town study area in Baird (2023) in accordance with the requirements of SPP2.6. The hazard assessment has defined coastal erosion allowances and inundation associated with extreme flood events across a 100-year planning timeframe with key findings presented in this section.

5.2 Summary - Hazard Assessment

5.2.1 Planning Timeframes and Sea Level Rise Allowances

The planning timeframes that will be adopted in the CHRMAP over the 100-year planning period are 2025 (present day), 2035, 2050, 2075 and 2125. Coastal hazard from erosion and inundation are calculated for each respective timeframe.

The sea level rise recommendations for Western Australia applicable at a planning level are outlined in DoT (2010). Sea level rise must be factored into future coastal planning with vertical sea level rise recommendations from DoT (2010) applied in the current study shown in Table 5.1 and Figure 5.1.

Table 5.1: Sea level rise allowances over the planning timeframe for the CHRMAP study (values rounded to nearest 0.05m).

Planning Year	2025	2035	2050	2075	2125
Sea Level Rise	0m	+0.1m	+0.2m	+0.5m	+1.05m

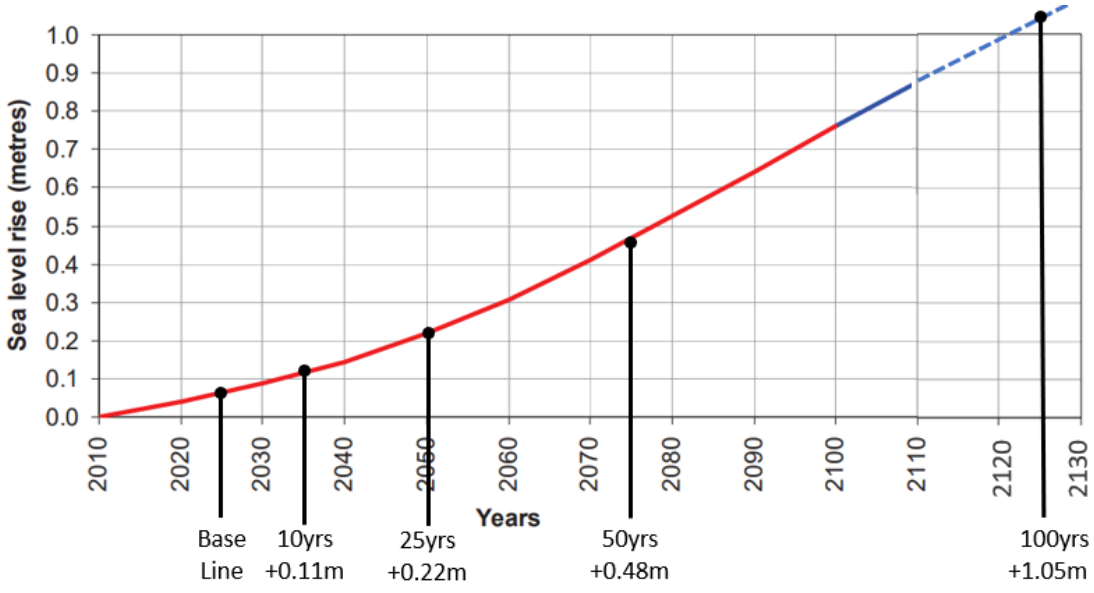

Figure 5.1: Sea level rise recommendation for coastal planning (based on DoT 2010). Graph extended to cover the period to 2125 consistent with the present study.

5.2.2 Study Area – Shoreline Management Units

The study area was considered in three distinct shoreline management units (SMU's) as discussed in Section 2 and presented in Figure 2.1. The SMU are:

1. Walled Zone – East Street to Niergarup Reserve.
2. Reclaimed Zone – Niergarup Reserve to W Wayman Reserve eastern end.
3. Natural Zone – W Wayman Reserve to Petra Street.

The delineation of the SMU's is based on recognising similar shoreline characteristics and features within each respective section. The shoreline areas are consistent with the zones adopted in the Town's Foreshore Master Plan (Ecoscape 2016).

5.2.3 Horizontal Shoreline Datum (HSD)

The horizontal shoreline datum (HSD) is a term used in SPP2.6 to define the active limit of the shoreline under storm activity, determined against the physical and biological features of the coast (WAPC 2019). It represents the point on the shoreline from which coastal erosion allowances are measured in the mapping presented in this report. For the river shorelines of the study area the HSD has been assumed at the level of highest astronomical tide (HAT) which is 0.6m AHD.

5.2.4 Coastal Structures

There are notable protection structures through the study area, which influence the coastal processes in the study area and serve to protect the shorelines from erosion. In Appendix B.1 mapping is presented indicating the protection features in each of the SMU's. Within the three zones the protection features are summarised in Table 5.2.

Table 5.2: Over

SMU	Protection Structures
Walled Zone	The entire section of river frontage is protected by hard engineered structures
Reclaimed Zone	Isolated sections of unprotected shoreline along the baech in front of Niergarup Reserve, the beach in front of McKenzie Park and a small section at the west end of W Wayman Park. Low seawall constructed in front of Zephyrs café, the Leeuwin Boat Ramp and a sloped revetment to the south of the boat ramp that all serve to protect this section of shoreline. Five detached groyne features and the Preston Point Groyne along the west facing section of shoreline in front of John Tonkin Reserve. The beach in the lee of the groynes has been stabilised following the installment of the groynes. Almost continuous seawall along the north facing shorelines of the Reclaimed Zone through the sites of the Swan Yacht Club, Aquarama Marina and W Wayman Park.
Natural Zone	There are engineered structures (seawalls) along the river sections occupied by the Department of Defence, the sea scouts and the East Fremantle Yacht Club.

In the coastal hazard assessment (Baird 2023) the respective shoreline sections are assessed in each SMU based on two separate assumptions:

- protection structures remain in place and are maintained in the future; and
- protection structures are removed.

This approach is used to understand the role of the protection structures in the shoreline.

5.2.5 Allowance for Erosion

The allowance for erosion of the shoreline areas adopted the following assumptions:

- The SPP2.6 coastal classification for the study area of the lower Swan River is generally considered as “Tidal reaches of inland waters”.
- For the majority of the shoreline areas there are walls and coastal protection structures in place to protect the shoreline from erosion (refer Appendix B.1) to indicate the sections of shoreline currently protected.
- For the Jerrat Drive escarpment in the Natural Zone where limestone is present through the shoreline, this has been classified as ‘rocky’ for the purposes of the coastal processes allowance under SPP2.6. The erosion allowances have been determined by calculating the annual rate of change over the past 75-years from analysis of aerial imagery through this section and applying this rate of change in future planning periods.
- In shoreline regions not afforded protection currently, the erosion allowances have been assessed based on estuary and river guidance in State Planning Policy 2.9 Water Resources (SPP2.9) as outlined in Baird (2023).
    - The coastal setback extent is assumed to be 50m over the 100-year planning period factored in the 2035, 2050, 2075 and 2125 planning periods by the relative sea level rise (Table 5.1).
    - This includes several sections of natural shoreline in the Reclaimed Zone such as the Niergarup Reserve shoreline and the shoreline areas at W. Wayman Reserve and Norm McKenzie Park.

DoT have accepted that 50m erosion setback for the study area is appropriate for coastal hazard due to the heavily engineered shorelines in the study area limiting the exposure areas. Whilst this is the case for the Town’s shoreline areas this should not be seen as a precedent for river shorelines in other locations.

Mapping is presented in Appendix B showing the coastal processes allowances through the three SMU based on two scenarios:

- Appendix B.2- with the present structures in place, under the assumption these are maintained; and
- Appendix B.3 - scenario where all structures are removed immediately.

The projected erosion allowance in each planning period is applied in the risk assessment process for CHRMAP. Erosion risk is assessed likelihood in each planning period in the risk assessment of coastal assets, with further discussion in the Vulnerability Analysis (Section 7).

5.2.6 Coastal Inundation Allowance (S4)

The extreme water levels that will be used to examine inundation impacts in the shoreline areas in CHRMAP at each return period are shown in Table 5.3. These are presented over the 100-yr planning timeframe (to 2125) with the appropriate sea level rise allowances from Baird (2023).

Table 5.3: Design Water Levels for planning periods to 2125

	Present Day 2025	10-yr Plan 2035	25-yr Plan 2050	50-yr Plan 2075	100-yr Plan 2125
Sea Level Rise	0m	+0.1m	+0.2m	+0.5	+1.05m
Return Period					
2-yr	1.0	1.1	1.2	1.5	2.1
10-yr	1.1	1.2	1.3	1.6	2.2
100-yr	1.3	1.4	1.5	1.8	2.4
500-yr	1.4	1.5	1.6	1.9	2.5

The coastal hazard from inundation (S4) is defined in SPP2.6 guidelines as the storm event that has a 0.2 percent or one-in-five hundred probability of being equaled or exceeded in any given year over the planning time frame. In the coastal hazard assessment this is the 500-yr ARI event and for CHRMAP this is the most severe storm event that is assessed.

As well as the 500-yr return period case, lower return period water levels will be required in the CHRMAP analysis. These have been defined at return periods of 2-yr and 10-yr ARI from the analysis of the Fremantle tide gauge, and at the 100-yr ARI and 500-yr ARI return period defined from modelling of extreme events reported in BMT (2017).

Flood mapping has been developed using elevation defined in LiDAR data captured over the area (Fugro 2008). The flood mapping represents the peak water depth over the land surface in each respective event and has been defined using a simple 'bathtub flooding' approach.

In Appendix C flood depth mapping for the 500-yr ARI scenarios is presented for the planning year 2025, 2035, 2050, 2075 and 2125.

5.3 Assumptions and Limitations

The assumptions and limitations of the hazard mapping are summarised in Table 5.4.

Table 5.4: Hazard Mapping Assumptions and Limitations

Data Source / Feature	Assumptions and Limitations
LiDAR capture date and accuracy	The LiDAR data (Fugro 2008). that describes the land surface through the study area was acquired in 2008. Modification to ground levels as a result of development post 2008 are not described. The stated accuracy of the dataset is +/- 0.15m.
Geotechnical Conditions	Detailed geotechnical data is not available for the study area. For the Jerrat Drive escarpment there is noted presence of limestone – the extent has not been confirmed through any historical geotechnical reporting.
Bathtub Flood Mapping	The 'bathtub' flood mapping approach does not account for frictional losses for overland flow during flood events (e.g. roughness, structures / obstacles). Stormwater connectivity is not considered in this type of assessment, whereby stormwater could be directed through the drainage network. The method is contingent on the accuracy of the LiDAR data stated as +/- 0.15m.
Flood Velocity	Velocity of flood waters in extreme events has not been determined.
Catchment Flooding	The localised land based flooding impact from catchment runoff and extreme rainfall has not been considered in the flood mapping presented.
Joint Occurrence	Joint occurrence with elevated ocean level / river level in the extreme is incorporated in the 100yr and 500yr flood mapping as defined from modelling of extreme events reported in BMT (2017).
Finished Floor Levels	The finished floor levels of built structures are not considered in the flood mapping. The flood depth is shown in mapping based on ground level data as defined in the LiDAR. Consideration of finished floor level for risk management is presented in Section 10 as part of the assessment of existing controls.
Groundwater	Groundwater is not considered in the study.
Boat Wakes	The contribution of boat wakes to the process of erosion has not been assessed in the present study. A separate study is being completed by SRT to determine the impact of boat wakes through the area and may be used to inform future understanding of the influence on erosion of shorelines.

5.4 Sediments

The sediment properties are important for understanding of coastal processes and recommendations for management of shoreline areas.

5.4.1 Sediment Type

The general soil and rock description in the study area is shown in Figure 5.2 from Ecoscape (2016). There has not been any sediment sample data located in the historical information to provide a description of sediment size in the shoreline areas (PSD).

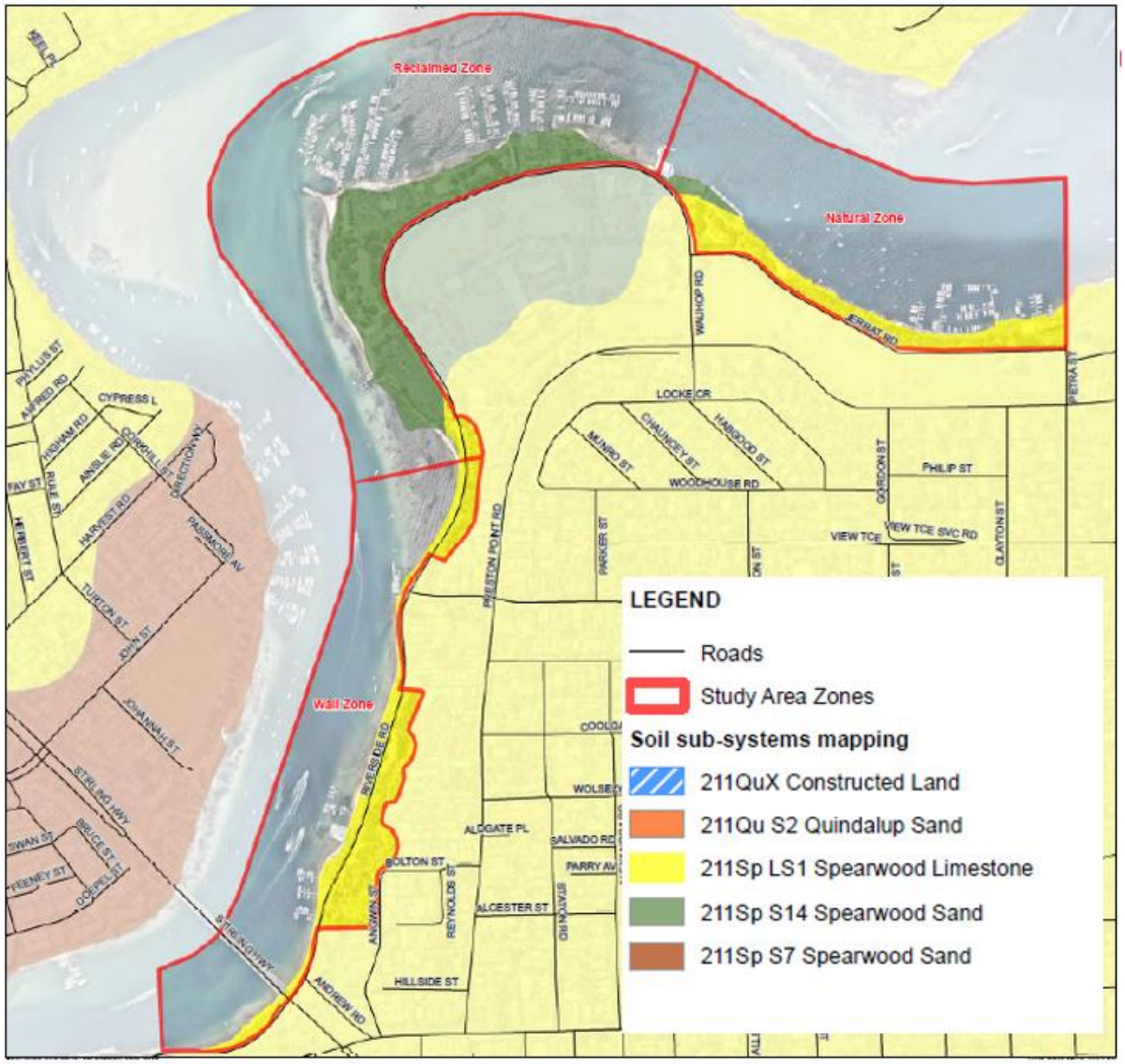

Figure 5.2: Soil Sub-Systems (Ecoscape 2016)

5.4.2 Contaminated Sediments

Between 2007 and 2012 the Swan River Trust (SRT) undertook studies which detected contaminant tributyltin (TBT) within the sediments of the wash down areas, slip areas and pens of the Swan Yacht club, East Fremantle Yacht Club and Aquarama Marina as noted in Baird (2023). CHRMAP recommendations in these areas will need to recognise the risk posed by these contaminated sediments.

The Acid Sulphate Soil Risk is summarised for the study area in Figure 5.3 from Ecoscape 2016. The river shoreline areas are rated at 'High to Moderate Risk'. The land areas across the Reclaimed Zone are rated at 'Moderate to Low Risk'. CHRMAP recommendations will need to recognise the risk from ASS.

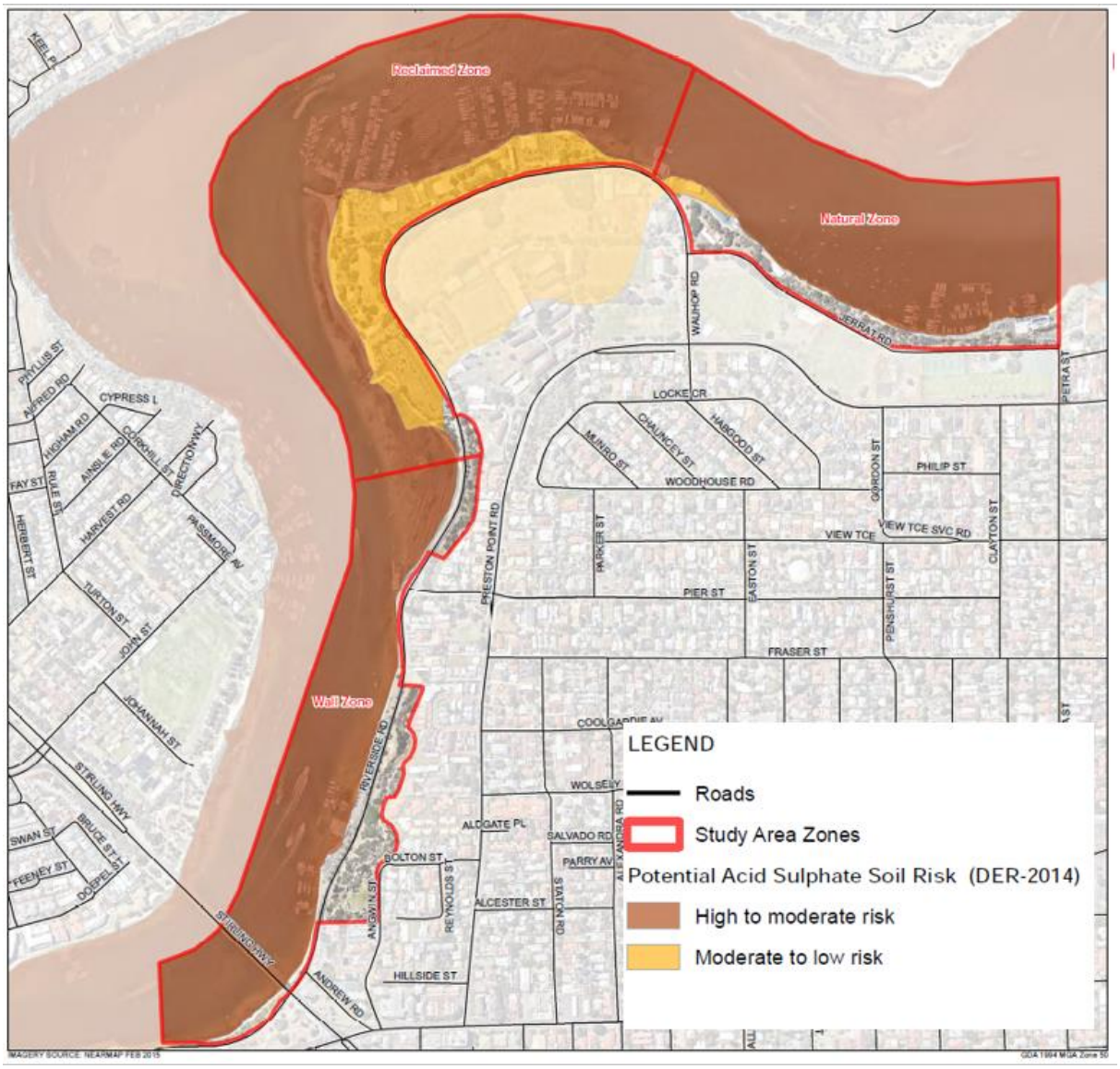

Figure 5.3: Potential Acid Sulphate Soil Risk (Ecoscape 2016)

6. Asset Identification

6.1 Coastal Assets

6.1.1 Asset Types

There are a range of coastal assets through the SMU that will be impacted by coastal erosion and/or inundation in future planning periods. Coastal assets are broadly described in the following categories:

- Social - examples include community use of coast, recreation along the coast.
- Economic – examples include facilities, services, jobs, industry, private property including infrastructure.
- Environmental – examples include environmental values, coastal flora and fauna, ecosystem, dunes.
- Heritage and Culture – significant sites and places of historical or cultural importance.

6.1.2 Asset Identification

The coastal assets in the study area were defined through the community engagement process which has included information sessions, meetings with the CBRG, the open workshop at the George Street Festival and the online coastal values survey.

6.1.3 Coastal Asset Functions, Services and Value

Coastal asset types through the study area and their functions, services and values are presented in Table 6.1, adapted from WAPC (2019) and informed by the stakeholder views captured through the community engagement activities (Appendix A).

6.2 Coastal Asset Register

6.2.1 Compilation of Asset Data

The coastal assets that are within the coastal hazard extent were identified and assigned a data type category as either Environment, Social, Economic or Heritage and Culture.

Maps showing the overview of each SMU and key assets are presented in Figure 6.1 to Figure 6.6.

Coastal Asset Services, functions and values are presented for each SMU in Table 6.2, Table 6.3 and Table 6.4.

Table 6.1: Overview of Coastal Asset functions, services, value (based on WAPC 2019)

Asset	Function, Service, Value
Environment	
Foreshore Reserve and Beaches	Coastal access, recreation, and conservation. Habitat for flora and fauna. Supports biodiversity and ecosystem benefits. Provides a place of tranquility and peace. Access to land based and river recreation activities.
Social	
Foreshore reserve amenity – dual use paths, toilet/picnic facilities,	Access to community facilities and services including community events. Opportunities for health and well-being. Social/family recreation.
Buildings for clubs (eg Yacht clubs, Sea Scout, Rowing clubs)	Strong community attachment and service.
Residential (existing/future) development	Provides housing for resident population and future population.
Economic	
Private Property	Housing / shelter. Financial investment.
Jetties and Boat Ramps	Provides recreation facilities. Provides local employment. Contributes to local economy. Community use for boating/fishing.
Foreshore reserve infrastructure – dual use paths, toilet/picnic facilities	Provides recreation facilities.
Roads	Access. Facilitates transport.
Commercial / Industrial Development and Infrastructure	Provides employment and contributes to economy. Serves community and provides recreational benefits.
Heritage and Culture	
Significant Sites e.g., Niergarup Trail	Significant site and place of historical importance. Historical value, tourist attraction, culture.

Table 6.2: Coastal Asset Identification. SMU1 – Walled Zone

Asset Type	Asset
Environmental	J Dolan Park
	Street Trees
	River walls protecting shoreline
Social	Coastal Pathways
	Residential homes
	River access through boat ramps and jetties
	Cycle Pathway on Riverside Road
Economic	Residential Properties
	Marine Education Boatshed
	Riverside Road and road connections
	Dome Café
	Town Infrastructure (eg bins, signage, shelters, fencing, water fountains, exercise equipment, beach access)
	Jetties and Moorings
	Carparks - Public Carpark No 4, J Dolan Park
	Left Bank
	Playground Equipment – north of Dome Café
	Shelters, seating and picnic tables – J Dolan Park, north of Dome Cafe
	Footpaths
	Drainage features (pits, pipes, culverts, stormwater outlets)
Heritage and Culture	Niergarup Trail
	Artwork along the riverfront (pink flower).
	Sites on the Town's heritage list: • Kitson Park & Plympton Steps, the Boatshed and Merv Cowan Reserve.
	Sites on Local Heritage Survey (Category E, low management level): • Kirkham and Cowan Parks and (Canary) Palms near the Dome carpark, a limestone wall on Canning Highway (at rear of No. 13 Riverside Road) and the Stirling Bridge and parklands.

Figure 6.1: Overview of key sites located in the shoreline section of the 'Wall Zone' (SMU1).

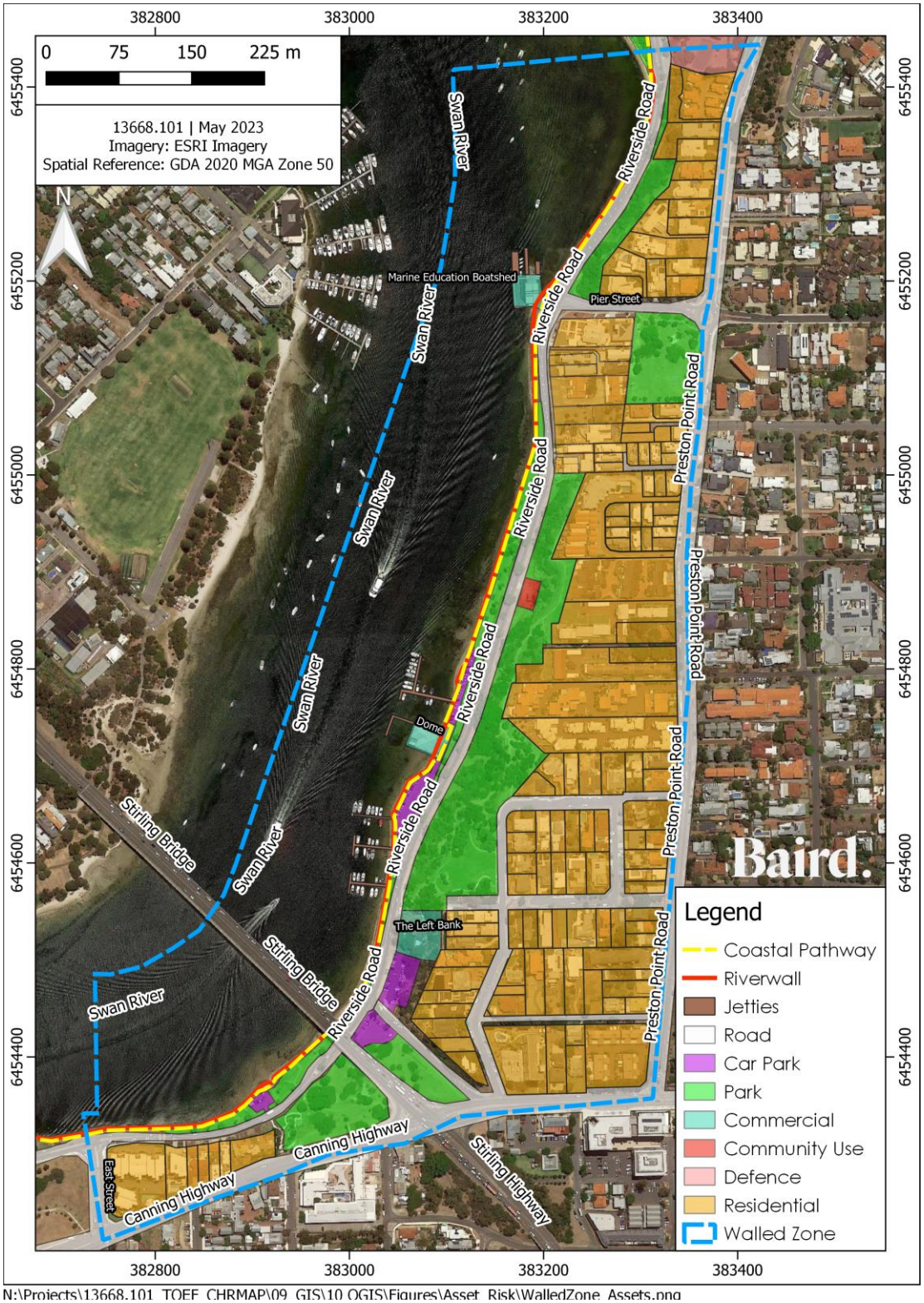

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Figure 6.2: Land use and coastal assets in the Walled Zone

Table 6.3: Coastal Asset Identification. SMU2 – Reclaimed Zone

Asset Type	Asset
Environmental	W Wayman Reserve
	Norm McKenzie Park
	Street Trees
	Detached groyne field
	Niergarup Reserve
	John Tonkin Reserve
	Coastal protection along shoreline areas
Social	Coastal Pathways
	Cycle Pathway on Riverside Road
	Boat Ramp
	Community and Sporting Groups (Swan Yacht Club, Rowing Club, Navy Cadets)
	Beach access pathways
Economic	Aquarama Marina
	8 Knots Tavern
	Rowing Club
	Town Infrastructure (bins, signage, shelters, fencing, water fountains, exercise equipment, beach access)
	Jetties and Moorings
	Cool Beans Café
	Swan Yacht Club
	Zephyr Cafe
	Toilet facilities in John Tonkin Park near Zephyrs.
	Boat Ramp
	Riverside Road and road connections
	Car parks – Public Car Park Nos 1, 2 and 5, John Tonkin Reserve, Zephyr Café, and within Swan Yacht Club, Fremantle Rowing Club and Aquarama precincts.
	Playground equipment – John Tonkin Reserve, W Wayman Reserve
	Shelters, seating and picnic tables – John Tonkin Reserve, Public Car Park No 1, W Wayman Reserve
	Leeuwin Barracks Site (Department of Defence)
	Drainage features (pits, pipes, culverts, stormwater outlets)

Asset Type	Asset
Heritage and Culture	Sculpture of the lady and dog in John Tonkin reserve
	Interpretation boardwalk and signs
	Historic river crossing point for the original road between Fremantle and Perth near W Wayman Reserve

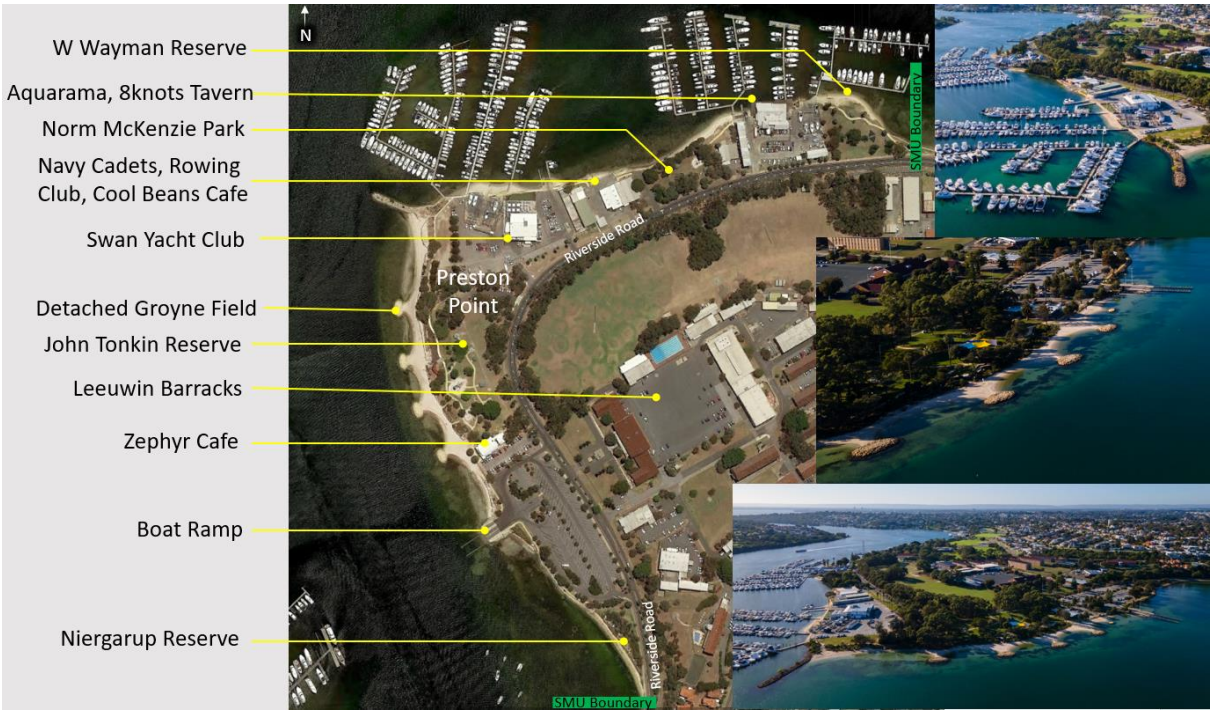

Figure 6.3: Overview of key sites located in the shoreline section of the 'Reclaimed Zone' (SMU2).

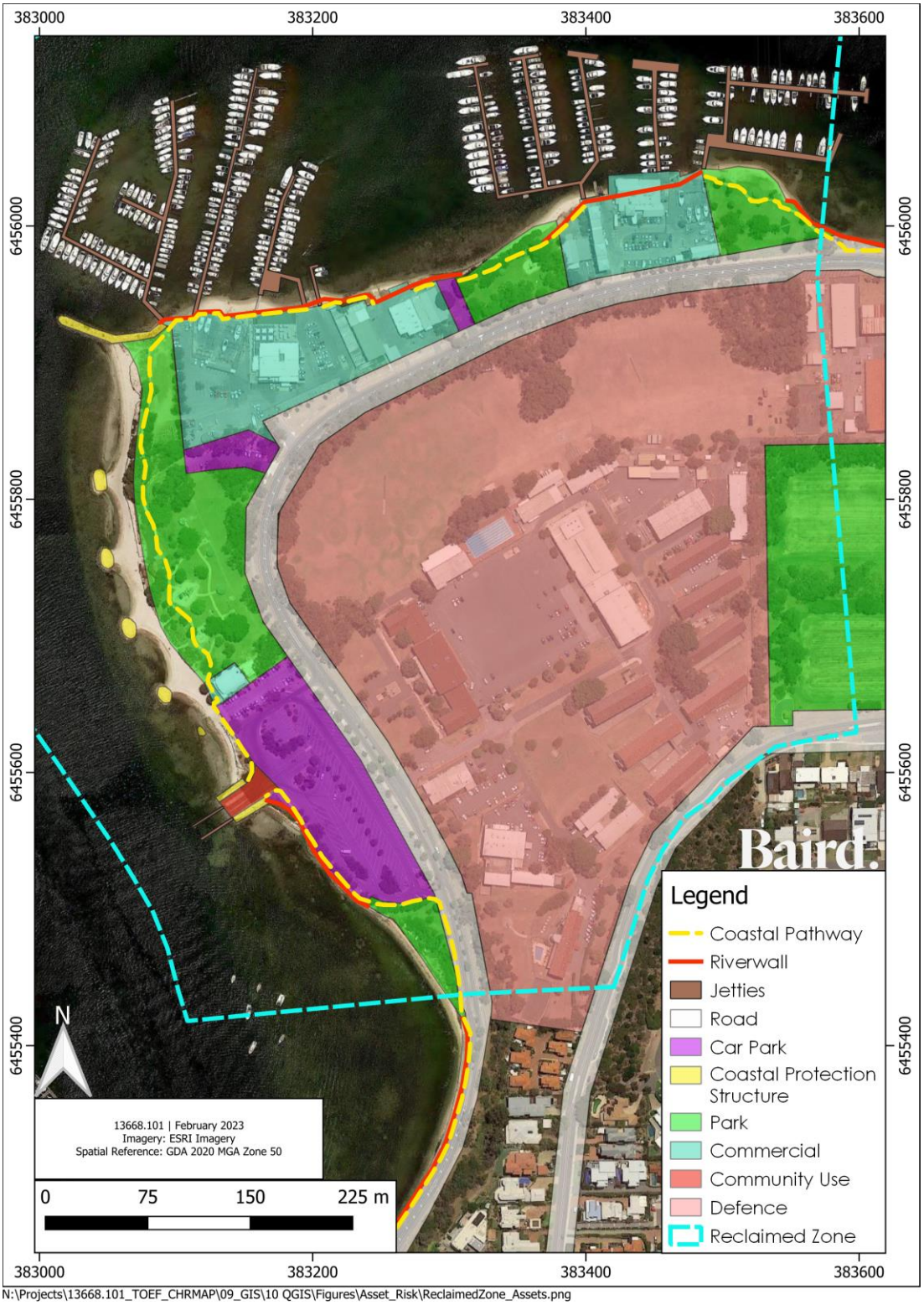

Figure 6.4: Land use and coastal assets in the Reclaimed Zone

Table 6.4: Coastal Asset Identification. SMU3 – Natural Zone.

Asset Type	Asset
Environmental	River walls
	Street Trees
	Beaches within Jerrat Drive escarpment
Social	Coastal Pathways
	Cycle Pathway on Riverside Road
	Community and Sporting Groups (EFYC, Sea Scouts, Sports grounds, Tennis Club etc)
	Beach access
Economic	East Fremantle Yacht Club, including car park
	Department of Defence buildings and wharves
	Riverside Drive, Jerrat Drive and road connections
	Boat ramps, moorings and jetties
	Town Infrastructure (bins, signage, shelters, fencing, water fountains, beach access stairs)
	Drainage features (pits, pipes, culverts, stormwater outlets)
	Minor carpark and seating at entrance to Jerrat Drive
	Drainage features (pits, pipes, culverts, stormwater outlets)
Heritage and Culture	The limestone cliffs near the East Fremantle Yacht Club are listed on the Town's Heritage List for conservation

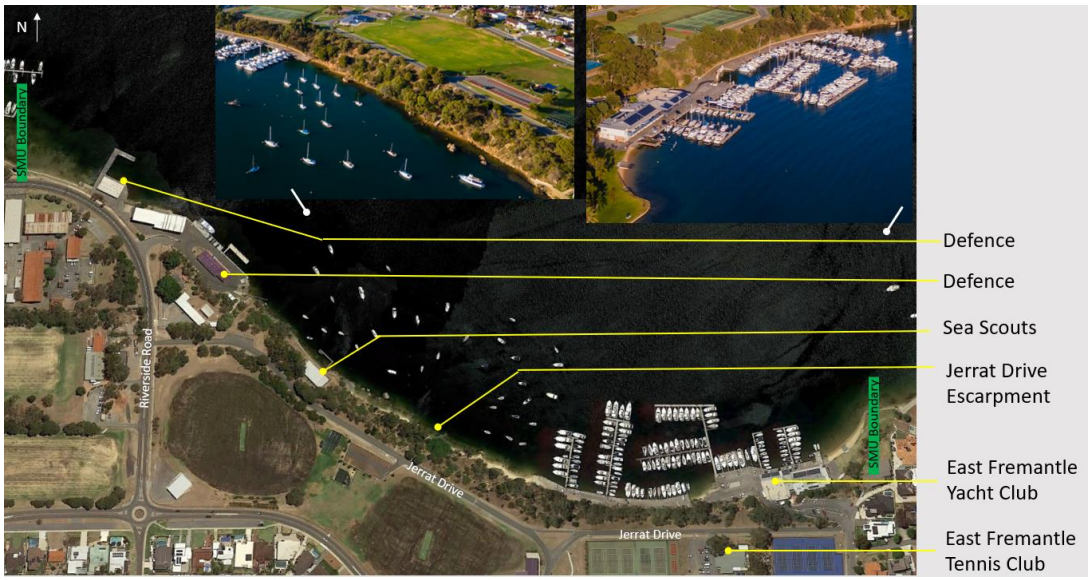

Figure 6.5: Overview of key sites located in the shoreline section of the 'Natural Zone' (SMU3)

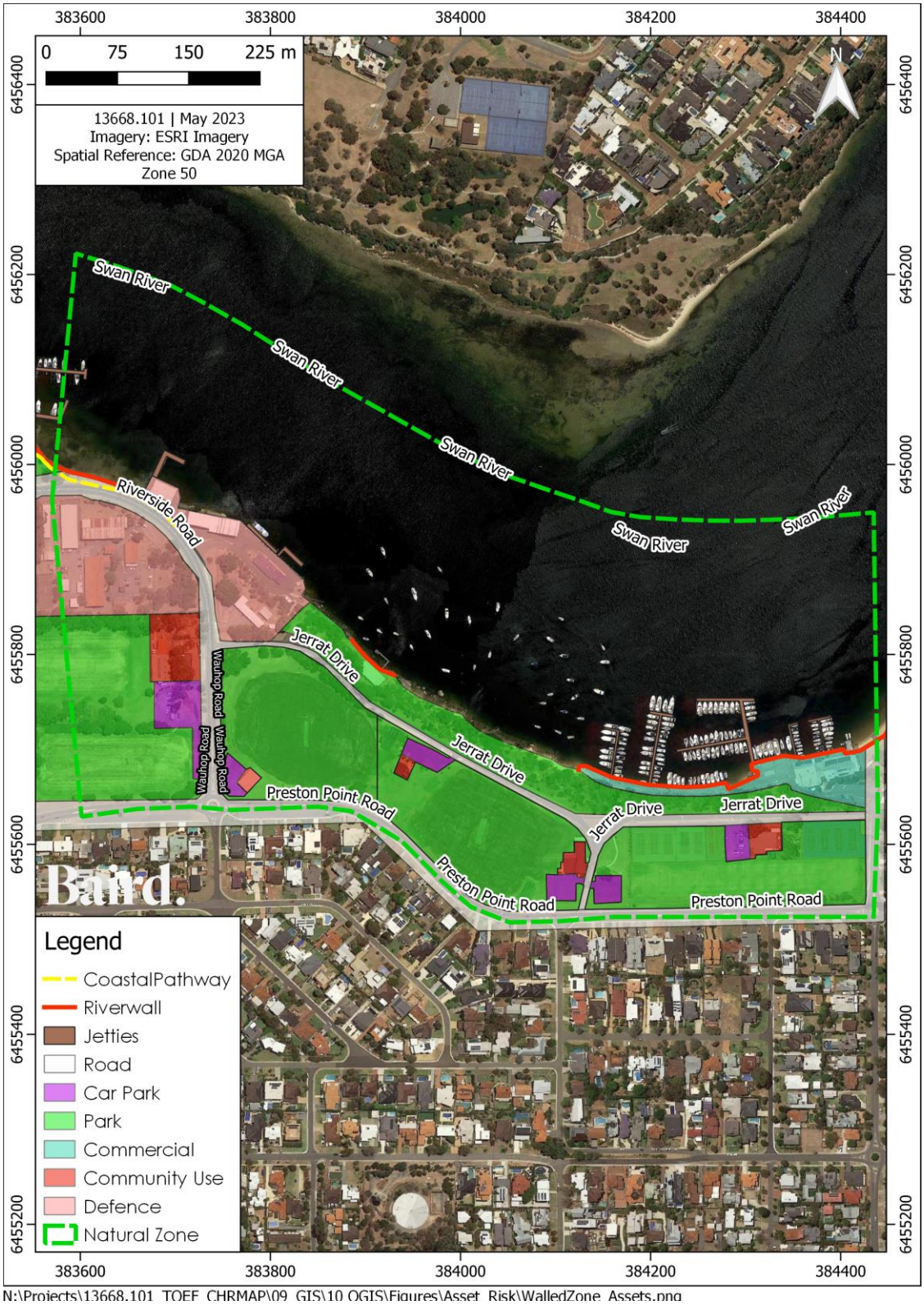

Figure 6.6: Land use and coastal assets in the Natural Zone

7. Risk Assessment Framework

7.1 Vulnerability Assessment

To determine the coastal assets that are most vulnerable to coastal hazard requires consideration of the asset's exposure to coastal hazard, the sensitivity of the asset to the impacts from exposure and its adaptive capacity.

For the coastal assets identified in each of the shoreline management units (SMU's) in the previous Section, a vulnerability assessment has been undertaken to determine how the effects of coastal hazards are predicted to impact assets in current and future planning periods.

The CHRMAP vulnerability assessment first considers the potential impact to coastal assets as a combination of the *likelihood* and the *consequence* of that hazard occurring. The vulnerability assessment then considers the adaptive capacity of coastal assets; that is, the ability of a coastal asset to accommodate coastal hazard impact.

The vulnerability assessment process is presented in Figure 7.1 (WAPC 2019).

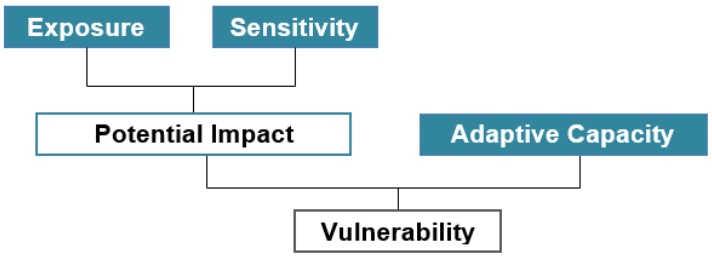

Figure 7.1: Vulnerability Assessment Flowchart (from WAPC 2014).

The key components in the vulnerability assessment are:

- Exposure = *Likelihood* of coastal hazard occurring
- Sensitivity = *Consequence* of coastal asset being impacted
- Potential impact = *Risk* to coastal assets as a product of likelihood and consequence
- Adaptive Capacity = The ability for an asset to accommodate the coastal hazard impact and recover
- Vulnerability = Final risk rating which incorporates the adaptive capacity of the asset

The application of the key components in the vulnerability assessment is explained in the following sections of this report.

7.2 Likelihood

7.2.1 Likelihood Definitions

In risk management terms, 'likelihood' is the chance of something happening, and is similar to the concept of probability. The likelihood scale that has been developed for the CHRMAP follows the guidance presented in WAPC (2019). The definitions for the likelihood scale are shown on Table 7.1 with each category associated in terms of a generalised description and approximate Annual Exceedence Probability (AEP).

Table 7.1: Likelihood Scale Definitions (WAPC 2019, AS5334-2013)

Rating	Description	Indicative Annual Exceedance Probability (AEP)
Almost Certain	The event is expected to occur in most circumstances	Has a greater than 95% chance of occurring in the identified time period if the risk is not mitigated
Likely	The event will probably occur in most circumstances	Has a 63-95% chance of occurring in the identified time period if the risk is not mitigated
Possible	The event should occur at some time	Has a 20-63% chance of occurring in the identified time period if the risk is not mitigated
Unlikely	The event could occur at some time	Has a 5-20% chance of occurring in the identified time period if the risk is not mitigated
Rare	The event may only occur in exceptional circumstances	May occur in exceptional circumstances, i.e. less than 5% chance of occurring in the identified time period if the risk is not mitigated

7.2.2 Likelihood Scale – Coastal Erosion

The erosion hazard for the shoreline areas is based on the coastal process allowances that have been calculated in the Coastal Hazard Assessment (Baird 2023). The planning timeframes adopted are 2025, 2035, 2050, 2075 and 2125. The CHRMAP erosion likelihood scale is developed based on the following:

- Coastal process allowances are considered as the 'Possible' category in each respective planning year.
- It is assumed that a level of erosion risk that is 'Possible' today becomes more likely in future time periods (i.e. 'Likely' or 'Almost Certain').
- Lower categories of likelihood ('Unlikely', 'Rare') can be defined by the scenarios defined at a future time frame.

Through this approach the likelihood scale has been developed. An example is given for the planning year 2050:

- Almost Certain Coastal Processes Allowance line 2025
- Likely Coastal Processes Allowance line 2035
- Possible Coastal Processes Allowance line 2050
- Unlikely Coastal Processes Allowance line 2075
- Rare Coastal Processes Allowance line 2125

The application of this process through all planning periods is presented in Table 7.2.

Table 7.2: Town of East Fremantle CHRMAP Likelihood Scale for Coastal Erosion

Likelihood Category	2025 Planning Period	2035 Planning Period	2050 Planning Period	2075 Planning Period	2125 Planning Period
Almost Certain	-	-	2025 Erosion	2035 Erosion	2050 Erosion
Likely	-	2025 Erosion	2035 Erosion	2050 Erosion	2075 Erosion
Possible	2025 Erosion	2035 Erosion	2050 Erosion	2075 Erosion	2125 Erosion
Unlikely	2035 Erosion	2050 Erosion	2075 Erosion	2125 Erosion	-
Rare	2050 Erosion	2075 Erosion	2125 Erosion	-	-

7.2.3 Coastal Inundation Likelihood Scale

The inundation likelihood scale is developed using the coastal hazard inundation levels calculated for the study area at return periods 2 yr, 10yr, 100 yr and 500 yr ARI. Each respective return period is assigned a likelihood category generally based on the probability of occurrence (refer Table 7.1).

In future planning periods sea level rise (SLR) is included in the likelihood scale. The SLR recommendations for Western Australia applicable at a planning level are outlined in DoT (2010) and have been adopted over the 2025 to 2125 period as summarised in Table 7.3.

Table 7.3: Sea level rise allowances over the planning timeframe of the CHRMAP study.

Planning Year	2025	2035	2050	2075	2125
Sea Level Rise	0m	+0.1m	+0.2m	+0.5m	+1.05m

The coastal inundation likelihood scale categories are shown in Table 7.4 and the corresponding level is shown in Table 7.5:

- The ARI categories selected to represent the likelihood categories ‘Likely’, ‘Possible’, ‘Unlikely’ and ‘Rare’ are based on the 2 yr, 10yr, 100 yr and 500 yr ARI respectively and include the SLR corresponding to the planning year.
- The Almost Certain category has been established based on the highest astronomical tide level (HAT).

Table 7.4: Inundation Likelihood Categories

Rating	2025	2035 +0.1m SLR	2050 +0.2m SLR	2075 +0.5m SLR	2125 +1.05m SLR
Almost Certain	2025 HAT	2035 HAT	2050 HAT	2075 HAT	2125 HAT
Likely	2025 2yr ARI	2035 2yr ARI	2050 2yr ARI	2075 2yr ARI	2125 2yr ARI
Possible	2025 10yr ARI	2035 10yr ARI	2050 10yr ARI	2075 10yr ARI	2125 10yr ARI
Unlikely	2025 100yr ARI	2035 100yr ARI	2050 100yr ARI	2075 100yr ARI	2125 100yr ARI
Rare	2025 500yr ARI	2035 500yr ARI	2050 500yr ARI	2075 500yr ARI	2125 500yr ARI

Table 7.5: Inundation Likelihood for East Fremantle - Water Level (Vertical Datum m AHD)

Rating	2025 Water Level (m AHD)	2035 Water Level (m AHD)	2050 Water Level (m AHD)	2075 Water Level (m AHD)	2125 Water Level (m AHD)
Almost Certain	<=0.6m	<=0.7m	<=0.8m	<=1.1m	<=1.7m
Likely	>0.6 to 1.0m	.>0.7 to 1.1m	>0.8 to 1.2m	>1.1 to <1.5m	>1.7 to 2.1m
Possible	>1.0 to 1.1m	>1.1 to 1.2m	>1.2 to 1.3m	>1.5m to 1.6m	>2.1 to 2.2m
Unlikely	>1.1 to 1.3m	>1.2 to 1.4m	>1.3 to 1.5m	>1.6m to 1.8m	>2.2 to 2.4m
Rare	>1.3m	>1.4m	>1.5m	>1.8m	>2.4m

7.3 Consequence

7.3.1 Consequence Scale

Consequence is used to describe the impact to assets when coastal hazard is realised. The consequence of coastal hazard is considered across a range of categories representing severity: 'Insignificant, Minor, Moderate, Major, Catastrophic'.

The consequence scale considers impact in terms of Physical, Environmental and Social impact and is shown in Table 7.6.

Table 7.6: Consequence Scale

Rating	Economic Impact	Environmental Impact	Social / Cultural Impact	Infrastructure
Catastrophic	Permanent loss or damage > $5 million	Permanent loss of flora and fauna – will not recover	Long-term or permanent loss of function >75% of community affected	Damage to majority of infrastructure (>75%)
Major	Permanent loss or damage $2 - $5 million	Long term loss of flora and fauna, limited chance of recovery	Medium-term disruption to function <50% of community affected	Damage to significant proportion of infrastructure (50% to 75%)
Moderate	Permanent loss or damage $200k -$2mil	Medium term loss of flora and fauna. Recovery likely	Minor long Term or major Short-Term loss of function <25% of community affected	Damage to up to half the infrastructure (25% to 50%)
Minor	Permanent loss or damage $20k - $200k	Short term loss of flora and fauna. Strong Recovery	Small to medium disruption to function <10% of community affected	Minor damage (10 to 25%)
Insignificant	Permanent loss or damage < $ 20k	Negligible to no loss of flora and fauna	Minimal short-term inconvenience <5% of community affected	Little or no damage (<10%)

The consequence scale was presented in the information boards of the George Street Festival engagement sessions (December 2022), with community discussion and feedback welcomed on the rating scale for erosion and inundation within each of the SMUs.

7.3.2 Safety and Structural Considerations

For the Town study area the risk of inundation will be an important consideration for the council owned and commercial structures in the shoreline areas. Inundation depth in extreme events and the safety and stability limits for people and structures in floodwaters generally requires consideration of flood depth and velocity. Safety limits for people and infrastructure based on velocity and depth is presented in Figure 7.2 (from Smith et al 2014).

A limitation of the flooding results available to the CHRMAP study is that velocity is not available for the extreme events. In the absence of velocity information, the flood hazard curve is used as follows:

- A flood level of 1m over the finished floor level has been adopted as representing a threshold where structures would fail, unless specifically constructed to withstand flooding (category H5 in Figure 7.2).
- At a depth of 1m, there is a risk posed to the safety of people. For the consequence rating for inundation of houses, a depth of flooding greater than 1.0m above the finished floor level is categorised as major consequence, below this depth the rating is moderate.

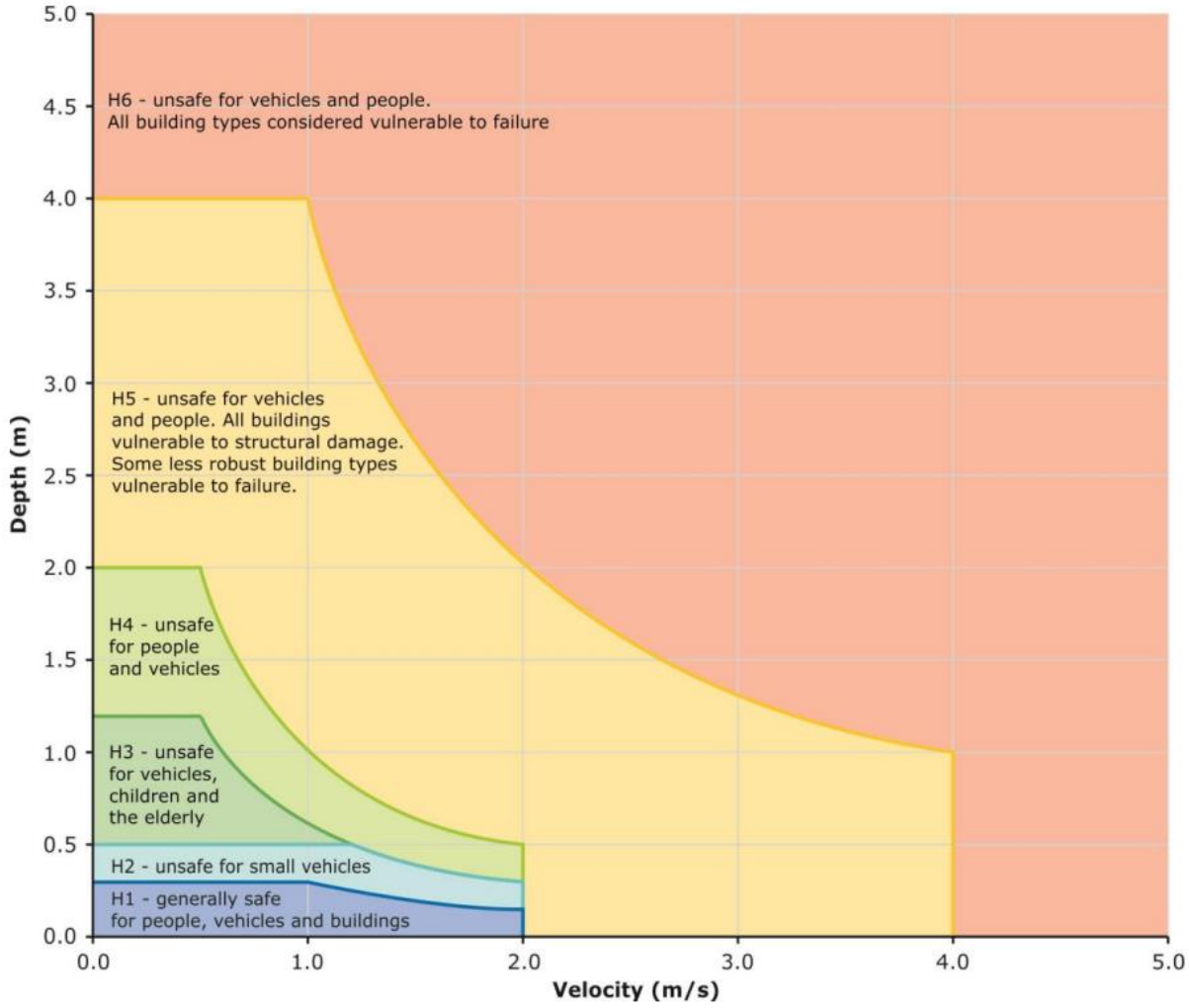

Figure 7.2: Flood Hazard Curve – Vulnerability thresholds as a Product of Inundation Depth and Velocity (from Smith et al 2014)

7.3.3 Consequence Rating – Coastal Asset Register

The consequence of coastal hazard impact is different for each respective coastal asset and severity of impact is dependent on the hazard type – as an example the consequence of erosion for a shoreline is much more severe than that of inundation.

The consequence rating is shown in Table 7.7 for each of the assets identified in the SMU's (refer Section 6). Separate ratings are presented for consequence of erosion and for consequence of inundation.

It is noted that the consequence rating in Table 7.7 overleaf is the 'worst' rating across the categories Economic, Environmental, Social/Cultural and Infrastructure for each respective asset.

Table 7.7: Consequence Rating for Coastal assets – Erosion and Inundation

Asset Type	Erosion	Inundation
	Consequence	Consequence
Houses	Major	Moderate[1]
Vacant Land (Residential)	Moderate	Minor
Commercial / Community Structures[2]	Major	Moderate[1]
Riverside Road	Major	Moderate
Carparks	Moderate	Minor
Beaches	Major	Insignificant
Riverbanks	Major	Insignificant
Foreshore Reserve	Moderate	Minor
Riverwalls and Revetments	Not Assessed	Minor
Jetties and Boat Ramps	Moderate	Minor
Park Furniture (Benches, Gazebo, BBQ, Play equipment)	Minor	Minor
Minor Infrastructure (signage, shelters, fencing)	Insignificant	Insignificant
Coastal Pathway / cycle paths	Moderate	Minor
Stormwater pipes / outlets, culverts	Moderate	Minor
Toilets	Minor	Minor
Footpaths	Minor	Minor

Notes

1. For buildings with depth of flooding >1.0m over the Finished Floor level the consequence is rated as major. Below this level the rating is moderate.
2. Swan Yacht Club, East Fremantle Yacht Club, Zephyrs, Sea Scouts, Marine Boatshed, Dome Café, The Left Bank, 8 Knots Tavern, Navy Cadets, Cool Beans, Rowing Club

8. Level of Risk

8.1 Potential Impact

The assessment of potential impact to coastal assets uses the product of the likelihood and consequence to determine a level of risk.

Risk ratings are designated in four categories based on WAPC (2019):

1. Extreme - risks are intolerable, requiring immediate implementation of risk management measures.
2. High - risks are the most severe that can be tolerated and need monitoring in the short term as risk management measures are likely to be needed in the short-term.
3. Medium - risk can be tolerated and need monitoring in the short to medium term.
4. Low - risk can be accepted, no risk management measures will be required in the short to medium term other than monitoring.

The risk level matrix is presented in Table 8.1.

Table 8.1: Potential Impact Scale - Likelihood / Consequences matrix to assess level of risk

		CONSEQUENCE				
		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Almost Certain	Medium	High	Extreme	Extreme	Extreme
	Likely	Low	Medium	High	Extreme	Extreme
	Possible	Low	Medium	High	High	Extreme
	Unlikely	Low	Low	Medium	Medium	High
	Rare	Low	Low	Low	Medium	Medium

For the assets in the asset register the risk rating has been determined in each planning timeframe for each of the SMU's. The summary is presented in Appendix D.1 for erosion and Appendix D.2 for inundation.

8.2 Risk Acceptance and Tolerance

The risk tolerance scale provides the basis for decision making to inform which risk, locations and assets require risk management measures as a priority. For the level of risk defined for the coastal assets, the corresponding tolerance scale is shown on Table 8.2. The tolerance scale has been developed from engagement with the community and based on the approach in WAPC (2019).

For a risk at the 'High' and 'Extreme' level, action to mitigate the risk is required. At lower level of risk, the risk is acceptable and no action is required.

Table 8.2: Risk Tolerance Scale

Risk Level	Action Required	Acceptance / Tolerance
Extreme	Immediate action required to eliminate or reduce the risk to acceptable levels	Unacceptable / Intolerable
High	Immediate to short term action required to eliminate or reduce the risk to acceptable levels	Tolerable
Medium	Short to medium term action to reduce the risk to acceptable levels, or accept risk	Tolerable / Acceptable
Low	Accept Risk	Acceptable

8.3 Adaptive Capacity

The concept of adaptive capacity recognises that some assets will cope with coastal hazard risk better than others. The coastal assets are rated with a consideration of how well they can recover from coastal inundation or erosion hazard, i.e. their potential to adjust to address risk arising from coastal hazards with minimal disruption and cost.

The adaptive capacity scale of the assets adopts a rating in one of three categories from worst performing ('Poor') to best performing ('Good') as shown in Table 8.3 developed from WAPC (2019).

Table 8.3: Adaptive Capacity Rating for Coastal Assets (based on WAPC 2019)

Rating	Adaptive Capacity
Poor	• Little or no adaptive capacity. Potential impact would destroy all functionality. Redesign required
Average	• Small amount of adaptive capacity. Difficult but possible to restore functionality through repair and redesign
Good	• Good adaptive capacity. Functionality restored easily. • Adaptive systems restored at a relatively low cost or naturally over time.

The potential for an asset to recover from the impact of either erosion or inundation is generally different and has been rated separately. A summary of the adaptive capacity ratings is provided in Table 8.4.

Table 8.4: Adaptive Capacity Ratings of Coastal Assets – Erosion and Inundation

	Adaptive Capacity Rating	
Asset Type	**Erosion**	**Inundation**
Houses	Poor	Average [1]
Vacant Land	Average	Good
Commercial / Community Structures[2]	Poor	Average[1]
Local Roads (eg Riverside Road)	Poor	Average
Carparks	Poor	Good
Beaches	Average	Good
Riverbanks	Average	Good
Foreshore Reserve	Average	Good
Riverwalls and Revetments	Not Assessed	Good
Jetties and Boat Ramps	Average	Good
Parks & Playgrounds (Benches, Gazebo, BBQ, Play equipment)	Average	Average
Minor Infrastructure (signage, shelters, fencing)	Good	Good
Coastal Pathway / cycle paths	Average	Good
Stormwater pipes / outlets, culverts	Poor	Average
Toilets	Poor	Average

Notes

1. For houses and commercial business with depth of flooding >1.0m over the Finished Floor level the adaptive capacity is rated as poor.

8.4 Vulnerability Scales

Using the risk level calculated in the potential impact stage the adaptive capacity of the respective assets was then considered to determine the final vulnerability rating for each of the assets.

Table 8.5: Asset Vulnerability Matrix

Potential Impact	Adaptive Capacity Rating		
	Poor	Average	Good
Extreme	Very High	Very High	High
High	Very High	High	Medium
Medium	High	Medium	Low
Low	Medium	Low	Low

A vulnerability tolerance scale determines the level at which vulnerability is deemed acceptable, tolerable or intolerable. The vulnerability tolerance scale is shown in Table 8.6 developed from WAPC (2019) and used to identify which risk, locations, assets and values require risk management measures as a priority.

Table 8.6: Vulnerability Tolerance Scale

Risk Level	Action Required	Acceptance / Tolerance
Very High	Asset has minimal ability to cope with the impacts of coastal hazards without additional support. Adaptation will need to be considered as a priority.	Unacceptable / Intolerable
High	Asset has limited ability to cope with the impacts of coastal hazards. Immediate to short-term adaptation is likely to be required to reduce risk to acceptable levels.	Tolerable
Medium	Asset has some ability to cope with the impacts of coastal hazards. However short to medium term actions are likely to be required to reduce risk to acceptable levels	Tolerable / Acceptable
Low	Asset has high resilience; it is able to cope with the impacts of coastal hazards without additional support. No immediate action required	Acceptable

9. Risk Assessment Outcomes

The outcomes of the risk assessment are discussed here for the three SMU's based on the full results of the risk assessment presented in **Appendix D.1** for erosion risk and **Appendix D.2** for inundation risk.

9.1 SMU1 – Walled Zone

The Walled Zone (SMU1) extends along approximately 1.4 km on the eastern side of the Swan River. There is a continuous line of river walls and revetments along the entire length of the shoreline, which prevents erosion. There is a coastal path along the edge of the shoreline which is highly utilised and valued by the community for recreation (eg walking, running, cycling) with foreshore reserve landward that varies in width with the proximity of Riverside Drive.

Along the foreshore there are parks, carparks, moorings and jetties as well as structures built over the water such as the Dome café and the Marine Education boatshed. Whilst the walled zone is afforded protection from erosion, the coastal pathway and carpark areas are susceptible to inundation from elevated ocean level during storm events. Additionally, boat wakes can cause overtopping of the shoreline in certain locations periodically.

Riverside drive is a key road connection which follows the shoreline. The elevation of Riverside drive is generally well above the 100-yr ARI water level (1.3m AHD, planning year 2025) with the exception of low points adjacent East Street (refer Figure 9.1) and north of the Marine boatshed. In the strip of land on the eastern side of Riverside Drive, there is road reserve, park areas, residential properties and The Left Bank hotel. The topography rises to a height of over 10mAHD very rapidly on the east side of the river approaching Canning Highway, offering natural protection from inundation.

There are two locations along the eastern edge of Riverside Road where residential property is situated. These are shown in Figure 9.1 for the section near East Street and in Figure 9.2 for the section south of Pier Street. For these locations the elevation data has been analysed to determine the critical point at which residential houses would be impacted by floodwaters which is at 2.0m and 2.5m AHD respectively. All other residential land in the Walled Zone SMU is located at a height above 5m AHD, well above any influence from extreme storm events.

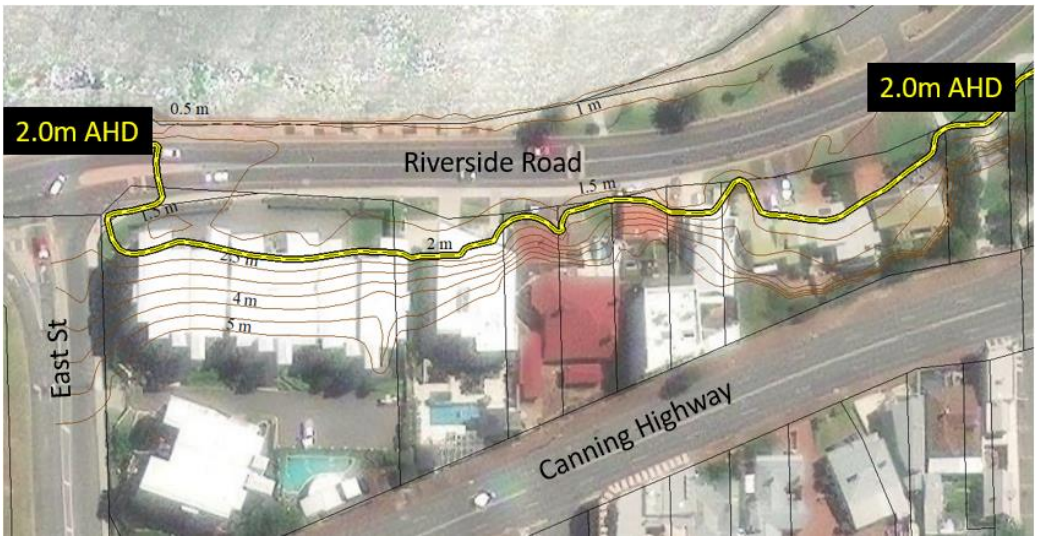

Figure 9.1: Residential properties on Riverside Road on the east side of East Street. The elevation contours are shown in the range of 0m to 5m AHD at 0.5m increments. The highlighted contour line at 2.0mAHD is adopted as the critical level for inundation of existing houses.

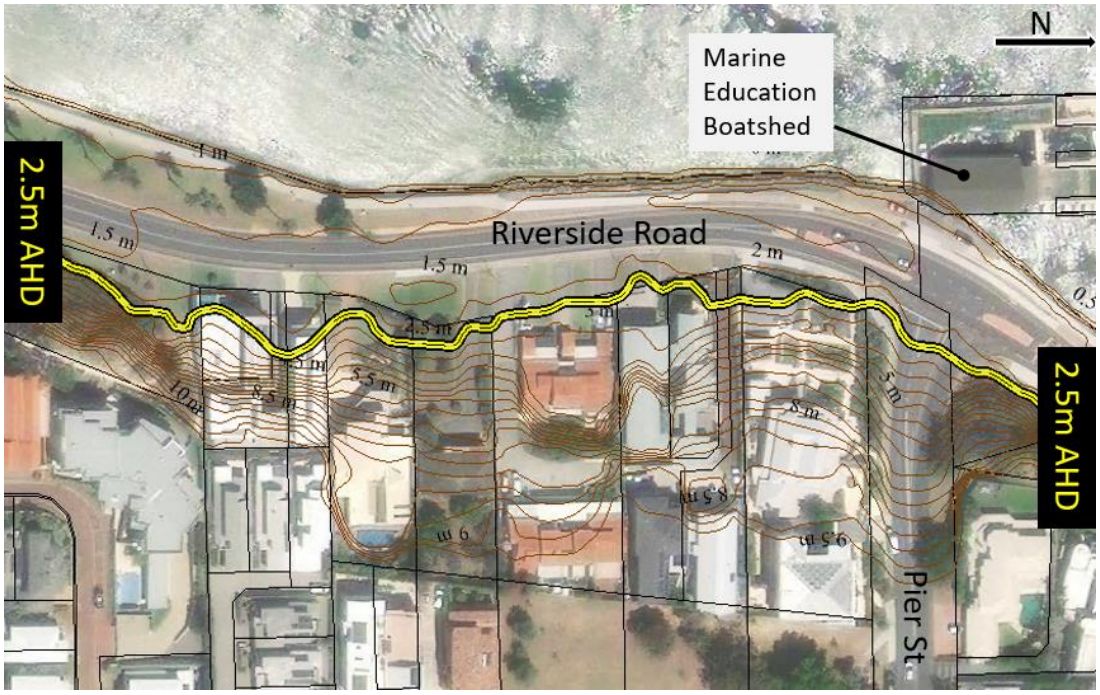

Figure 9.2: Residential properties on Riverside Road on the south side of Pier Street. The elevation contours are shown in the range of 0m to 10m AHD at 0.5m increments. The highlighted contour line at 2.5mAHD is adopted as the critical level for inundation of existing houses.

9.1.1 Vulnerability of Coastal Assets to Erosion in SMU1

The erosion risk for coastal assets in the Walled Zone is minimal, due to the continuous riverwall and protection structures along the shoreline (Table 9.1). The coastal assets rated as being 'Highly vulnerable' are the drainage outfall pipes, the jetties and moorings all of which are located directly at the water's edge.

The importance of Riverside Road and high value of the foreshore reserve for the community warrants that in future planning periods the protection of the shore will continue, to maintain the present-day level of protection for the road (refer guidance from the DBCA in Section 13.3).

The format of the protection may be riverwalls as exists presently or some other shoreline feature (eg engineered solution, nature based option or another yet to be determined approach) that can deliver the required outcome of protecting Riverside Road from erosion risk. This is discussed further in the Risk Treatment stage of CHRMAP (Chapter 13).

Table 9.1: Walled Zone (SMU1) Vulnerability analysis - Erosion

	Vulnerability - Incl. Adaptive Capacity			
	2035	2050	2075	2125
Road Reserve - Lower Merv Cowan (East Riv Drv)	L	L	L	L
Toilet Block - Lower Merv Cowan (East Riv Drv)	L	L	L	L
Riverside Road - Niergarup Reserve to Pier Street	L	L	L	L
Riverside Road - Pier Street to Dome Café	L	L	L	L
Riverside Road Dome Café to Stirling Bridge	L	L	L	L
Riverside Road - Stirling Bridge to J Dolan Park	L	L	L	L
J Dolan Park	L	L	L	L
Riverwalls protecting shoreline				
Coastal Pathways - Niergarup Reserve to Pier Street	L	L	L	L
Coastal Pathways - Pier Street to Dome Café	L	L	L	L
Coastal Pathways - Dome Café to Stirling Bridge	L	L	L	L
Coastal Pathways - Stirling Bridge to J Dolan Park	L	L	L	L
Boat ramps, moorings, jetties	H	H	E	E
Residential Properties - Riverside Rd / East St	L	L	L	L
Residential Properties - Riverside Rd / Pier St	L	L	L	L
Marine Education Boatshed	L	L	L	L
Dome Café	L	L	L	L
Minor Infrastructure (bins, signage, shelters, fencing)	L	L	L	L
Carpark - Public Carpark No 4 (Dome Cafe)	L	L	L	L
Carpark - J Dolan Park	L	L	L	L
Left Bank	L	L	L	L
Playground Equipment – north of Dome Cafe	L	L	L	L
Shelters, seating and picnic tables – J Dolan Park	L	L	L	L
Shelters, seating and picnic tables – North of Dome Cafe	L	L	L	L
Drainage features (pits, pipes, culverts, stormwater outlets)	H	H	E	E

9.1.2 Vulnerability of Coastal Assets to inundation in SMU1

The vulnerability of coastal assets to inundation for SMU1 is shown in Table 9.2:

- Carparks at the Dome café and J.Dolan park are rated Moderate at the 2035 planning period, and rated High in the 2050 and 2075 periods respectively.
- The Marine Education boatshed and Dome café are rated High at 2035, increasing to Extreme in the 2075 and 2125 periods respectively.
- Coastal pathways are rated at Low vulnerability presently and increase to Moderate rating in the 2050 to 2075 planning period.
- Riverside Road is rated Moderate at the section north of Pier St in the 2035 planning period. The whole of riverside Rd is rated Highly vulnerable at the 2125 period.
- Riverside Rd residential properties adjacent East St are rated at Low vulnerability presently and up until the 2125 planning period where they are rated as Highly vulnerable driven by projected sea level rise.
- The Left Bank hotel is rated at Low vulnerability presently and up until the 2125 planning period where its rating increases to Highly vulnerable driven by projected sea level rise.

It is noted that the elevation of the Marine Education boatshed, Dome Café and Riverside Road residential properties is based on nearby land levels captured by survey (LiDAR). The additional raised finished floor level is not considered in this initial analysis. The assumption of floor levels is considered in more detail in the Risk Evaluation phase (Section 13).

Table 9.2: Walled Zone (SMU1) Vulnerability analysis - Inundation

	Vulnerability - Incl. Adaptive Capacity			
Description	2035	2050	2075	2125
Road Reserve - Lower Merv Cowan (East Riv Drv)	L	L	L	M
Toilet Block - Lower Merv Cowan (East Riv Drv)	L	L	L	M
Riverside Road - Niergarup Reserve to Pier Street	M	M	M	H
Riverside Road - Pier Street to Dome Café	L	L	M	H
Riverside Road Dome Café to Stirling Bridge	L	L	M	H
Riverside Road - Stirling Bridge to J Dolan Park	M	M	M	H
J Dolan Park	L	L	M	M
Riverwalls protecting shoreline	L	L	M	M
Coastal Pathways - Niergarup Reserve to Pier Street	L	L	M	M
Coastal Pathways - Pier Street to Dome Café	L	L	M	M
Coastal Pathways - Dome Café to Stirling Bridge	L	M	M	M
Coastal Pathways - Stirling Bridge to J Dolan Park	L	L	M	M
Boat ramps, moorings, jetties	M	M	M	M
Residential Properties - Riverside Rd / East St	L	L	L	H
Residential Properties - Riverside Rd / Pier St	L	L	L	L
Marine Education Boatshed	H	H	E	E
Dome Café	H	H	H	E
Minor Infrastructure (bins, signage, shelters, fencing)	L	L	M	M
Carpark - Public Carpark No 4 (Dome Cafe)	M	H	H	H
Carpark - J Dolan Park	M	M	H	H
Left Bank	L	L	L	H
Playground Equipment – north of Dome Cafe	L	L	M	M
Shelters, seating and picnic tables – J Dolan Park	L	L	M	M
Shelters, seating and picnic tables – North of Dome Cafe	L	L	M	M
Drainage features (pits, pipes, culverts, stormwater outlets)	L	L	M	M

9.2 SMU2 – Reclaimed Zone

The Reclaimed Zone (SMU2) extends along approximately 1.2 km of the river and is comparatively lower elevation compared with the adjacent sections of the shoreline. The elevation on the section of Riverside Rd adjacent Aquarama is lowest at approximately 1m AHD, with the rest of Riverside Rd in the range of 1.1m to 1.3m AHD. The river bends around Preston Point in this section and the shoreline along the John Tonkin Park side faces west-southwest whilst the shoreline is generally north facing for the section on which the Swan Yacht Club, Aquarama and W Wayman Reserve are located.

The shoreline features change along the SMU from natural sandy shoreline fronting the Niergarup Reserve, to a sloped rock revetment and boat ramp adjacent Zephyr's café, to the sandy shoreline in the lee of the detached breakwaters at John Tonkin Park. Along the north facing shorelines around Preston Point, there are moorings and jetties for the Swan Yacht Club with seawalls protecting the shoreline as well as sections of natural shoreline in front of Norm McKenzie Park.

Commercial sites along the north facing section of river cater for the Swan Yacht Club, Aquarama, 8 Knots Tavern, Cool Beans café and several clubs and community groups. There are three parks in the SMU, several car parks and Riverside Road. The Leuuwin Barracks site occupies the majority of the area landward of Riverside Road.

9.2.1 Vulnerability of Coastal Assets to Erosion

For vulnerability rating of assets to erosion is shown in Table 9.3:

- For coastal assets landward of the shoreline where protection structures are located presently there is no risk (Rated 'Low'). Vulnerability rating in the assessment in Table 9.3 considers the structures remain in place. The future strategy to either continue to protect the shoreline or to pursue a different approach (such as accommodate or managed retreat) is examined in more detail in the Risk Treatment (Section 13).
- The natural shoreline areas at the beach of Niergarup Reserve, Norm McKenzie Park and W. Wayman Reserve are all rated as highly vulnerable from the 2035 period, with the rating of Extreme from 2075.
- The section of Riverside Road adjacent the Niergarup Reserve is rated as highly vulnerable in the planning year 2050 and extreme in the year 2075.
- The coastal pathway at W.Wayman Reserve is rated as Highly vulnerable by 2035.

Table 9.3: Reclaimed Zone (SMU2) Vulnerability analysis - Erosion

	Vulnerability - Incl. Adaptive Capacity			
	2035	2050	2075	2125
Niergarup Reserve	H	H	E	E
Coastal Pathway - John Tonkin Reserve	L	L	L	L
Coastal Pathway - Norm McKenzie Park	M	H	H	E
Norm McKenzie Park Foreshore Reserve Area	H	H	E	E
Norm McKenzie Park - Playground	L	L	M	H
Norm McKenzie Park - Roadside Shelter and BBQ	L	L	M	M
W Wayman Reserve - Foreshore Reserve Area	H	H	E	E
W Wayman Reserve - Pathway	H	H	E	E
W Wayman Reserve - Shelter	L	M	M	H
W Wayman Reserve - Exercise Equipment	L	L	L	L
Detached groyne field	L	L	L	L
John Tonkin Reserve - Playground	L	L	L	L
John Tonkin Reserve - Gazebos	L	L	L	L
Riverwalls protecting shoreline				
Navy Cadets	L	L	L	L
Beach access pathways	L	L	L	L
Leeuwin Barracks - Existing Carpark / Builings	L	L	L	L
Leeuwin Barracks -Park Area Adjacent Riv Drv	L	L	L	L
Aquarama Marina (CarPark East Side)	L	L	L	L
Aquamarina Bulding (adj Riv Drv)	L	L	L	L
8 Knots Tavern	L	L	L	L
Rowing Club	L	L	M	H
Minor Infrastructure (bins,signage, shelters, fencing)	L	L	L	L
Moorings	L	L	L	L
Cool Beans Café	L	L	L	L
Swan Yacht Club	L	L	L	L
Zephyr Cafe	L	L	L	L
Boat Ramp	L	L	L	L
Riverside Road	M	H	E	E
Car parks – Public Car Park No 1 (Boat Ramp)	L	L	L	L
Car parks – Public Car Park No 2 (John Tonkin North)	L	L	L	L
Car parks – Public Car Park No 5 (Cool Beans)	L	L	L	L
Car parks - Public Car Park No 3 – Zephyr Café	L	L	L	L
Car parks – Swan Yacht Club	L	L	L	L
Car parks – Fremantle Rowing Club	L	L	L	L
Drainage features (pits, pipes, culverts, outlets)	H	H	E	E

9.2.2 Vulnerability of Coastal Assets to Inundation

For inundation the results are shown in Table 9.4:

- The 8 Knots tavern, Cool Beans Café and Rowing Club are rated highly vulnerable by 2035. The Swan Yacht Club, Aquarama and Navy Cadets are similarly rated highly vulnerable at 2050 with 8 Knots Tavern rating moving to Extreme.
- Carparks are generally rated Moderate till the 2075 period, moving to be rated Highly vulnerable in the 2075 to 2125 planning period.
- Coastal pathways are rated as Low to Moderate throughout, recognising the high adaptive capacity to short term inundation.
- Playground areas in John Tonkin Park and Norm McKenzie Park are rated highly vulnerable by 2075.
- Riverside Road is rated highly vulnerable from the 2075 period onwards.

It is noted that the elevation of the commercial and club buildings (eg Swan yacht club, 8 Knots Tavern) assumed in the analysis is based on nearby land levels captured by survey (LiDAR). The additional raised finished floor level is not considered in this initial analysis. This will be captured in the Risk Evaluation phase (Section 11).

Table 9.4: Reclaimed Zone (SMU2) Vulnerability analysis - Inundation

	Vulnerability - Incl. Adaptive Capacity			
Description	2035	2050	2075	2125
Niergarup Reserve	L	M	M	M
Coastal Pathway - John Tonkin Reserve	L	L	M	M
Coastal Pathway - Norm McKenzie Park	L	L	M	M
Norm McKenzie Park Foreshore Reserve Area	L	L	M	M
Norm McKenzie Park - Playground	M	M	H	H
Norm McKenzie Park - Roadside Shelter and BBQ	L	M	M	H
W Wayman Reserve - Foreshore Reserve Area	M	M	M	M
W Wayman Reserve - Pathway	L	L	M	M
W Wayman Reserve - Shelter	L	L	M	M
W Wayman Reserve - Exercise Equipment	L	M	M	H
Detached groyne field	M	M	M	M
John Tonkin Reserve - Playground	M	M	H	H
John Tonkin Reserve - Gazebos	L	L	M	M
Riverwalls protecting shoreline	L	L	M	M
Navy Cadets	M	H	H	E
Beach access pathways	M	M	M	M
Leeuwin Barracks - Existing Carpark / Builings	L	L	H	E
Leeuwin Barracks -Park Area Adjacent Riv Drv	L	L	L	M
Aquarama Marina (CarPark East Side)	M	M	H	H
Aquamarina Bulding (adj Riv Drv)	M	H	H	E
8 Knots Tavern	H	E	E	E
Rowing Club	H	H	H	E
Minor Infrastructure (bins,signage, shelters, fencing)	L	L	M	M
Moorings	L	M	M	M
Cool Beans Café	H	H	H	E
Swan Yacht Club	M	H	H	E
Zephyr Cafe	L	M	H	E
Boat Ramp	M	M	M	M
Riverside Road	M	M	H	H
Car parks – Public Car Park No 1 (Boat Ramp)	M	M	H	H
Car parks – Public Car Park No 2 (John Tonkin North)	L	M	M	H
Car parks – Public Car Park No 5 (Cool Beans)	L	M	M	H
Car parks - Public Car Park No 3 – Zephyr Café	M	M	M	H
Car parks – Swan Yacht Club	L	M	M	H
Car parks – Fremantle Rowing Club	M	M	M	H
Drainage features (pits, pipes, culverts, outlets)	L	L	M	M

9.3 SMU3 – Natural Zone

The Natural Zone (SMU3) commences from the end of W Wayman Reserve heading east along the river approximately 1km to the end of the East Fremantle Yacht club site. The shoreline area encompasses developed sections of river that are occupied by the Department of Defence, the Sea Scouts and the East Fremantle Yacht Club, with vertical walls, quayside walls and rubble mound fronting the shoreline.

The remainder of the shoreline is natural principally along the section of the Jerrat Drive escarpment between the sea scouts building and the East Fremantle Yacht club. The shoreline is north facing and there are narrow beaches of sandy riverbed meeting the limestone-based escarpment which is covered

with native vegetation. The escarpment is a highly valued natural site by the community and used for recreation.

The East Fremantle Yacht Club occupies a section of the shoreline at the eastern end of SMU3. The shoreline here has continuous vertical quaywall of varying types, with several ramps as well as jetties and moorings extending out from the shore. There is a small beach in front of the vertical wall on the eastern side of the Yacht Club.

A summary of the key findings for the Natural Zone (SMU3) are:

For erosion the results are shown in Table 9.5:

- The section of beach at the base of the Jerrat Drive escarpment is rated as Highly vulnerable by 2035 and Extreme from 2050 onwards.
- The foreshore area and access stairs at the base of the Jerrat Drive escarpment is rated as Highly vulnerable by 2035 and Extreme from 2075 onwards.
- For sections where coastal protection is in place currently at the Sea Scouts site and the East Fremantle Yacht Club, the rating is low for all assets landward. It is assumed these structures are maintained in future planning periods, continuing the present-day level of protection along the shoreline.

For inundation the results are shown in Table 9.6:

- The buildings of the East Fremantle Yacht Club are rated highly vulnerable by 2035, with the rating increasing to Extreme in the 2075 to 2125 period.
- The Sea Scouts building is rated highly vulnerable by 2050, with the rating increasing to Extreme in the 2075 to 2125 period.
- The foreshore at the base of Jerrat Drive and the quayside and carpark adjacent the East Fremantle Yacht Club is rated as Moderate at 2035 moving up to High from 2075 onwards.

It is noted that the elevation of the East Fremantle Yacht Club and Sea Scout buildings assumed in the analysis is based on nearby land levels captured by survey (LiDAR). The additional raised finished floor level is not considered in this initial analysis. This will be captured in the Risk Evaluation phase (Section 11).

Table 9.5: Natural Zone (SMU3) Vulnerability analysis - Erosion

	Vulnerability - Incl. Adaptive Capacity			
Description	**2035**	**2050**	**2075**	**2125**
Riverwalls				
Foreshore along Jerrat Drive	H	H	E	E
Beaches within Jerrat Drive escarpment	H	E	E	E
Fremantle Sea Scouts building	L	L	L	L
Beach access stairs to Jerrat Drive escarpment Beach	H	H	E	E
Department of Defence wharves				
East Fremantle Yacht Club Building	L	L	L	L
East Fremantle Yacht Club Lower Car Park, Boat Access Pathway	L	L	L	L
Jerrat Drive and road network	L	L	M	H
Boat ramps, moorings and jetties	M	H	H	H
Minor Infrastructure (bins, signage, shelters, fencing	L	L	L	L
Carpark at Jerrat Drive	L	L	L	M
Drainage features (pits, pipes, culverts, stormwater outlets)	H	H	E	E

Table 9.6: Natural Zone (SMU3) Vulnerability analysis - Inundation

	Vulnerability - Incl. Adaptive Capacity			
Description	**2035**	**2050**	**2075**	**2125**
Riverwalls	L	L	M	M
Foreshore along Jerrat Drive	L	L	M	M
Beaches within Jerrat Drive escarpment	L	L	L	L
Fremantle Sea Scouts building	M	H	H	E
Beach access stairs to Jerrat Drive escarpment Beach	L	L	M	M
Department of Defence wharves	L	L	M	H
East Fremantle Yacht Club (BUILDING)	H	H	H	E
East Fremantle Yacht Club Lower Car Park, Boat Access Pathway	M	M	H	H
Jerrat Drive and road network	L	L	L	L
Boat ramps, moorings and jetties	L	M	M	M
Minor Infrastructure (bins, signage, shelters, fencing, beach access stairs)	L	L	L	M
Carpark at Jerrat Drive	L	L	L	L
Drainage features (pits, pipes, culverts, stormwater outlets)	L	L	M	M

10. Risk Evaluation – Existing Controls

Existing controls and risk management measures already in place in the study area have the potential to reduce the consequences and/or likelihood of coastal hazard. Controls can be in the form of

- Physical controls (e.g. shoreline protection structures or seawalls);
- Natural controls (e.g. shoreline topography features); or
- Planning Controls (e.g. controls on building development like finished floor levels).

10.1 Physical and Natural Controls

Within the shoreline areas there are a range of physical and Natural controls. For each of the SMU's these controls and their influence are summarised in Table 10.1.

Table 10.1: Summary of Existing Controls in the Shoreline Management Units

SMU	Control	Comment
Walled Zone	1. Continuous line of shoreline protection - River walls, Revetments	Provide protection to areas landward from erosion. Assumed these are maintained in future planning years.
	2. Development controls	Finished floor level of buildings raised above ground level as flood mitigation (this is a planning recommendation as part of development approval) Dome Café and Marine Education Boatshed assumed at +300mm above adjacent land level
	3. Development setacks	Residential development is setback from the coast to allow for coastal processes in the future. Some areas of land are at risk of erosion and/ or inundation hazard.
Reclaimed Zone	1. Natural shoreline areas	Beach at Niergarup Reserve, interface between John Tonkin and the beach area. Provide buffer against erosion for landward areas. No development in the shoreline.
	2. Development controls	Finished floor level of buildings raised above ground level as flood mitigation (this is a planning recommendation as part of development approval) Swan Yacht Club, 8 knots Tavern and Aquarama Marina Office are assumed at +300mm above adjacent surveyed land level.
	3. Boat Ramp – control structures either side on foreshore	Localised impacts - control of alongshore flow of sediment. The boat ramp is flanked by rock groynes either side of the structure.
	4. Preston Beach Groyne	Localised impacts - control of alongshore flow of sediment. Assumed this will be maintained in future.
	5. Offshore Groyne Structures at John Tonkin	Stabilises the beach in the lee of the structures by reducing wave impacts and creating a calm area where

SMU	Control	Comment
		sand accumulates and acts as a buffer in large storm events. Assumed these structures are maintained in their present form and the beach maintained by the Town following large storm events in the erosion assessment.
	6. Shoreline protection – Revetment in front of Boat Ramp carpark, river walls in front of the SPYC and rowing club, seawall fronting W. Wayman Reserve,	Provide protection to areas landward from erosion. Assumed these are maintained in future planning years.
Natural Zone	1. Natural control - Limestone in Jerrat Drive escarpment	Natural feature providing resilience to the shoreline from erosion.
	2. Development Controls	Finished floor level of buildings raised above ground level as flood mitigation (this is a planning recommendation as part of development approval). East Fremantle Yacht Club (EFYC) and Sea Scout Building are assumed at +300mm above adjacent surveyed land level.
	3. Shoreline Structures Quay Walls at EFYC, river wall at the Sea Scout site	Assumed these are maintained in future planning years. Provide protection to areas landward from erosion.

10.2 Planning Controls

The existing planning controls applicable to land use and development within the Town have been reviewed with a complete summary in Appendix E.1 (element 2022). The review has a particular focus on coastal planning and management aspects relating to the preparation of this CHRMAP.

10.2.1 Policy Framework Overview

Western Australia's State planning framework includes strategic and statutory planning functions set out in the Planning and Development Act 2005. The planning system is hierarchical, requiring increasing levels of detail as a proposal progresses through the state and local planning systems, including subdivision and development of individual sites. The relationships of the various policies are presented in Figure 10.1.

This CHRMAP provides the overarching blueprint for the Town's local planning framework to deliver the requirements of SPP2.6.

Figure 10.1: Western Australian planning hierarchy (State Coastal Planning Policy Guidelines, 2020)

SPP 2.6 considers the impacts of coastal related processes along the coastline and tidal reaches including river mouths and estuaries. SPP 2.6 provides the basis for coastal planning and seeks to ensure coastal hazard risk management and adaptation planning is established to guide the location and form of future development along the coast. SPP 2.6 is applicable to every stage of the planning process and provides a range of policy measures to consider in the decision-making process.

This section reviews the existing planning framework relevant to coastal processes along the Swan River foreshore within the Town. The primary aim of this review is to:

- Ensure the CHRMAP aligns with aims and objectives of the relevant state and local planning frameworks.
- Assess the adequacy of the existing planning framework and controls for addressing hazard issues.
- Identify any potential constraints and/or opportunities with the existing planning framework, including controls for addressing hazard issues.

10.2.2 Key Planning Controls Relevant to the CHRMAP

The following documents are included in the review:

1. Corporate Governance Framework:
    - Town of East Fremantle Strategic Community Plan 2020 – 2030
    - Town of East Fremantle Corporate Business Plan 2019 – 2023
    - Town of East Fremantle Strategic Resource Plan 2019 – 2034
2. Relevant Legislation:
    - Planning and Development (Local Planning Schemes) Regulations 2015
3. State Planning Framework:
    - Perth and Peel @3.5 million and Sub-Regional Planning Framework
    - Metropolitan Region Scheme
    - WA Coastal Zone Strategy
    - State Planning Policy 2.6 – State Coastal Planning and Guidelines
    - Coastal hazard risk management and adaptation planning guidelines
    - State Planning Policy 3.4 – Natural Hazards and Disasters
    - State Planning Policy 2.10 – Swan Canning River System
    - Draft State Planning Policy 2.9 – Planning for Water
    - Swan and Canning Rivers Management Act 2006

4. Local Planning Framework:
    - Town of East Fremantle Local Planning Strategy (2022)
    - Town of East Fremantle Local Planning Scheme No.3 (LPS 3)
    - Residential Design Guideline (Local Planning Policy 3.1.1).
    - Leeuwin Vision Plan (2016)
    - Preston Point Road North Recreation Precinct Master Plan (2020)
    - East Fremantle Foreshore Master Plan (2016)

10.2.3 Summary of Statutory Planning Mechanisms

There are various planning mechanisms that will be considered in the CHRMAP process and recommended for implementation, where appropriate. The statutory planning mechanisms that may be available to address coastal related hazards within the Town are considered in Table 10.2 which outlines the advantages and disadvantages of each option.

Based on the review the use of Local Structure Plans, a Special Control Area within LPS 3 and a CHRMAP Local Planning Policy are considered the most appropriate.

Table 10.2: Summary of Existing Planning Controls

Statutory Measure	Advantages	Disadvantages
Structure Plan / Activity Centre Plan	Can address location specific issues i.e. identification of foreshore physical setbacks and areas affected by erosion and inundation.	Does not have the force and effect of the local planning scheme. Decision makers to have due regard only. Structure Plan cannot specify / enforce built form requirements. Location specific only and therefore cannot address hazard issues on a broad scale. Generally, requires the land to be appropriately zoned to require the preparation of a structure plan.
Local Development Plan	Can specify built form requirements to address location specific hazard issues i.e. increased setbacks, minimum habitable floor levels, etc. Has due regard of the local planning scheme. Can vary 'deemed-to-comply' development requirements.	Location specific only and therefore cannot address hazard issues on a broad scale.
Local Planning Policies and Design Guidelines	Can address coastal hazard and risk issues at a district (broad) level and/or at a location specific level. Can include mapping of coastal hazard issues with flexibility to	Is only a 'due regard' document and does not have the full force and effect as provisions contained in a local planning scheme.

Statutory Measure	Advantages	Disadvantages
	update mapping as and when amendments are required to be undertaken. Can vary 'deemed-to-comply' development requirements. Can be amended relatively quickly (compared to local planning scheme amendment as new coastal studies are completed.	
Special Control Area (SCA)	SCAs may establish specific provisions to address a specific issue such as erosion and inundation. SCAs can broadly address unique issues that extend across multiple zones and/ or reserves. SCAs can be used to require development approval for otherwise normally 'exempted' development. In this regard, SCAs are the preferred mechanism to identify where and what type of development requires development approval to allow for appropriate consideration of the risk of erosion and inundation.	A scheme amendment would potentially need to be progressed every time mapping of the coastal issue is amended and/or updated. This may be avoided if the Special Control Area refers to a separate Local Planning Policy which may contain reference to mapping of coastal hazards.
General Development Provisions of LPS1	Can establish provisions which broadly address hazard issues. Can introduce provisions which relate to a local planning policy addressing hazard issues and which may contain hazard mapping.	Given the specific nature of erosion and inundation issues, including the varied locational extent to which it may affect land within a district, specific development requirements would more appropriately be established within a Special Control Area as opposed to general provisions within a local planning scheme.
Supplemental Provisions to Schedule 1 and 2 of the Regulations	May be used to supplement the standard scheme provisions set out in Schedule 1 and 2 of the Regulations to address specific hazard issues.	Given the specific nature of erosion and inundation issues, including the varied locational extent to which it may affect land within a district, specific development requirements would more appropriately be established within a Special Control Area as opposed to the supplemental provisions of a scheme.

11. Residual Risk and Priority for Treatment

11.1 Overview

The Risk Evaluation phase of the CHRMAP is used to prioritise risk management measures for the study area. The results from the risk assessment detailed in Section 9 are examined in greater detail for assets with vulnerability risk rated high and very high.

The risk evaluation considers if there are already risk management measures in place or existing controls that can be taken into consideration to reduce the risk rating determined through the vulnerability assessment. Upon completion of this stage, the residual risk rating for assets through the study area will be determined and the most vulnerable assets requiring risk management measures as a priority will be identified.

The vulnerability rating for assets is presented in this section, which incorporates consideration of existing controls through each SMU (Table 10.1).

The final asset vulnerability rating is presented in a traffic light system as shown in Table 11.1.

Table 11.1: Vulnerability Rating Summary

Rating	Description of Asset Vulnerability and Action Required
Low	Asset has high resilience; it is able to cope with the impacts of coastal hazards without additional support. No immediate action required
Medium	Asset has some ability to cope with the impacts of coastal hazards. However short to medium term actions are likely to be required to reduce risk to acceptable levels
High	Asset has limited ability to cope with the impacts of coastal hazards. Immediate to short-term adaptation is likely to be required to reduce risk to acceptable levels.
Very High	Asset has minimal ability to cope with the impacts of coastal hazards without additional support. Adaptation will need to be considered as a priority.

11.2 SMU1 -Walled Zone

The vulnerability rating for assets in SMU1 are presented in Table 11.2 for erosion and inundation. The priority assets that require risk management are driven by inundation impacts and include:

- The Carpark at Dome Café is rated as Highly vulnerable by 2050. The J Dolan Park carpark is rated Highly vulnerable by 2075.
- The Marine Education boatshed is rated Highly vulnerable by 2035 and Extreme in 2075.
- The Dome café is rated as Highly vulnerable in 2075 and Extreme in the 2125 period.
- Riverside Road is rated as Highly vulnerable in the timeframe 2075 to 2125.

It is noted that the continuous shoreline protection along the shoreline of the Walled Zone is assumed to be maintained in future years. In this assessment this is assumed to continue to provide erosion protection afforded to the coastal assets presently.

Table 11.2: Vulnerability Rating – SMU 1: Walled Zone

	Assets	2035	2050	2075	2125
	Erosion				
1	Road Reserve - Lower Merv Cowan (East	🟢	🟢	🟢	🟢
2	Toilet Block - Lower Merv Cowan (East Riv	🟢	🟢	🟢	🟢
3	Riverside Road - Niergarup Reserve to Pier	🟢	🟢	🟢	🟢
4	Riverside Road - Pier Street to Dome Café	🟢	🟢	🟢	🟢
5	Riverside Road Dome Café to Stirling Bridge	🟢	🟢	🟢	🟢
6	Riverside Road - Stirling Bridge to J Dolan	🟢	🟢	🟢	🟢
7	J Dolan Park	🟢	🟢	🟢	🟢
8	Riverwalls protecting shoreline	Not Rated			
9	Coastal Pathways - Niergarup Reserve to	🟢	🟢	🟢	🟢
10	Coastal Pathways - Pier St to Dome Café	🟢	🟢	🟢	🟢
11	Coastal Pathways - Dome Café to Stirling Br.	🟢	🟢	🟢	🟢
12	Coastal Pathways - Stirling Bridge to J Dolan	🟢	🟢	🟢	🟢
13	Boat ramps, moorings, jetties	🟡	🟡	🟡	🟡
14	Residential Properties - Riverside / East St	🟢	🟢	🟢	🟢
15	Residential Properties – Riverside / Pier St	🟢	🟢	🟢	🟢
16	Marine Education Boatshed	🟢	🟢	🟢	🟢
17	Dome Café	🟢	🟢	🟢	🟢
18	Minor Infrastructure (bins, signage, shelters, fencing)	🟢	🟢	🟢	🟢
19	Carpark - Public Carpark No 4 (Dome Cafe)	🟢	🟢	🟢	🟢
20	Carpark - J Dolan Park	🟢	🟢	🟢	🟢
21	The Left Bank	🟢	🟢	🟢	🟢
22	Playground Equipment – north of Dome Cafe	🟢	🟢	🟢	🟢
23	Shelters, seating and picnic tables – J Dolan Park	🟢	🟢	🟢	🟢
24	Shelters, seating and picnic tables – North of Dome Cafe	🟢	🟢	🟢	🟢
25	Drainage features (pits, pipes, culverts, stormwater outlets)	🟡	🟡	🟡	🟡

	Assets	2035	2050	2075	2125
	Inundation				
1	Road Res - Merv Cowan (East Riv Drv)	Low	Low	Low	Medium
2	Toilet Block -Merv Cowan (East Riv Drv)	Low	Low	Low	Medium
3	Riverside Road - Niergarup Res - Pier Street	Medium	Medium	Medium	High
4	Riverside Road - Pier Street to Dome Café	Low	Low	Medium	High
5	Riverside Road Dome Café to Stirling Bridge	Low	Low	Medium	High
6	Riverside Road - Stirling Br. to J Dolan Park	Medium	Medium	Medium	High
7	J Dolan Park	Medium	Medium	Medium	Medium
8	Riverwalls protecting shoreline	Low	Low	Medium	Medium
9	Coastal Pathways - Niergarup Res to Pier St	Low	Low	Medium	Medium
10	Coastal Pathways - Pier St to Dome Café	Low	Low	Medium	Medium
11	Coastal Pathways - Dome Café to Stirling Br.	Low	Medium	Medium	Medium
12	Coastal Pathways - Stirling Bridge to J Dolan	Low	Low	Medium	Medium
13	Boat ramps, moorings, jetties	Medium	Medium	Medium	Medium
14	Residential Properties - Riverside / East St	Low	Low	Low	Medium
15	Residential Properties – Riverside / Pier St	Low	Low	Low	Low
16	Marine Education Boatshed	High	High	Very High	Very High
17	Dome Café	Low	Medium	High	Very High
18	Minor Infrastructure (bins, signage, shelters, fencing)	Low	Low	Medium	Medium
19	Carpark - Public Carpark No 4 (Dome Cafe)	Medium	High	High	High
20	Carpark - J Dolan Park	Medium	Medium	High	High
21	The Left Bank	Low	Low	Low	High
22	Playground Equipment – north of Dome Cafe	Low	Low	Medium	Medium
23	Shelters, seating and picnic tables – J Dolan Park	Low	Low	Medium	Medium
24	Shelters, seating and picnic tables – North of Dome Café	Low	Low	Medium	Medium

Vulnerability Rating: Low Medium High Very High

11.3 SMU2 – Reclaimed Zone

The vulnerability rating for assets in SMU2 are presented in Table 11.3 for erosion and inundation.

The priority assets that require risk management are driven by inundation impacts and erosion impacts and include the following locations:

- The Niergarup Reserve is rated as Highly vulnerable to erosion by 2035 and Extreme in the year 2075.
- Norm Mckenzie foreshore reserve is rated as Highly vulnerable to erosion in 2035 and Extreme by 2075.
- W Wayman Reserve foreshore is rated as Highly vulnerable to erosion in 2035 and Extreme by 2075.
- Riverside Road behind the Nieragup Reserve is rated as Highly vulnerable to erosion in 2050 and Extreme by 2075.
- Coastal pathways in W Wayman Reserve and Norm McKenzie are rated Highly vulnerable to erosion by 2035 and 2050 respectively.
- The buildings of the Navy cadets, Cool Beans café, Rowing Club are all rated as Highly Vulnerable to inundation in 2075, rising to extreme towards 2125.
- The 8 Knots Tavern is rated at Highly vulnerable to inundation in 2035 and Extreme in 2075.
- Riverside Road is rated as Highly vulnerable to inundation in 2075.
- There are six carparks around the area which are rated as Moderate in the 2035 and 2050 periods and Highly vulnerable in the 2075 to 2125 period.

The beach at John Tonkin reserve in the lee of the detached breakwaters is assumed to be maintained following large erosion events.

It is noted that the current sections of shoreline protection along the Reclaimed Zone area are assumed to be maintained in the short to medium term (approximately 50 years). Under projected sea level rise a vertical sea level 0.5m to 1.05m higher than present day is forecast in the 2075 to 2125 planning period. With this magnitude of sea level rise in the future, to continue to provide protection to the assets in the shoreline of SMU2 may be too difficult and / or expensive, with the land level of the foreshore reserves susceptible to regular flooding. A decision on whether to continue protection of the shorelines or execute a planned and managed retreat of the shoreline areas triggered by sea level rise impacts will be required, discussed further in Section 13.

Table 11.3: Vulnerability Rating – SMU 2: Reclaimed Zone

	Erosion				
	Assets	**2035**	**2050**	**2075**	**2125**
1	Niergarup Reserve				
2	Coastal Pathway – John Tonkin Reserve				
3	Coastal Pathway – Norm McKenzie Park				
4	Norm McKenzie Park Foreshore Reserve				
5	Norm McKenzie Park – Playground				
6	Norm McKenzie Park Roadside shelter, BBQ				
7	W Wayman Reserve– Foreshore reserve				
8	W Wayman Reserve – Pathway				

	Erosion				
9	W Wayman Reserve – Shelter				
10	W Wayman Reserve - Exercise Equipment				
11	Detached groyne field				
12	John Tonkin Reserve Playground				
13	John Tonkin Reserve – Gazebos				
14	Riverwalls protecting shoreline	Not Assessed			
15	Navy Cadets				
16	Beach access pathways				
17	Leeuwin Barracks Existing Carparks / Bldgs				
18	Leeuwin Barracks Park Area adjacent Riv				
19	Aquarama Marina (Car Park East side)				
20	Aquamarina Building adj Riv Rve				
21	8 Knots Tavern				
22	Rowing Club				
23	Minor Infra (bins, signage, shelters, fencing)				
24	Moorings				
25	Cool Beans Café				
26	Swan Yacht Club				
27	Zephyr Café				
28	Boat Ramp				
29	Riverside Road – Behind Nieragup Res.				
30	Car parks – TOEF Public Car Park Nos 1, 2 and 5, John Tonkin Reserve, Zephyr Café, and within Swan Yacht Club, Fremantle Rowing Club and Aquarama precincts.				
31	Drainage features (culverts, S/water				
	Inundation				
	Assets	**2035**	**2050**	**2075**	**2125**
1	Niergarup Reserve				
2	Coastal Pathway - John Tonkin Reserve				
3	Coastal Pathway - Norm McKenzie Park				

	Erosion				
4	Norm McKenzie Park Foreshore Reserve				
5	Norm McKenzie Park - Playground				
6	Norm McKenzie Park – Shelter / BBQ				
7	W Wayman Reserve - Foreshore Reserve				
8	W Wayman Reserve – Pathway				
9	W Wayman Reserve – Shelter				
10	W Wayman Reserve - Exercise Equipment				
11	Detached groyne field				
12	John Tonkin Reserve – Playground				
13	John Tonkin Reserve – Gazebos				
14	Riverwalls protecting shoreline				
15	Navy Cadets				
16	Beach access pathways				
17	Leeuwin Barracks - Ext Carpark / Buildings				
18	Leeuwin Barracks -Park Area Adj Riv Drv				
19	Aquarama Marina (Car Park East Side)				
20	Aquarama Building (adj Riv Drv)				
21	8 Knots Tavern				
22	Rowing Club				
23	Minor Infra (bins, signage, shelters, fencing)				
24	Moorings				
25	Cool Beans Café				
26	Swan Yacht Club				
27	Zephyr Café				
28	Boat Ramp				
29	Riverside Road				
30a	TOEF Public Car Park No 1 (Boat Ramp)				
30b	TOEF Public Car Park No 2 (John Tonkin Nth)				
30c	TOEF Public Car Park No 5 (Cool Beans)				
30d	TOEF Public Car Park No 3 – Zephyr Café				

	Erosion				
30e	Car Park Swan Yacht Club	🟢	🟡	🟡	🟠
30f	Car park– Fremantle Rowing Club	🟡	🟡	🟡	🟠
31	Drainage features (pits, pipes, culverts,	🟢	🟢	🟡	🟡

Vulnerability Rating: 🟢 Low 🟡 Medium 🟠 High 🔴 Very High

11.4 SMU3 –Natural Zone

The vulnerability rating for assets in SMU3 are presented in Table 11.4 for erosion and inundation.

The priority assets that require risk management driven by erosion impacts are:

- The foreshore, beach and stairs at the base of Jerrat Drive which are rated as Highly vulnerable to erosion by 2035. The rating increases to Extreme for the beach in 2050 and for the other assets in 2075.
- For inundation the buildings at the Sea Scouts and East Fremantle Yacht Club and the lower carpark areas at the East Fremantle Yacht Club are rated Highly vulnerable in 2075.

It is noted that the sections of shoreline currently protected along the Natural Zone will be maintained in future years and will continue to provide erosion protection afforded to the coastal assets presently.

Table 11.4: Vulnerability Rating – SMU 3: Natural Zone

	Erosion				
	Assets	**2035**	**2050**	**2075**	**2125**
1	Riverwalls		Not Assessed		
2	Foreshore Area along Jerrat Drive	🟠	🟠	🔴	🔴
3	Beaches below Jerrat Drive escarpment	🟠	🔴	🔴	🔴
4	Sea Scouts building	🟢	🟢	🟢	🟢
5	Beach access stairs to Jerrat Drive	🟠	🟠	🔴	🔴
6	East Fremantle Yacht Club Building	🟢	🟢	🟢	🟢
7	East Fremantle Yacht Club car park	🟢	🟢	🟢	🟢
8	Jerrat Drive and road network	🟢	🟢	🟡	🟠
9	Boat ramps, moorings and jetties	🟡	🟠	🟠	🟠
10	Minor Infra (signage, seating, fencing)	🟢	🟢	🟡	🟡
11	Carpark at Jerrat Drive	🟢	🟢	🟢	🟡
12	Drainage Features	🟠	🟠	🟠	🟠
	Inundation				
	Assets	**2035**	**2050**	**2075**	**2125**

	Erosion				
1	Riverwalls	Not Assessed			
2	Foreshore Area along Jerrat Drive				
3	Beaches below Jerrat Drive escarpment				
4	Sea Scouts building				
5	Beach access stairs to Jerrat Drive				
6	East Fremantle Yacht Club Building				
7	East Fremantle Yacht Club car park				
8	Jerrat Drive and road network				
9	Boat ramps, moorings and jetties				
10	Minor Infra (signage, seating, fencing)				
11	Carpark at Jerrat Drive				
12	Drainage Features				

Vulnerability Rating: Low Medium High Very H

12. Risk Treatment Framework

12.1 Adaptation Planning Overview

The risk treatment and adaptation stage of the CHRMAP considers the approaches that can be used to address the residual risk to coastal assets identified in the Risk Evaluation (Section 11). The goal of this stage is to determine appropriate risk treatment responses that can mitigate coastal hazard risk identified for the Town's shoreline areas and coastal assets over the immediate short term (next 10-15 years) and which can maintain a level of flexibility for future decision making. This will provide a basis for decision makers on what is important to focus on today, and what locations could be potentially affected in the future should projected sea level rise and climate change impacts be realised over the 100-year planning timeframe.

The level of coastal hazard risk for the coastal assets through the study area is generally low for the present day, however this risk is projected to increase associated with sea level rise in future years. Sea level rise scenarios consistent with SPP2.6 have been examined to understand how coastal assets could be affected by coastal hazard in future. This process has also considered a range of possible scenarios ranging from events that occur annually up to extreme events with a low likelihood of occurrence (1-in-100yr and 1-in-500yr ARI). It is recognised that there is uncertainty in making long term predictions on both the timing and nature of sea level rise and climate change, and in the risk treatment process this uncertainty is taken into consideration. The role of the CHRMAP is to focus attention today on the most critical areas of the shoreline requiring management for the short-term timeframe and to identify the trigger points at which a change in risk treatment may be required to meet the challenge of a higher level of risk to coastal assets in the future planning years.

Consultation with stakeholders and the community has provided a platform for discussions on how the shoreline areas could be affected in the future under projected sea level rise. The engineering structures that have been implemented at the river's edge such as river walls and groynes have created a highly modified shoreline area that safeguards the locations landward. In addition there has been extension of the natural foreshore areas in the Reclaimed Zone through reclamation actions. This allows for community access to roads (Riverside Drive), parks, walkways, cafes, marinas and many other facilities which are highly utilised and valued for social, commercial and recreational use. Maintaining this protection in the short to medium term is the intention, however, it is recognised that the protection that is offered today to the shoreline areas may at some point in the future become too expensive to maintain in its current form with projected sea level rise of 1.05m over the next 100-yrs. The intention of CHRMAP is to provide guidance on management of the shoreline areas so that they continue to provide the community with high value, whilst recognising that transitioning the shoreline areas to a long-term, sustainable future may require a change in strategy from 'Protect' and/or 'Accommodate' to 'Planned and Managed Retreat' when the cost of protection cannot be justified.

The ability of the shoreline areas to adapt and respond to the changing conditions in future planning periods will be the responsibility of the relevant authority in the shoreline areas. The roles of the various State Agencies in planning, management and development within these areas is discussed in this section.

12.2 Swan and Canning Rivers Management Act 2006

The Swan and Canning Rivers Management Act 2006 (SCRM Act) makes provision for the protection of the Swan and Canning Rivers to ensure ecological values and community benefits are maintained. Under the SCRM Act, the Swan Canning Development Control Area (DCA) has been established which comprises of all the land and waters shown in Figure 12.1 and generally includes:

- Waters of the Swan River reserved under Clause 12 of the Metropolitan Region Scheme (MRS) for 'waterways'; and

- Lands adjoining those waters that are reserved for 'parks and recreation' under Clause 12 of the MRS.

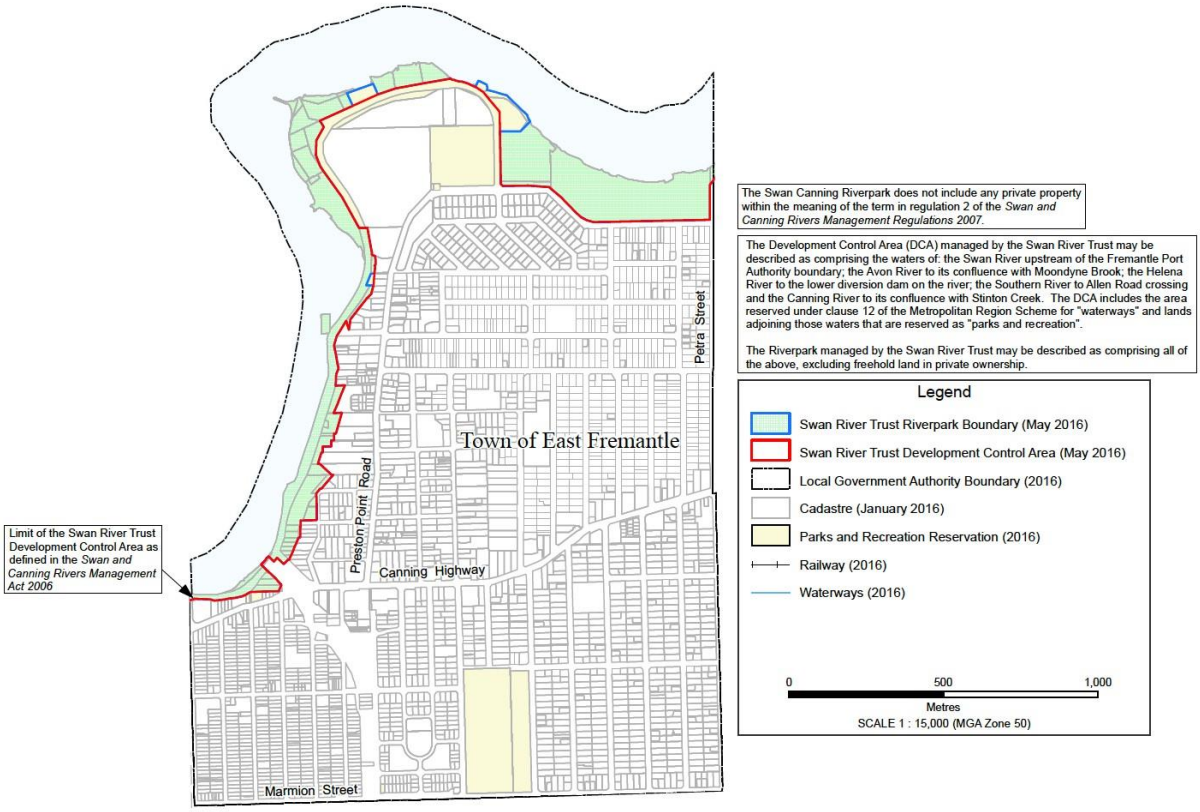

Figure 12.1: Swan Canning Development Control Area

The DCA boundary generally aligns with the boundary of land reserved for 'parks and recreation' under the MRS. Where the 'parks and recreation' reserve changes under the MRS, the DCA is often updated by the Department of Biodiversity, Conservation and Attractions (DBCA).

The DBCA, SRT, WAPC and State and local governments are responsible for the effective planning and management of land use and development within, abutting and affecting the waters and associated land within the DCA, at all stages of the planning process.

Section 70 of the SCRM Act sets out the statutory planning role of DBCA and the SRT in relation to development located in the DCA. The SCRM Act is guided by the Swan and Canning Rivers Management Regulations 2017 (SCRM Regulations) which defines development as:

- the erection, construction, demolition, alteration or carrying out of any building, excavation, or other works in, on, over or under land or waters;
- a material change in use of land or waters; and
- any other act or activity in relation to land or waters declared under the SCRM Regulations to constitute development.

12.3 DBCA Roles and Procedures

In considering development within the DCA, the DBCA is responsible for:

- Making recommendations to the Minister for Environment;
- Issuing permits and licences for works, acts and activities in accordance with the SCRM Regulations, including development that is considered exempt from development approval;

- Providing advice to the WAPC concerning amendments to the MRS and other strategic planning instruments;
- Providing advice to the WAPC in relation to subdivision proposals ;
- Providing advice to the Town on local planning scheme amendments, or other proposals that may affect the DCA, such as structure plans and local development plans;
- Provide advice to and obtain advice from public authorities concerning their responsibilities in terms of the SCRM Act;
- Provide clearance of conditions of approval and advice on implementation of DBCA approvals; and
- Update procedural matters associated with development assessments, review of development control policies, model conditions and DCA boundary as necessary.

Development proposed to be undertaken in the DCA shall be assessed by the DBCA in accordance with Part 5 of the SCRM Act with reference to the SCRM Regulations, policies and any other documents considered relevant. The development application will be referred to the Town for comment whereby certain implementation measures identified in this CHRMAP can be recommended to the DBCA for consideration prior to determination by the Minister for Environment.

It is important to note that as a result of the interactions between the Planning and Development Act and SCRM Act, the statutory decision maker may vary. However, considering that all the land within the DCA and the East Fremantle Local Government Area is Parks and Recreation reserved under the MRS, statutory decision-making authority rests with the Minister for Environment, DBCA or the WAPC. Further, the Local planning Scheme does not apply over land within the Parks and Recreation Reserve.

12.4 Swan River Trust Roles and Procedures

The SRT is responsible for providing advice to the DBCA, WAPC and local governments in accordance with the statutory processes outlined in the MRS, specifically:

- Clause 30A(2)(a):

(i) development of land, any part of which is in the DCA.

(ii) development of land that is not in the DCA but abuts waters in the DCA.

Development applications considered under Clause 30A(2)(a) of the MRS shall be determined by the WAPC in a manner consistent with the advice of the SRT. If the WAPC disagrees with the advice, the development application is to be determined with the involvement of the Minister for Planning and the Minister for Environment.

- Clause 30A(2)(b):

(i) development of land that abuts land in the DCA.

(ii) development likely to affect waters in the DCA, other than a development to which the above-mentioned processes apply.

For development applications considered under Clause 30A(2)(b) the Town shall provide advice to DBCA and WAPC to ensure their decisions align with the overarching objectives and recommendations of this CHRMAP. Consideration to be given to other planning mechanisms that would be more appropriate in assisting DBCA, the Minster for Environment or DPLH in implementing the recommendations of the CHRMAP.

A summary of the abovementioned approval processes is outlined in Table 12.1. While the Town cannot determine development applications under Clause 30A(2)(b) of the MRS, there is the opportunity to

provide advice to the DBCA and WAPC to ensure their decisions align with the overarching objectives and recommendations of this CHRMAP.

Table 12.1: Approval Process – Proposed Development in the DCA

Development Application Type	Part 5 of SCRM Act	Clause 30A(2)(a) of the MRS	Clause 30A(2)(b) of the MRS
Definition	Development proposed on land or in waters that are wholly in the DCA.	Development proposed on land that is partially in or abutting the DCA.	Development proposed on land that abuts other land in the DCA, or that are likely to affect waters in the DCA.
Assessing Body	The DBCA is the primary assessing authority under Part 5 of the SCRM Act. The DCBA makes a recommendation to the Minister for Environment, who makes the final determination on the application. In formulating advice, the DBCA must consult with the Swan River Trust and provide the Swan River Trust's views to the Minister.	Under Clause 30A(2)(a) of the MRS, the Swan River Trust provides advice to the WAPC. In routine cases, this function will be performed under delegated authority by DBCA officers. Complex issues may be considered by the Swan River Trust Board.	Under Clause 30A(2)(b) of the MRS, the Swan River Trust provides advice to the Town (who act under delegated authority from the WAPC). In routine cases, this Swan River Trust function will be performed under delegated authority by DBCA officers. Complex issues may be considered by the Swan River Trust Board.

12.5 Swan River Trust and DBCA Policy Framework

The SRT and DBCA have adopted policies and locality plans to guide development in and around the DCA and support the implementation of the SCRM Act. The policy framework includes provisions that can be used to respond to coastal hazards along the Swan River foreshore. In addition, any mitigation works to be undertaken by the Town in the DCA in response to the CHRMAP shall have regard to these policy requirements.

The relevant policy statements and locality plans applicable to the Town and the CHRMAP have been reviewed in Table 12.2, inclusive of draft policies currently being considered.

Table 12.2: Policy Statements

Policy Statement	CHRMAP Relevance
Corporate Policy Statement No. 42 – Planning for Land Use, Development and Permitting Affecting the Swan Canning Development Control Area.	Provisions relating to subdivision and development of properties within and around the Development Control Area, including: • General presumption against supporting development that could prejudice the future acquisition of the river foreshore for Parks and Recreation. • Requirement for landowners to prepare foreshore management plans. • Development within the flood fringe to be designed to minimise damage during a major flood event. A minimum finished floor level of 0.5m above the 100-year ARI flood level shall be provided. • Requiring any filling proposed as part of development in the DCA and within the floor fringe to be graded to existing nature contours,

Policy Statement	CHRMAP Relevance
	with side slopes to be no steeper than 1:4 and be suitably protected against erosion during storm events and major river flows. • Ensuring land parcels created through subdivision are located outside of the flood fringe area.
Corporate Policy Statement No. 48 – Planning for Development Setback Requirements Affecting the Swan Canning Development Control Area	Outlines provisions relating to subdivision and development of properties within and around the DCA, including: • Residential development on urban zoned land adjacent the DCA shall be setback a minimum 10m or 20 per cent of the average distance to the opposite boundary, whichever is the lesser, from the boundary of the DCA. DBCA reserve the right to define setbacks with respect to the DCA and the location of river systems. • Non-residential development on urban, industrial or public purposes zoned land shall be setback a minimum 10m or 20 per cent of the average depth of the lot, whichever is lesser, from the boundary of the DCA. • Where development is proposed on urban zoned land adjoining the rivers (including riparian areas) in the DCA, require a development setback of 50m from the high watermark to ensure that adequate separation between riparian area of the river and the proposed development is maintained. • Require any development that would likely be obstructive to major floods to be located outside of the floodway, as defined by the floodplain mapping available or as identified in this CHRMAP. • Support the implementation of SPP 2.6 which indicates that a vertical sea level rise of 0.9m over a 100-year planning timeframe to 2110 should be adopted when considering setback distance and elevation. • Requirements for the location and design of retaining walls where land is adjacent the DCA
Planning for Localities Along the Swan Canning Development Control Area (Draft)	Outlines provisions relating to subdivision, development and works within and around the DCA, including the requirement for development to be designed to accommodate inundation.
Blackwall Reach Jenalup Locality Plan (Draft)	Recommends key actions for the Town relevant to the CHRMAP, including: • Increasing the width of the foreshore Parks and Recreation Reserve. • Master plan the adjacent foreshore concurrently with any proposal for rezoning of the Leeuwin Barracks. • Undertake a foreshore risk assessment to understand potential climate change impacts.

12.6 Local Planning Framework

12.6.1 Local Planning Strategy

The Local Planning Strategy (the Strategy) establishes the vision and long-term planning directions for the Town over the next decade and beyond. The Town has recently adopted the Strategy which received final endorsement of the Western Australian Planning Commission (WAPC) in 2022.

A key planning direction of the Strategy is to "ensure protection of assets along or near the Swan River foreshore from hazards associated with climate change and rising sea levels through land use planning and management whilst engaging stakeholders and the community in the decision-making process."

The Strategy aims to achieve this through the preparation of this CHRMAP to assist the Town in identifying and managing risks to existing and future assets along the Swan River foreshore.

The Strategy also identifies the Leeuwin Barracks site as a potential site for future urban intensification which could ultimately accommodate up to 1,440 new dwellings. The outcomes and recommendations of this CHRMAP will be of particular importance to the planning and redevelopment of the Leeuwin Barracks site for residential purposes.

Some progress has been made to further the planning for the Leeuwin Barracks redevelopment site, led by the Department of Defence together with a working group comprising of consultants, State Government agencies and the Town. This is currently on hold however, pending the result of a Department for Defence study into the need to retain existing assets for defence purposes or not.

13. Risk Treatment

13.1 Risk Treatment and Adaptation Hierachy

The Risk Treatment options that are considered in this CHRMAP have been developed from a range of sources. The key guidance comes from the CHRMAP guidelines (WAPC 2019) which describes the general risk treatment categories in a risk treatment and adaptation hierarchy.

The hierarchy was developed on the principal of maintaining flexibility for decision makers in the future. The management approaches at the top of the list allow greater flexibility for decision makers in future (eg Avoid), whilst options further down the list in the hierarchy moving towards the final option of Protect limit the future decision making options available.

The categories in brief are described as follows from highest to lowest management categories:

1. **Avoid**: this approach is to simply avoid new development in areas at risk of coastal hazard. This approach is only applicable to locations where development has not commenced; The aim of this risk treatment option is to avoid the construction of new public and private assets within areas identified to be impacted by coastal hazards. Avoidance risk treatment options are the best form of risk management (mitigation) and where possible should be the risk treatment option of choice (WAPC 2019). Avoidance is particularly applicable to all land use and development in greenfield locations.

2. **Planned or Managed Retreat**: the concept of planned or managed retreat allows existing public assets and private property to remain in place until such time as coastal hazard from erosion or inundation is untenable. Planned or managed retreat for existing development involves relocating or sacrificing infrastructure, both public assets and private property, when erosion and recession impacts reach action trigger points. Under this option the use of temporary coastal protection structures and/or restoration of natural controls such as dunes and shoreline areas is supported to maintain or create a buffer against storm erosion. As existing assets reach the end of their functional life (or if they are substantially damaged by a storm event), they would be removed, including any associated coastal protection structures.

3. **Accommodate**: The accommodate risk treatment option aims to utilise design and management strategies which render the risks as tolerable/acceptable, allowing land to continue to be utilised until risks become intolerable. Design and management strategies may include a mix of structural or non-structural approaches. Structural approaches include minimum finished floor levels and elevated electrical circuitry, and relocatable structures which can be moved to a different location on- or off-site to manage risk arising from inundation coastal hazards. Non-structural approaches such as modifications to local planning frameworks (eg inclusion of a special control area) can also enable accommodate risk treatment options.

4. **Protect**: Protect risk treatment options aim to protect assets from damage resulting from erosion and recession and storm surge inundation. Protect risk treatment options should be primarily proposed in the public interest and enhance or preserve beach and foreshore reserve amenity. The Protect option

is only available when all other options are exhausted and should be justified in terms of the benefit it delivers to the community.

- Common hard protection structures include seawalls; groynes; offshore breakwaters and soft protection measures such as beach nourishment.
- Interim protection structures can be applied to delay shoreline recession over the short to medium term. This might be achieved through soft protection measures such as regular sand renourishment and revegetating shoreline areas.

In addition to the four main categories, additional management approaches considered in the CHRMAP are:

5. No Regrets

The no-regrets category is used for approaches that can improve resilience and preparedness against the impact of coastal hazards. These can be implemented where further understanding of the risk to assets is being collected or while the assessments to determine a preferred risk treatment option.

6. Do Nothing

The do-nothing risk treatment option assumes that all levels of risk is accepted and that no further action will be taken. This risk treatment option provides a basis for comparison of all other risk treatment options.

13.2 Adaptation Tools

A range of adaptation tools available to mitigate coastal risk applied in the CHRMAP under the key category definitions is summarised in Table 13.1. These have been developed from a range of sources including WAPC 2019 and the National Climate Change Adaptation Research Facility (NCCARF) Coast Adapt tools, as well as incorporating options provided through the community involvement in the CHRMAP engagement activities.

The coastal hazard and risk level identified for the assets within each of the coastal management units is considered with reference to the adaptation approaches in the adaptation hierarchy. Adaptation responses can vary within coastal compartments, and in many instances a range of complementary adaptation responses that mitigate the coastal risk are applied.

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Table 13.1: Adaptation Options Toolbox (Adapted from WAPC 2019)

	Code	Adaptation Type	Applicable	Measure
Avoid	Av.1	Locating Assets in areas that are not vulnerable to coastal hazards	Can be applied to all asset types. Applicable to undeveloped residential and commercial land.	1. Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion of inundation hazard over the 100-year planning period. 2. Establish planning-based controls that only allow development in the SCA that can address coastal hazard.
Planned / Managed Retreat	MR.1	Leaving Assets Unprotected	Low cost, Temporary and easily relocatable recreation amenities. At end of lifecycle, allow impacts to occur, accept loss of asset once design event occurs.	1. Amend local planning scheme to include Special Control Area. 2. Determine assets that are deemed sacrificial. 3. Monitoring (NR1) to identify when trigger is reached.
	MR.2	Demolition, Removal or relocation of Assets from inside the hazard area	Assets of low value where it is impractical both technically and financially to design the asset to withstand the impact of the coastal hazards instead of relocating it.	1. Amend local planning scheme to include Special Control Area. 2. Determine assets that are deemed sacrificial or relocatable, and update Council's Asset register to reflect likely timeframe for impact to assist in prioritising asset relocation. 3. Monitoring (NR1) to identify when trigger is reached.
	MR.3	Event limited development approval / prohibit expansion of existing use rights.	Generally applicable where protection of assets is not viable. All assets where it is impractical to ultimately implement protection.	Amend local planning scheme to include Special Control Area.
	MR.4	Voluntary Acquisition	All private property where it is impractical to ultimately implement protection. This risk treatment option would require the acquisition of affected properties, on a voluntary basis. Ensures land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation.	1. Investigate/put in place funding for acquisition of priority properties. 2. Offer voluntary acquisitions reflecting asset value in light of hazard.

	Code	Adaptation Type	Applicable	Measure
	MR.5	Limit Further Subdivision	Limit further subdivision of existing lots identified in the hazard area.	Amend local planning scheme to include Special Control Area.
Accommodate	**Ac.1**	Building Design Relocatable Structures	Design assets to be relocatable. Structures can be moved in future as risk increases and becomes intolerable.	1. Amend local planning scheme to include Special Control Area. 2. Prepare local planning policy containing relevant inundation and wave overtopping development controls. 3. Approval of local planning policy by Council. 4. Implement local planning policy development controls to all properties within the special control area for coastal hazards within the local government area.
	Ac.2	Building Design Design assets to withstand impacts.	Where avoiding or relocating an asset is not an option, design of assets to withstand the impact of inundation. Roads, car parks, residential property, commercial property, hospitals, aged care facilities, schools, childcare facilities.	
	Ac.3	Building Design Appropriate Finished Floor Levels		
	AC.4	Filling Land		
Protect	**Pr.1**	Beach Management / sand management	Placement of sand to provide buffer against erosion or reinstate sediment that has been lost from the system.	Investigate and secure suitable sand sources for nourishment, planning approvals and to determine funding mechanisms.
	Pr.2	Nature Based Solutions	This approach refers to ‘soft engineering’ methods that are in keeping with nature. Includes revegetation, oyster beds, gabion baskets, natural materials such as brushing. Used to provide increased resilience to erosion process where wave conditions are mild.	There exists a guideline on river erosion edge treatments that provide a framework for approaches dependent on local conditions (SRT).
	Pr.3	Groynes. Can be land based or detached groynes (eg at John Tonkin Reserve)	Rock structures placed to reduce the wave conditions at the shore and promote sediment accumulation in the relatively calm conditions in the lee.	Requires detailed technical study to assess appropriateness of the option for the location. Considerations include modification of hydrodynamics and sediment transport processes. Undertake investigation of rock and sand sources for detailed costing’s, design, planning approvals and funding mechanisms.

	Code	Adaptation Type	Applicable	Measure
	Pr.4	Seawalls	Involves construction of a seawall usually along a shoreline to maintain the shoreline position and protect important built assets from erosion. Seawalls are currently in place in many of the Town's shorelines.	1. Investigate viability of existing seawalls on beaches. 2. Consider in accordance with Council's Asset Management Plan. 3. Undertake investigation of rock and sand sources for detailed costing's, design of seawall and nourishment, planning approvals and funding mechanisms. 4. Continued monitoring for trigger.
	Pr.5	Flood Mitigation Structure	Involves construction of a flood control which is either permanent or temporary along an entire section of shoreline.	1. Undertake investigation of rock and sand sources for detailed costing's, design of flood structure and nourishment, planning approvals and developing business case for funding. 2. Continued monitoring for trigger.
No Regrets	**NR1**	Monitoring	Applicable all areas. Long term baseline monitoring and event-based monitoring following storm erosion events.	1. Set up a baseline monitoring program for long term trend and condition following major events. 2. Review results for particular asset triggers regularly. 3. Re-run risk assessment based on monitoring results and revise risk management measures if risk level changes (i.e. increase or decrease in level of risk).
	NR2	Protection Structure Audit	All existing coastal protection structures. This risk treatment option involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential.	1. Conduct audit of existing protection structures. 2. Update hazard lines where relevant to account for existing protection structures. 3. Update CHRMAP proposed actions to account for condition (life) of existing protection structures. 4. Protection structures added to the Town's Asset Management Plan, and outcomes of audit used to determine asset replacement and maintenance schedules for the structures.
	NR3	Notification on title (also relevant to, planned/	All assets located within an area vulnerable to coastal hazards within the planning timeframe.	Implement in accordance with the planning framework, and as conditions of approval for subdivision and development.

	Code	Adaptation Type	Applicable	Measure
		managed retreat, accommodate and protect options).	Indicates to current and future landowners that an asset is likely to be affected by coastal erosion and/or inundation over the planning timeframe. Helps current and future owners make informed decision about level of risk they are/may be willing to accept, and that risk management is likely to be required at some stage within the planning timeframe.	
	NR4	Emergency evacuation plans (also relevant to accommodate options)	Roads (with regard to managing traffic flows during an event), car parks, residential property, commercial property, hospitals, aged care facilities, schools, childcare facilities.	1. Development evacuation plans for locations without existing inundation mapping as a priority. 2. Update evacuation plans with latest inundation mapping available or include coastal inundation area into existing evacuation plans.
	NR5	Reduce Vessel Speeds in the waterways	Review the speed limits for vessels travelling through the lower Swan River.	1. Require studies to examine erosion impacts to the riverbanks from vessel speed and provide basis for reduction in speed for vessels and or vessel activities. 2. Implement revised speed limits through the River (signage etc).
Do Nothing	**DN1**	Doing nothing and accepting the risk to the assets	Low value assets and assets that must be located in the shoreline areas for their function / purpose.	Take no action and accept risk.

13.3 Guidance from Management Authority (DBCA)

A discussion with representatives from the DBCA regarding adaptation approaches in the three SMU provided the following guidance:

For the Walled Zone

- Maintaining shoreline revetments and riverwalls to ensure the protection of Riverside Road and raising the height at shoreline in response to future sea level rise needs to be done in balance with the viability of the road over the long term. In this CHRMAP, maintaining the current extent of river walls to provide protection to the foreshore and Riverside Road has been adopted.
- Under projected sea level rise the inundation hazard for Riverside Road will increase in extreme events in the future. At present the risk is manageable. At the time when sea level rise of approximately 0.5m to 1m above the present-day level is realised (projected to be in the 2075 to 2125 period) the risk management will be more difficult (expensive). The coastal hazard risk to Riverside Drive and the foreshore area will be reviewed in future revisions of the CHRMAP.

Within the Reclaimed Zone

- there is presently 'hard engineering' river walls and revetments that offer protection; however, it is not a given that this type of foreshore edge treatment will continue to be used in the future. As the infrastructure ages in the shoreline areas there will need to be consideration and discussion on what is appropriate in terms of replacement. The intention will be to deliver an outcome that satisfies the community need whilst being environmentally sensitive. For the Reclaimed Zone, using fill in the foreshore areas to address inundation risk is not supported. Nature based solutions are supported , noting there may be engineering alternatives that are yet to emerge that could provide the right solution.
- In future there may be a point where it becomes too difficult and expensive to provide protection to the shoreline areas from erosion and inundation hazard (with rising sea level) and planning the process of Managed Retreat may be required. A future scenario could be to retreat the foreshore areas back to Riverside Road and use this as the interface to the shoreline, due to the land levels being generally higher from this section landward.
- Tenure within the Reclaimed Zone is generally managed by the SRT / DBCA apart from the Rowing Club which is freehold. Tenure is generally managed by the local government or DPLH. In contrast, planning and development (including statutory planning) is generally the responsibility of DBCA, SRT and the Minister for Environment.
- For the foreseeable future the Leeuwin Barracks site will remain under the ownership of the Department of Defence. Any changes to the use of the site with regard to residential development would need to consider the coastal hazard from the CHRMAP and ensure the risk is addressed as part of future planning and development.

Within the Natural Zone

- Nature based solutions are supported in the management of shoreline areas.
- For the Jerrat Drive escarpment section of foreshore, this is highly regarded as a key coastal asset for the Community as a site of recreation and environmental importance. Further understanding of the processes driving changes in this area is required – assessment of the present state of the foreshore (vegetation cover, habitat, drainage, underscoring at the shoreline and tree loss) and development and update to the existing foreshore management plan to guide future actions is considered a priority of the CHRMAP.

Other general comments from the discussion are as follows:

- Asset life and the timing of replacement should be factored into the CHRMAP decision making process.

- There was a request by DBCA that the drainage network be included as part of future CHRMAP assessment, to understand in more detail the interaction between catchment-based flooding through the stormwater network and riverine flooding.
- It was noted that the approaches developed for the Town's shorelines in this CHRMAP are location specific, and do not set a precedent for other sections of the Swan River (ie other Council areas). For other locations there would need to be site specific adaptation approaches developed.
- There has been a high-level study completed at the entrance to the Swan River by a University of Western Australia PHD student to examine the concept of installing a large-scale storm surge barrier. The details of this assessment have not been provided to the current study; however, the general outcome was conveyed that the investment cost would be too significant compared with the flood reduction benefits, whilst the local scale issues that drive erosion in the foreshore presently (eg boat wakes, local processes) would still persist.

13.4 General Approaches

In general, the Town's minor infrastructure in coastal areas (coastal pathways, benches, signage etc) will continue to be used under a 'Managed Retreat' scenario. This allows continued use of the infrastructure until such time as it is unsafe or un-useable at which time asset removal is required, or where maintenance costs consistent with the design life of the structure may be required.

For major infrastructure in the foreshore reserve (eg car parks, jetties, boat ramps) these are required to remain in hazard areas as part of their function and will continue to be used under a 'Managed Retreat' scenario. At the point in the future where these assets are too difficult or expensive to remain (as sea level rise increases the inundation and erosion hazard) these may be moved landward.

The preparation for managed retreat would be informed through the planned annual monitoring program (Section 17.3), asset management program and future revisions of the CHRMAP.

14. Economic Analysis

14.1 Multi Criteria Analysis (MCA)

A multi-criteria analysis (MCA) was completed to contrast and compare adaptation options in the three SMU's. An MCA is a tool to compare various alternatives or options. It provides a structured way to compare and contrast options and uses a number of criteria, and scoring of those criteria, to compare options.

The MCA incorporates community and stakeholder feedback gained through the coastal values survey, the information sessions and the George Street Festival workshop sessions. The outcomes are used to inform selection of adaptation pathways in future planning periods for each of the SMU.

The key focus areas for management in each SMU include:

- Walled Zone
  - Foreshore areas and coastal pathways
  - Riverside Road
  - Structures over the water (Dome Café and Marine Boatshed)
- Reclaimed Zone
  - Niergarup Reserve – Increasing resilience to erosion using nature based solutions
  - Commercial and Community Structures (Swan Yacht Club, 8 Knots etc)
  - Potential use of Leeuwin Barracks Site for residential development in Reclaimed Area
  - Riverside Road
  - Foreshore Reserve and Beach in John Tonkin Reserve
  - Foreshore Reserve at W Wayman Reserve
- Natural Zone
  - Beach and foreshore at base of Jerrat Drive
  - Commercial and Community Structures (EFYC, Sea Scouts)

For the MCA scoring there are five criteria that are assigned a "score" based on the expected performance:

- Technical
- Social
- Environmental
- Legal
- Cost

The assessment categories are outlined in Table 14.1

Table 14.1: MCA Categories and Key Criteria

Category	Criteria
Technical	Feasibility – the feasibility of designing and implementing the option (also incorporates legal considerations) Effectiveness – how effective the option is at achieving the outcome Climate Change Adaptation – how adaptable the option is to meet the likely changes due to climate change Construction and Maintenance – ease of construction and associated maintenance
Social	Community – impacts on the community Public Amenity – impacts on the recreational use of areas, access to areas etc
Environmental	Natural Environment – impacts on the natural environment Visual Amenity – visual impacts associated with the option
Legal	Legal implications associated with respective option
Cost	High level comparative estimate of the cost of the option (capital and ongoing cost)

The MCA scoring was developed to provide a basis for assessment across the categories with the approach summarised in Table 14.2 and Table 14.3.

Table 14.2: MCA Scoring – Performance and Impact

Score	Technical	Social and Environmental	Legal
-2	Very Poor Performance	High Negative Impact	Very Difficult
-1	Poor Performance	Medium Negative Impact	Difficult
0		Low to No Impact	
+1	Good Performance	Medium Positive Impact	Relatively Easy
+2	Very Good Performance	High Positive Impact	No Issues

Table 14.3: MCA Scoring - Cost

Score	Technical
1	Most Expensive
2	
3	
4	
5	Least Expensive

14.2 Key Outcomes from MCA

The scoring from the MCA is summarised in this section. The total score is based on an equal weighting of the scores from the respective categories of Technical, Social, Environmental, Legal and Cost. The final score is presented in a colour coded format to indicate best performing (green) and worst performing options (red).

14.2.1 Walled Zone

For the Walled Zone the MCA scoring is shown in Figure 14.1. The highest performing options by respective categories are:

- Avoid
  - Avoid development (Av.1) in areas determined as being at risk of coastal hazard in the 100-year planning period (applies to undeveloped areas only).
- Managed Retreat
  - For Minor Infrastructure
    - Leave assets unprotected under Managed Retreat (MR.1)
    - Removal of assets once trigger reached (MR.2)
  - Limit further Subdivision (MR.5)
- Accommodate
  - Building Design options to raise floor levels, build structures to withstand flooding impacts and use of relocatable structures (Ac.1s Ac.2 Ac.3)
  - For Major Infrastructure (Riverside Road and Carparks) raise surface level to mitigate flooding (Ac.3, Ac.4)). It is noted that the use of fill is not supported by DBCA policy in the Reclaimed Zone.
- Protect
  - Seawalls (Pr.4) and Nature Based solutions (Pr.2) scored highest.
- No Regrets
  - All options scored highly – Monitoring (NR.1), Protection Structure Audits (NR.2), Notification on Title (NR.3), Emergency Evacuation Plans (NR.4)

14.2.2 Reclaimed Zone

For the Reclaimed Zone the MCA scoring is shown in Figure 14.2. The highest performing options by respective categories are:

- Avoid
  - Avoid development (Av.1) in areas determined as being at risk of erosion or inundation hazard in the 100-year planning period (applies to undeveloped areas only).
- Managed Retreat
  - For Minor Infrastructure
    - Leave assets unprotected under Managed Retreat (MR.1)
    - Removal of assets once trigger reached (MR.2)
  - Limit further Subdivision (MR.5)
- Accommodate
  - Building Design options to raise floor levels, build structures to withstand flooding impacts and use of relocatable structures (Ac.1s Ac.2 Ac.3)
- Protect
  - Beach management / sand management (Pr.1) and Nature Based solutions (Pr.2) scored highest.

- The current practice of Groynes (Pr.3) and Seawalls (Pr.4) scored marginally lower
- No Regrets
  - All options scored highly – Monitoring (NR.1), Protection Structure Audits (NR.2), Notification on Title (NR.3), Emergency Evacuation Plans (NR.4)

14.2.3 Natural Zone

For the Natural Zone the MCA scoring is shown in Figure 14.3. The highest performing options by respective categories are:

- Avoid
  - Avoid development (Av.1) in areas determined as being at risk of coastal hazard in the 100-year planning period (applies to undeveloped areas only).
- Managed Retreat
  - For Minor Infrastructure
    - Leave assets unprotected under Managed Retreat (MR.1)
    - Removal of assets once trigger reached (MR.2)
- Accommodate
  - Building Design options to raise floor levels, build structures to withstand flooding impacts and use of relocatable structures (Ac.1s Ac.2 Ac.3)
- Protect
  - Beach management / sand management (Pr.1) and Nature Based solutions (Pr.2) scored highest.
  - Maintaining current Seawalls (eg at the East Fremantle Yacht club) location scored marginally lower (Pr.4).
- No Regrets
  - All options scored highly – Monitoring (NR.1), Protection Structure Audits (NR.2), Notification on Title (NR.3), Emergency Evacuation Plans (NR.4)

			Technical				Social		Environment		Legal	Cost	
Code	Adaptation Option	Asset Types	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	Community	Public Amenity	Natural Environment	Visual Amenity	Legal Implications	Capital and Lifecycle	TOTAL
Av.1	Locating Assets in areas that are not vulnerable to coastal hazards	Land within the Hazard extent - applicable for undeveloped land or redevelopment	2	2	2	2	1	2	2	2	0	5	11
MR.1	Leaving Assets Unprotected	Minor Infrastructure	1	0	2	2	1	0	1	0	2	4	8
		Major Infrastructure	0	-2	2	2	-1	-1	0	-1	0	4	3
		Residential and Commercial Property	-2	-2	1	0	-2	-2	0	-1	-2	4	-1
MR.2	Demolition, Removal or relocation of Assets from inside the hazard area once trigger reached (flood or erosion trigger)	Minor Infrastructure	2	2	2	1	1	2	1	1	1	4	9
		Major Infrastructure	1	1	1	0	0	1	0	0	0	3	4
		Residential and Commercial Property	1	1	1	0	0	1	0	0	0	3	4
MR.3	Event limited development approval / prohibit expansion of existing use rights.	Residential and Commercial Property	0	1	1	1	0	0	1	2	-1	4	5
MR.4	Voluntary Acquisition	Residential and Commercial Property	1	1	1	1	1	1	1	2	-1	1	4
MR.5	Limit Further Subdivision	Residential and Commercial Property	2	2	2	2	1	1	1	1	0	5	9
Ac.1	Building Design - Relocatable Structures	Residential and Commercial Property	1	1	1	0	1	1	1	1	1	4	8
Ac.2	Building Design Design assets to withstand impacts.	Residential and Commercial Property	1	2	2	1	2	1	2	1	1	4	10
Ac.3	Building Design - Raise Finished Floor Levels	Residential and Commercial Property	2	2	2	0	2	1	2	1	1	4	10
		Major Infrastructure	2	2	2	0	2	1	2	1	1	4	10
AC.4	Filling Land	Residential and Commercial Property	0	1	1	-1	1	0	-1	0	0	3	3
		Major Infrastructure	1	1	1	1	1	2	0	0	1	3	7
Pr.1	Beach Management / sand management	Foreshore areas and Beaches	0	-1	1	-1	0	0	0	1	1	3	4
Pr.2	Nature Based Solutions	Foreshore areas and Beaches	0	0	1	0	2	1	2	2	1	3	8
Pr.3	Groynes. Can be land based (eg Preston Point) or detached groynes (eg at John Tonkin Reserve)	Foreshore areas and Beaches	-1	0	1	-1	-1	-1	0	0	-1	2	0
Pr.4	Seawalls	Foreshore areas and Beaches	2	2	1	1	1	1	0	2	2	2	8
Pr.5	Flood Mitigation Structure (Storm Surge Barrier)	Large Scale Flood Protection for Swan River	-1	2	0	-2	1	-1	0	-1	-1	1	-1
NR1	Monitoring	All Areas	2	0	0	0	2	2	2	1	2	4	10
NR2	Protection Structure Audit	Location of existing Structures	2	1	1	1	2	2	1	1	2	4	10
NR3	Notification on title	Residential and Commercial Property	2	1	2	2	1	1	1	1	-1	5	8
NR4	Emergency evacuation plans	Community, Residential and Commercial	2	0	2	2	1	1	1	1	1	5	10
DN1	Doing nothing - accept the risk to assets	All Areas	0	-2	2	2	-1	-2	-1	0	0	5	4

Figure 14.1: MCA scoring for adaptation approaches in the Walled Zone

			Technical				Social		Environment		Legal	Cost	
Code	Adaptation Option	Asset Types	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	Community	Public Amenity	Natural Environment	Visual Amenity	Legal Implications	Capital and Lifecycle	TOTAL
Av.1	Locating Assets in areas that are not vulnerable to coastal hazards	Land within the Hazard extent - applicable for undeveloped land or redevelopment	2	2	2	2	1	2	2	2	0	5	11
MR.1	Leaving Assets Unprotected	Minor Infrastructure	1	0	2	2	1	0	1	0	2	4	8
		Major Infrastructure	0	-2	2	2	-1	-1	0	-1	0	4	3
		Residential and Commercial Property	-2	-2	1	0	-2	-2	0	-1	-2	4	-1
MR.2	Demolition, Removal or relocation of Assets from inside the hazard area once trigger reached (flood or erosion trigger)	Minor Infrastructure	2	2	2	1	1	2	1	1	1	4	9
		Major Infrastructure	1	1	1	0	0	1	0	0	0	3	4
		Residential and Commercial Property	1	1	1	0	0	1	0	0	0	3	4
MR.3	Event limited development approval / prohibit expansion of existing use rights.	Residential and Commercial Property	0	1	1	1	0	0	1	2	-1	4	5
MR.4	Voluntary Acquisition	Residential and Commercial Property	1	1	1	1	1	1	1	2	-1	1	4
MR.5	Limit Further Subdivision	Residential and Commercial Property	2	2	2	2	1	1	1	1	0	5	9
Ac.1	Building Design - Relocatable Structures	Residential and Commercial Property	1	1	1	0	1	1	1	1	1	4	8
Ac.2	Building Design Design assets to withstand impacts.	Residential and Commercial Property	1	2	2	1	2	1	2	1	1	4	10
Ac.3	Building Design - Raise Finished Floor Levels	Residential and Commercial Property	2	2	2	0	2	1	2	1	1	4	10
		Major Infrastructure	2	2	2	0	2	1	2	1	1	4	10
AC.4	Filling Land	Residential and Commercial Property	0	1	1	-1	1	0	-1	0	0	3	3
		Major Infrastructure	0	1	1	-1	1	0	-1	-1	0	3	3
Pr.1	Beach Management / sand management	Foreshore areas and Beaches	1	1	1	1	1	1	2	2	1	3	8
Pr.2	Nature Based Solutions	Foreshore areas and Beaches	1	1	1	1	2	2	2	2	1	3	9
Pr.3	Groynes. Can be land based (eg Preston Point) or detached groynes (eg at John Tonkin Reserve)	Foreshore areas and Beaches	2	2	1	1	1	1	0	0	1	2	6
Pr.4	Seawalls	Foreshore areas and Beaches	2	2	1	1	1	1	0	0	1	2	6
Pr.5	Flood Mitigation Structure (Storm Surge Barrier)	Large Scale Flood Protection for Swan River	-1	2	0	-2	1	-1	0	-1	-1	1	-1
NR1	Monitoring	All Areas	2	0	0	0	2	2	2	1	2	4	10
NR2	Protection Structure Audit	Location of existing Structures	2	1	1	1	2	2	1	1	2	4	10
NR3	Notification on title	Residential and Commercial Property	2	1	2	2	1	1	1	1	-1	5	8
NR4	Emergency evacuation plans	Community, Residential and Commercial	2	0	2	2	1	1	1	1	1	5	10
DN1	Doing nothing - accept the risk to assets	All Areas	0	-2	2	2	-1	-2	-1	0	0	5	4

Figure 14.2: MCA scoring for adaptation approaches in the Reclaimed Zone

			Technical				Social		Environment		Legal	Cost	
Code	Adaptation Option	Asset Types	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	Community	Public Amenity	Natural Environment	Visual Amenity	Legal Implications	Capital and Lifecycle	TOTAL
Av.1	Locating Assets in areas that are not vulnerable to coastal hazards	Land within the Hazard extent - applicable for undeveloped land or redevelopment	2	2	2	2	1	2	2	2	0	5	11
MR.1	Leaving Assets Unprotected	Minor Infrastructure	1	0	2	2	1	0	1	0	2	4	8
		Major Infrastructure	0	-2	2	2	-1	-1	0	-1	0	4	3
		Residential and Commercial Property	-2	-2	1	0	-2	-2	0	-1	-2	4	-1
MR.2	Demolition, Removal or relocation of Assets from inside the hazard area once trigger reached (flood or erosion trigger)	Minor Infrastructure	2	2	2	1	1	2	1	1	1	4	9
		Major Infrastructure	1	1	1	0	0	1	0	0	0	3	4
		Residential and Commercial Property	1	1	1	0	0	1	0	0	0	3	4
MR.3	Event limited development approval / prohibit expansion of existing use rights.	Residential and Commercial Property	0	1	1	1	0	0	1	2	-1	4	5
MR.4	Voluntary Acquisition	Residential and Commercial Property	1	1	1	1	1	1	1	2	-1	1	4
MR.5	Limit Further Subdivision	Residential and Commercial Property	2	2	2	2	1	1	1	1	0	5	9
Ac.1	Building Design - Relocatable Structures	Residential and Commercial Property	1	1	1	0	1	1	1	1	1	4	8
Ac.2	Building Design Design assets to withstand impacts.	Residential and Commercial Property	1	2	2	1	2	1	2	1	1	4	10
Ac.3	Building Design - Raise Finished Floor Levels	Residential and Commercial Property	2	2	2	0	2	1	2	1	1	4	10
		Major Infrastructure	2	2	2	0	2	1	2	1	1	4	10
AC.4	Filling Land	Residential and Commercial Property	0	1	1	-1	1	0	-1	0	0	3	3
		Major Infrastructure	0	1	1	-1	1	0	-1	-1	0	3	3
Pr.1	Beach Management / sand management	Foreshore areas and Beaches	1	1	1	1	1	1	2	2	1	3	8
Pr.2	Nature Based Solutions	Foreshore areas and Beaches	1	1	1	1	2	2	2	2	1	3	9
Pr.3	Groynes. Can be land based (eg Preston Point) or detached groynes (eg at John Tonkin Reserve)	Foreshore areas and Beaches	-2	1	1	1	-1	0	0	-1	-1	2	0
Pr.4	Seawalls (currently in place at East Fremantle YC)	Foreshore areas and Beaches	1	2	1	1	1	1	1	1	1	2	6
Pr.5	Flood Mitigation Structure (Storm Surge Barrier)	Large Scale Flood Protection for Swan River	-1	2	0	-2	1	-1	0	-1	-1	1	-1
NR1	Monitoring	All Areas	2	0	0	0	2	2	2	1	2	4	10
NR2	Protection Structure Audit	Location of existing Structures	2	1	1	1	2	2	1	1	2	4	10
NR3	Notification on title	Residential and Commercial Property	2	1	2	2	1	1	1	1	-1	5	8
NR4	Emergency evacuation plans	Community, Residential and Commercial	2	0	2	2	1	1	1	1	1	5	10
DN1	Doing nothing - accept the risk to assets	All Areas	0	-2	2	2	-1	-2	-1	0	0	5	4

Figure 14.3: MCA scoring for adaptation approaches in the Natural Zone

14.3 Economic Analysis – Reclaimed Zone

An economic analysis of impacts from projected inundation hazard in the Reclaimed Zone (SMU2) was undertaken (Rhelm 2023). The economic analysis evaluates impacts from inundation hazard associated with projected sea level rise using the value of assets to assist in understanding the economic costs of a Managed Retreat approach. The results provide a preliminary estimate of the magnitude of the economic cost of sea level rise and timing of asset loss within the Reclaimed Zone.

14.3.1 Assumptions in Economic Analysis

A number of assumptions were adopted within the economic analysis including:

- Sea level rise projections as noted in Section 5.
- The assets within the Reclaimed Zone were valued using a range of methods and parameter values in Rhelm (2023). Valuation methods are summarised in Table 14.4. The adoption of replacement costs for a number of the assets in the absence of more detailed information is considered a conservative approach.
- Economic assessment period: 100-years (to align with the planning horizon and the projected changes as a result of climate change). Discount rate: 7%.
- Floor height above ground level for buildings in the study area: 0.3 metres. Threshold at which commercial and recreation buildings retreat (or are lost): general tide level equal to floor level. Threshold at which reserves and car parks retreat: 50% coverage of site.
- For the marinas, it was assumed that the moorings would not be affected by sea level rise and would be adapted progressively. Therefore, the amenity value is retained and the key loss in this case is the buildings associated with these marinas.
- For the reserves, it was assumed that the land will eventually be lost and not relocated and so there will be a loss in amenity value to the community as well as the value of the land. This assumption was based on the limited availability of suitable relocation sites within the immediate area.

Table 14.4: Economic Assessment in Reclaimed Zone - Asset Valuation Methods

Site	Valuation method
Leeuwin carpark and boat ramp	Car park: replacement value (resealing cost x area m^2) Boat ramp: construction cost (original cost escalated to $2023)
Zephyr Café and carpark	Replacement cost (assumed replacement cost/m^2 x area m^2)
Swan Yacht Club and carpark	
Navy Cadets Building	
Fremantle Rowing Club	
Cool Beans and carpark	
Hurricane Dragon Boat	
Aquarama Marina (various sites) and car park	
Riverside Road	

Site	Valuation method
W Wayman Reserve	Replacement cost (assumed replacement cost/m^2 x area m^2)
Norm McKenzie Reserve	Amenity value – proxy value based Breunig et al. (2018) study of impact of property prices in Australia multiplied by the number of houses within a 600-metre radius.
John Tonkin reserve	

14.3.2 Assessment Method

The economic assessment examines the inundation of sites in Table 14.4 under a range of flooding events, with the incorporation of projected sea level rise across the 100-year planning horizon. Analysis of the depth of inundation against the ground level and floor level of the key assets is used to estimate the potential damage costs that would be incurred.

Currently, assets within the Reclaimed Zone are only susceptible to flooding in an extreme coastal storm event. This will be further exacerbated with the impacts of climate change. In future sea level rise scenarios for the 2125 timeframe, a projected +1.05m sea level rise would result in many of the assets being inundated in the general tides.

The assessment method assumes that no mitigation works will be completed within the one-hundred-year assessment period to offset the damages that will be incurred as a result of the sea level rise scenarios.

Tidal inundation will have two distinct impacts on assets within the reclaimed zone:

1. Loss of assets: with the onset of sea level rise some assets within the Reclaimed Zone will be impacted frequently by the general tide inundating the asset (car parks and reserves) and floor levels (commercial and recreation venues). The total loss value of the asset was incurred at the threshold point for retreating from the location and discounted to present value using the adopted discount rate.
2. Economic impact of coastal storm events: To incorporate the costs of overfloor flooding from coastal storm events, the annual average damages were calculated at the planning horizons and interpolated over the one-hundred-year assessment period. The annualised damage costs were set to zero from the year the asset was assumed to be abandoned (Item 1 above) as once the asset is lost there is no longer a damage cost incurred. The present value of the total annualised damage costs over the one-hundred-year assessment period was calculated using the adopted discount rate.

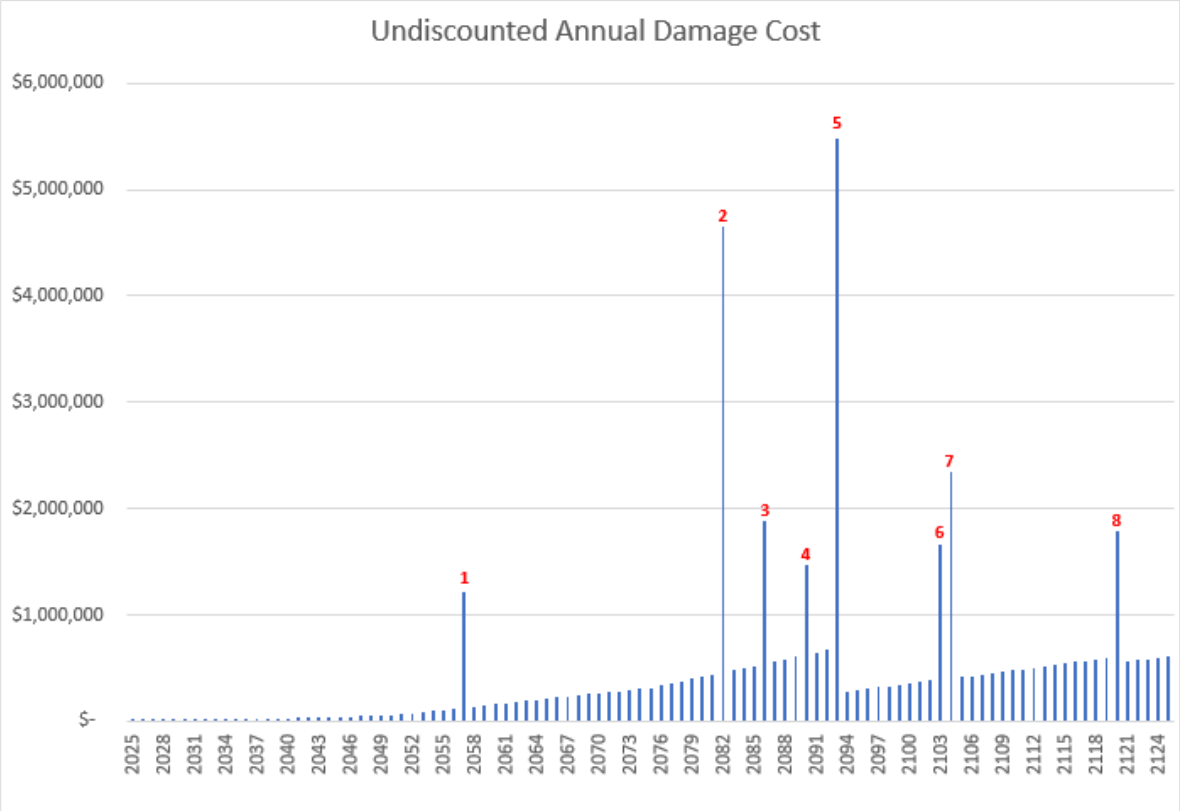
14.3.3 Total Present Value of Inundation

An estimate of the total present value of tidal inundation on the Reclaimed Zone is forecast to be $2.7 million. The present value result is reflective of the gradual impact of the onset of sea level rise on the Reclaimed Zone, and the likelihood that the majority of damages will be incurred towards the end of the one-hundred-year assessment period. This value will progressively increase in coming years as we reach a period where there is a greater influence of sea level rise. This will mean that mitigation options that are not feasible now (because the impacts primarily occur after 2050) may be viable in the future.

14.3.4 Undiscounted annual Damage Cost

The undiscounted gradual impact of damages is shown in Figure 14.4. The total undiscounted cost of sea level rise on the Reclaimed Zone is conservatively estimated at $46.2 million.

The spikes in the figure show the year at which retreat from the site occurs, and the total economic loss incurred, due to the general tide reaching the assumed abandonment threshold points. The spikes are generally followed by a drop or slowing rate of annual damages, this is due to the annualised damages of high tide events no longer being incurred by the abandoned assets. That is, there are less assets in the total Reclaimed Zone ‘asset stock’ that are vulnerable to tidal inundation.



Retreat Sites

1 Leeuwin boat ramp and car park
2 John Tonkin Reserve
3 W Wayman Reserve
4 Norm McKenzie Reserve
5 Aquarama (various assets)
6 Riverside Road overtops
7 Fremantle Rowing Club
8 Hurricane dragon Boat

Figure 14.4: Undiscounted Annual damages cost summary (2025 to 2125)

14.3.5 Summary of Outcomes and Recommendations for Future Work

The results provide a preliminary estimate of the magnitude of the economic cost of sea level rise and timing of asset loss within the Reclaimed Zone. The analysis is not intended to provide a precise valuation of the economic values of assets or timing of asset loss. The results are provided to inform discussions on sea level rise mitigation options within the Reclaimed Zone.

There are a number of assumptions and uncertainties in the analysis which could be refined to provide greater certainty in a future more comprehensive analysis which could include:

- Refinement of short-term protection and long-term relocation options for assets within the Reclaimed Zone.
- Collation of data on the John Tonkin, W Wayman and Norm McKenzie reserve visitor numbers and distanced travelled by visitors.
- Collation of data on the Leeuwin Boat Ramp usage numbers and distance travelled by boat ramp users.
- Collation of data on the Riverside Road usage numbers.

15. Adaptation Pathways

15.1 Risk Management Pathway

In the CHRMAP guidelines the risk management pathway(s) approach enables the establishment of a decision-making strategy that is made up of a sequence of decision points over time, preventing a decision-maker from being locked into a risk treatment option (and associated risk management measures), which may not be appropriate for dealing with the long-term problem. The intent is for decision-making to be responsive to changing circumstances over time, while not all decisions can be made today, they can be planned, prioritised and prepared for (WAPC 2019).

The risk management pathways approach is used to inform decision-making at defined trigger points. The trigger points define the point at which a change in risk management approach / measure should be enacted as part of the ongoing strategic planning process.

15.2 Management Triggers

The concept of a trigger point is to have a pre-determined point that is set to 'trigger' the commencement of planning and/or implementation actions relating to a risk management option.

Triggers for the decision points are generally associated with the observation of key events on the ground rather than being time based. Estimated timeframes presented in the CHRMAP are driven by sea level rise impacts to inundation hazard that is projected to occur in future planning periods. The triggers would be assessed as part of future monitoring, to determine when they are reached or approaching.

The Trigger points, Decision Making and Measures that will be applied in the risk management pathways are summarised in Table 15.1.

The key activities that are used to monitor trigger points and inform where these are reached or close to being reached are:

- Annual Monitoring Program
  - The annual monitoring program (outlined in Section 17.3) would be used to examine changes in the shoreline areas and examine triggers for:
    - Erosion: identify the position of the shoreline (HSD) and whether this moves either landward (as a result of erosion) or seaward (as a result of accretion).
    - Inundation: track the rate of sea level rise (from Fremantle tide gauge and technical studies) and on the ground impacts from extreme flooding events that occur
- Asset Management and Structure condition reporting
  - Condition reports and asset management will provide the basis for understanding when structures need replacement or upgrade. The Town currently undertake inspections, upgrades and maintenance as part of the East Fremantle River walls 10 Year Priority Plan (2022).
- Review of CHRMAP (recommended every 5 to 10 years)
  - It is recommended that the CHRMAP be reviewed and updated every five to ten years. As part of this review the following would be included:
    - The improved knowledge of coastal hazards in the shoreline areas from the annual monitoring and additional studies should be incorporated into the review and where this may impact any of the recommendations in the CHRMAP
    - The guidance on sea level rise projections by the DoT (DoT 2010) should be reviewed for any updates. Any change to the projected sea level rise allowances would require assessment of updates to the CHRMAP.

- Review of changes in the SPP2.6 advice (WAPC 2013) or updates to the CHRMAP guidelines (WAPC 2019) would be assessed as part of the review process.
- Engagement with the community to provide an overview of learnings from the annual monitoring program and outline how these are captured in the CHRMAP review process. A review of the community values to determine if they are consistent with values collected in the previous version of the CHRMAP would be sought as part of the engagement activities.
- Assets that are predicted to become highly or very highly vulnerable within the next planning timeframe (or within 10 years) would be identified.

Table 15.1: Trigger Points Decision Making and Measures (Adapted from WAPC 2019)

Trigger Name	Trigger	Action	Measures	Identification Method
T1	The distance between an asset and the Horizontal Shoreline Datum (HSD) is less than the shoreline loss predicted from the erosion associated with a 1 in 100-yr storm event (S1).	Ongoing Monitoring to define changes to the HSD line Refinement to the S1 value based on field data collected following extreme events / updated modelling information	Provide interim protection for major infrastructure (roads, carparks), residential and commercial buildings Remove major infrastructure (roads, carparks), residential and commercial buildings, transfer land to public realm Prepare response plans for minor infrastructure that could be impacted	Assessment of the shoreline position will be a task included in the annual monitoring program.
T2	A public road is no longer available or able to provide legal access to a property	Liaison with/notification by relevant level of government	Remove residential and commercial buildings, and transfer land to public realm	Task included in the annual monitoring program.
T3	Water, sewer or electricity to a lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards	Liaison with/notification by utility providers	Remove residential and commercial buildings, and transfer land to public realm	Task included in the annual monitoring program.
T4	Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent	Definition of hazard extents through CHRMAP. CHRMAP and hazard extent updates due to availability of more relevant/recent information (such as updated sea level rise predictions) and changes in	Include all affected land in a Special Control Area (SCA) which is not in the DCA and ensure the hazard information is incorporated in structure planning.	This is defined in the SCA as an outcome of the CHRMAP.

Trigger Name	Trigger	Action	Measures	Identification Method
		environmental conditions (such as changes to tidal planes / Mean seal level).	Provide notification of potential hazards on certificates of title where reasonably practicable and by direct contact with affected landholders	
T5	An asset is damaged, destroyed or becomes unsafe	Inspection of coastal assets following storm events or during times of increased longshore erosion. Town asset management includes inspection and reporting on condition of the structures. Notification by the public	Remove assets and relocate to less hazardous area if possible/appropriate	Informed by the Asset management and Structure Condition Assessments undertaken by the Town. Also captured in Annual Monitoring program
T6	Assets are predicted to become highly or very highly vulnerable within the next planning timeframe or within 10 years	Definition of hazard extents through CHRMAP. CHRMAP and hazard extent updates due to availability of more relevant/recent information (such as updated sea level rise predictions) and changes in environmental conditions.	Undertake detailed cost-benefit analysis and assessment of community acceptance of interim protection vs. managed retreat of the affected asset; Identify sources and begin to allocate funding for risk management measures	As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).
T7	The overall community and stakeholders are no longer supportive of a specific risk management technique or approach	Ongoing community engagement; Cost-benefit analysis	Investigate, identify and implement a change in the risk management pathway, if appropriate	As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).

Trigger Name	Trigger	Action	Measures	Identification Method
T8	A specific risk management technique is forecast to no longer be economically or physically feasible within 10 years	Ongoing shoreline and coastal asset monitoring Budget expenditure and forecasts Cost-benefit analysis	Investigate, identify and implement a change in the risk management pathway, if appropriate	As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).
T9	The beach and coastal foreshore reserve is significantly diminished with respect to its original state and function	Long-term coastal monitoring program Assessment of aerial imagery Feedback through ongoing community consultation	Investigate, identify and implement a change in the risk management pathway, if appropriate	Assessment of the shoreline position will be a task included in the annual monitoring program.
T10	Undeveloped land is identified as lying within the hazard extents	Definition of hazard extents through CHRMAP. CHRMAP and hazard extent updates due to availability of more relevant/recent information (such as updated sea level rise predictions) and changes in environmental conditions (such as changes to tidal planes / Mean seal level).	Implement planning controls to avoid inappropriate development of the land	This is defined in the SCA. As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).

15.3 Walled Zone (SMU1) – Adaptation Pathways

15.3.1 Risk Treatment

For the Walled Zone, Riverside Road is recognised as an important connection for the community and stakeholders and from discussions with the DBCA (refer Section 13.3) there is support to maintain the road in its current location in future. Additionally, the foreshore area is host to highly valued community assets such as the coastal pathways and parks.

The riverwalls that are in place along the Walled Zone will be maintained in future planning periods, as these provide erosion protection to the foreshore and all assets landward (foreshore reserve, Riverside Road, Carparks, minor infrastructure, private property). Whilst the objective is for erosion protection, there will still exist inundation hazard for the foreshore areas in extreme events that will require appropriate management responses with rising sea levels. The management of this risk will require a strategy that can adjust over time. For Riverside Road and Carparks along the section of the shore, there would be a need to lift the surface level incrementally to keep up with sea level rise. This could be done periodically (every 10 to 20 years) and factored into the general maintenance and upgrading of the road surface. Upgrades to drainage would also need to be considered as part of road upgrades.

There are approximately 15 properties that are located within the coastal inundation hazard extent for the 2125 planning period at Riverside Road in the sections adjacent Pier St and Near East St (Figure 15.1). These are protected from erosion under the assumption the riverwalls are maintained, however the inundation hazard associated with projected SLR in the 2075 – 2125 timeframe increases significantly. It is recommended that an accommodate approach is adopted to manage the risk from inundation, with planning-based measures used to mitigate the risk.

Figure 15.1: Inundation risk to existing properties on Riverside Road near Pier St and East St

The key CHRMAP recommendations for the management of the SMU are summarised as follows:

- The approach to manage erosion risk for the foreshore area is Protect, to be achieved through maintaining the continuous riverwall and revetment structures along the shoreline.
- To manage inundation risk to assets in the foreshore, the general approach is Accommodate until such time as this is too expensive and a Managed Retreat is enacted.
    - The Protect option at the shoreline will provide erosion protection for the Town and community assets located landward in the foreshore reserve area including pathways, carparks and minor infrastructure (shelters, seats, BBQ's etc). The adoption of a Protect strategy at the shoreline ensures Riverside Road is not subject to erosion impacts, recognising its importance. The Town should undertake audits of the existing riverwalls and protection structures to determine the current condition and schedule future maintenance and replacement costs into budget planning as part of management actions.
    - The inundation hazard in the shoreline areas will increase under projected sea level rise in future planning periods. To manage this risk an Accommodate approach is recommended that allows the use of respective coastal assets to continue until the asset is no longer safe or structurally sound. Minor repair would be permitted consistent with asset lifecycle and expected planning timeframe, including the raising of assets to keep up with sea level rise (eg raising the floor level of Dome Café and Marine Boatshed or increasing the Carpark surface as part of scheduled design life upgrades). At the point in time at which risk to assets become intolerable, or cost of the Accommodate option becomes too high, the strategy would change to Managed Retreat. This would relocate the respective assets further landward as required consistent with design life upgrades.
- The properties that are located within the coastal inundation hazard extent for the 2125 planning period are assumed to be protected from erosion under the assumption the riverwalls are maintained. It is recommended an SCA covering the region of the identified inundation is established with a Local Planning Policy (LPP) that implements the planning-based controls within the SCA. A map of the proposed area for the SCA is presented in Appendix E. Development controls for these areas is recommended in the LPP that would provide guidance for appropriate development controls within the SCA including:
    - Accommodating the inundation risk consistent with planning timeframes to 2125 through design and planning measures which include appropriate Building Design (Ac.2), Appropriate Finished floor levels (Ac.3), Filling Land (Ac.4).
    - Placement of a Notification on title (Ac.1) to indicate to current and future landowners that the property is within a coastal hazard area and likely to be affected by coastal erosion and/or inundation over the planning timeframe.
- It is noted there are a range of utilities infrastructure that are affected by inundation and erosion risk through the SMU. Utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk (WaterCorp etc).
- Emergency planning to determine the accessibility to Riverside Road in extreme events should be undertaken. This will be further discussed in the Implementation Plan (Section 17).

Adaptation approaches are summarised in Table 15.2.

Table 15.2: Risk Treatment – Walled Zone (SMU1)

Asset / Location	Erosion	Inundation
Riverside Road	Protected through maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4). Drainage upgrades would need to be considered. Emergency planning (Nr.4) for this key route
Foreshore Reserve areas	Protected through maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Short term inundation in large events is acceptable (MR.1).
Coastal Pathways	Protected through maintenance of the existing riverwall network (Pr.4). May be a need to relocate the pathways further landward in future associated with adjustments to the overall protection solution.	Design pathways to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4)
Minor Infrastructure (BBQ.s, benches, signs etc)	Protected through maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Longer Term – 0.5m to 1m Sea Level Rise Short term inundation in large events is acceptable (MR.1). Remove and relocate further landward if needed (MR2) Monitor for safety following impacts (NR1)
Existing Residential Properties	Erosion protection provided by the maintenance of the continuous riverwalls.	Planning controls implemented through SCA and LPP with Notification on title (Ac.1) Accommodate inundation consistent with planning timeframes to 2125 through design and planning measures specified in LPP which outlines requirements for: • Building Design / Design to withstand inundation impacts (Ac.2) • Appropriate Finished floor levels (Ac.3) • Filling Land (Ac.4)
Dome Café and Marine Education Boatshed	N/A	Planning controls implemented through SCA and LPP. Accommodate inundation consistent with planning timeframes to 2125 through design and planning measures which outlines requirement for: • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.3) Monitor for safety following impacts (NR1)

Asset / Location	Erosion	Inundation
Carparks	Protected through maintenance of the existing riverwall network (Pr.4). May be a need to relocate further landward in future associated with adjustments to the riverwall protection solution.	Design to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4) Longer Term – 0.5m to 1m Sea Level Rise Short term inundation in large events is acceptable (MR.1). Relocate when too expensive or difficult to mitigate the flood risk (MR.2) Monitor for safety following impacts (NR1)

15.3.2 Risk Management Pathways – SMU1

Long term adaptation pathways for the key at risk assets identified in SMU1 are summarised in Table 15.3 based on the format recommended in WAPC 2019. The long-term pathways are based on trigger points that would signal a change in management response. Trigger points and their monitoring are detailed in the Implementation Plan (Section 17).

The colour legend in the table is based on the general adaptation categories in the table below.

Table 15.3: Risk management pathway and triggers for the Walled Zone (SMU1)

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Sea Level Rise projection. End of period	0.1m	0.2m	0.5m	1.05m
Assets	**Foreshore Areas and All Assets Landward – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using Riverwalls and Revetments (Pr.4)			
Pathway	Protection Structure Audits (NR.4)			
Assets	**Carparks and Coastal Pathway – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise level in step with SLR (AC3)			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent			T5: Damaged/ unsafe T6: Highly Vulnerable T7: Lack public support T9: Economic feasibility
Assets	**Riverside Road – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise surface level in step with Sea Level Rise (AC3)			
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal inundation hazard extent			
Pathway	Develop emergency planning for use of Riverside Road in extreme events (NR.4)			
Assets	**Residential Properties (Riverside Road near Pier St and East St). Inundation Hazard**			
Pathway	Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion or inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development in the SCA that can address coastal hazard.			
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4,T10)			

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Assets	**Dome Café and Marine Education Boatshed. Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise floor level in step with SLR (AC3)		Managed Retreat Remove and relocate the assets (MR1, MR2).	
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4)		T5: Damaged/ unsafe T6: Highly Vulnerable T9: Economic feasibility	
Assets	**Minor Infrastructure – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)		Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).	
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent		T5: Damaged/ unsafe T6: Highly Vulnerable Next 10-yrs T9: Economic feasibility	

15.4 Reclaimed Zone (SMU2) – Adaptation Pathways

15.4.1 Risk Treatment

The foreshore area around the Reclaimed Zone on the river side of Riverside Road is generally low lying, with mixed use including foreshore reserves and parks, Leeuwin boat ramp and carpark, commercial and community premises (Café's, Swan Yacht Club, Aquarama, 8 Knots Tavern etc). The area is highly valued by the community for recreational and social purposes.

The majority of the foreshore of the Reclaimed Zone is currently protected from erosion by several different hard engineering methods. This includes pitched rock revetment adjacent the Leeuwing boat ramp, detached groynes offshore of John Tonkin Reserve, groyne at Preston Point and almost continuous seawall along the north facing section of shoreline from Preston Point to the east side of W.Wayman Reserve. There are short sections of natural beach at the shoreline of Niergarup reserve, John Tonkin Reserve, Merv Cowan Park and W.Wayman Reserve.

The protection structures that are currently in the shorelines are recommended to be maintained in the short to medium term. With projected sea level rise it is anticipated that at a point in the future the impacts from inundation may become too difficult and expensive to mitigate for foreshore reserves, with a change in the adaptation pathway to planned and managed retreat. This would be triggered by a sea level rise at the end of the planning period considered in this study (2125 period +1.05m). Under this scenario, the low-lying foreshore areas of the reclaimed zone would be inundated regularly by the general tide range (mean high high water (MHHW)) in spring tides as shown in Figure 15.2. For a large storm event (eg 1 in 2yr ARI) the inundation hazard would impact areas landward of Riverside Road as shown in Figure 15.2.

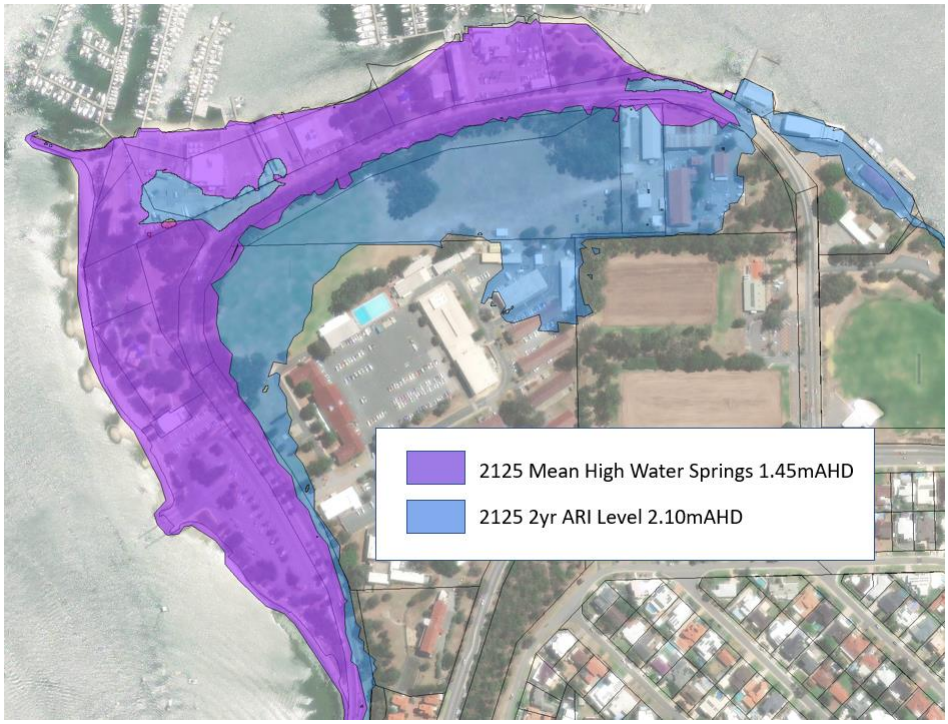


Figure 15.2: Reclaimed Zone Flooding Scenarios for 2125 with 1.05m Sea Level Rise. Inundation extent shown for spring tide mean high water level of 1.45m AHD (purple) and the 2yr ARI event peak water level (Blue).

Discussions with the DBCA have indicated that filling land in the foreshore to manage the inundation hazard would not be supported. The regular flooding of the foreshore under this scenario warrants a change in management strategy, recommended to be 'Managed Retreat'. The managed retreat of the foreshore area and associated infrastructure should consider retreat to the area bound by Riverside Road, as this represents a physical asset that provides connection to the location, whilst also being the point where the land level elevation is higher and less susceptible to inundation.

General recommendations for the Reclaimed Zone are:

- Accommodate flood risk to Riverside Road through periodic incremental raising of the road level in accordance with the rate of sea level rise and general road upgrade / maintenance schedule.
- Accommodate coastal hazard risk from inundation to commercial and community buildings (Swan Yacht Club, 8 Knots Tavern etc) through improved building design and the use of planning controls (minimum floor levels)
- Examine appropriate nature-based solutions to implement and provide resilience to shorelines including Niergarup Reserve, John Tonkin Reserve, Merv Cowan and W.Wayman Park, supported through grant funding and local volunteer groups. It is noted that application of Nature Based Solutions is an area that is still developing. While the intention is to maintain these shoreline areas with natural approaches (supported by the feedback received by the local community) their effectiveness in delivering the required outcomes would need to be examined in practice. In areas where these do not work well, the application of traditional 'hard engineering' methods or hybrid solution of hard engineering and Nature based options could be applied.
- For the Reclaimed Zone, the short to medium term adaptation pathway is to maintain existing erosion protection along the foreshore areas through traditional 'hard engineering' methods currently in place - river walls, revetments and detached groynes. Examine alternative methods of protection that can be achieved through other 'soft engineering' methods (eg Nature Based Solutions) and look for opportunities to implement as part of the asset replacement lifecycle.

- For the Reclaimed Zone the long-term adaptation pathway is expected to require a managed retreat approach, triggered by the difficulty and cost of mitigating inundation hazard with projected sea level rise of 1.05m in the 100-yr planning period. This scenario is driven by future sea level rise where the current foreshore areas are inundated regularly in the general tides and it is too difficult and/or expensive to maintain the current extent of the foreshore. There is a general presumption against using fill in the foreshore areas to address inundation risk.
- A future scenario of Managed Retreat of the foreshore area and associated infrastructure along the Reclaimed Zone should consider retreat to the area on the land side of Riverside Road.
- If there is a future change in the land use at the Leeuwin Barracks site to redevelop the location for residential and commercial property, then this would need to address the risk from erosion and inundation across the 100-years planning timeframe through planning-based approaches.
- It is noted there are a range of utilities infrastructure that are affected by inundation and erosion risk through the SMU. Utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk (WaterCorp etc).
- Emergency planning to determine the accessibility to Riverside Road in extreme events should be undertaken. This will be further discussed in the Implementation Plan (Section 16.4.2).

Adaptation approaches are summarised in Table 15.4.

Table 15.4: Risk Treatment – Reclaimed Zone (SMU2)

Asset / Location	Erosion	Inundation
Riverside Road	Protected through maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4) Emergency planning (Nr.4) for this key route
Foreshore Reserve areas	Protected through existing detached groyne field at John Tonkin (Pr.4), maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Short term inundation in large events is acceptable (MR.1).
Coastal Pathways	Protected through existing detached groyne field at John Tonkin (Pr.4), maintenance of the existing riverwall network (Pr.4). May be a need to relocate the pathways further landward in future associated with adjustments to the overall protection solution.	Design pathways to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4) Longer Term – 0.5m to 1m Sea Level Rise Short term inundation in large events is acceptable (MR.1). Remove and relocate further landward if needed (MR2) Monitor for safety following impacts (NR1)
Minor Infrastructure (BBQ.s, benches, signs etc)	Protected through existing detached groyne field at John Tonkin (Pr.4), maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Longer Term – 0.5m to 1m Sea Level Rise

Asset / Location	Erosion	Inundation
		Short term inundation in large events is acceptable (MR.1). Remove and relocate further landward if needed (MR2) Monitor for safety following impacts (NR1)
Commercial and Community premises	Protected through existing detached groyne field at John Tonkin (Pr.4), maintenance of the existing riverwall network (Pr.4).	Accommodate inundation consistent with planning timeframes to 2125 through design and planning measures which outlines requirement for: • Building Design / design to withstand impacts (Ac.2) • Appropriate Finished floor levels (Ac.3) Monitor for safety following impacts (NR1)
Carparks	Protected through existing detached groyne field at John Tonkin (Pr.4), maintenance of the existing riverwall network (Pr.4). May be a need to relocate further landward in future associated with Inundation risk triggering Managed Retreat..	Design to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4) Longer Term – 0.5m to 1m Sea Level Rise Short term inundation in large events is acceptable (MR.1). Relocate when too expensive or difficult to mitigate the flood risk (MR.2) Monitor for safety following impacts (NR1)

15.4.2 Risk Management Pathways – Reclaimed Zone SMU2

Long term adaptation pathways for the key at risk assets identified in SMU2 are summarised in Table 15.5 based on the format recommended in WAPC 2019. The long-term pathways are based on trigger points that would signal a change in management response. Trigger points and their monitoring are detailed in the Implementation Plan (Section 17).

The colour legend in the table is based on the general adaptation categories in the table below.

Table 15.5: Risk management pathway and triggers for the Reclaimed Zone (SMU2)

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Sea Level Rise projection. End of period	0.1m	0.2m	0.5m	1.05m
Assets	**Foreshore Areas and All Assets Landward – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using offshore detached groyne field, riverwalls and revetments (Pr.4) where currently in use. Apply Nature based solutions (Pr.2) to areas that are currently unprotected			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Pathway	Protection Structure Audits (NR.4)			T9: Economic feasibility
Assets	**Carparks and Coastal Pathway – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise level in step with SLR (AC3)			Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent			T5: Damaged/ unsafe T6: Highly Vulnerable

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
				T7: Lack public support T9: Economic feasibility
Assets	**Riverside Road – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2) • Raise surface level in step with SLR (AC3)			
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal inundation hazard extent			
Pathway	Develop emergency planning for use of Riverside Road in extreme events (NR.4)			
Assets	**Commercial Properties - Inundation Hazard**			
Pathway	Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion of inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development that can address coastal hazard.			
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4,T10)			
Assets	**Minor Infrastructure – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)		Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).	
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent		T5: Damaged/ unsafe T6: Highly Vulnerable Next 10-yrs T9: Economic feasibility	

15.5 Natural Zone (SMU3)

15.5.1 Risk Treatment

For the Natural Zone, the key areas requiring management are the Jerrat Drive foreshore, the Sea Scouts location and the East Fremantle Yacht Club.

For the buildings at the site of the Sea Scouts and the East Fremantle Yacht Club, the key risk to manage is that from inundation hazard with projected sea level rise. The management of the risk is recommended to be addressed through planning responses (minimum finished floor levels) and building design (use of relocatable structures where appropriate, designing new structures to withstand inundation impacts). A foreshore management plan to guide management actions in the foreshore of the Jerrat Drive escarpment is recommended and further studies to better understand the site.

The key CHRMAP recommendations for the management of the SMU are summarised as follows:

- The approach to manage erosion risk is as follows:
  - For the East Fremantle Yacht Club foreshore area the adaptation approach is Protect. This is to be achieved through either maintaining the continuous riverwall and revetment structures along the shoreline or consideration of alternative options that are not traditional 'hard engineering' structures that would continue to provide the current level of protection. The practice of structure audits of the existing riverwalls to determine the current condition is recommended to inform future maintenance and replacement costs for budget planning.
  - For the Sea Scouts the adaptation approach is Protect. This is to be achieved through either maintaining the continuous riverwall and revetment structures along the shoreline or consideration of alternative options that are not traditional 'hard engineering' structures that would continue to provide the current level of protection.
  - The potential option to co-locate to a shared premises could be considered for East Fremantle Yacht Club and the Sea Scouts. This would allow the Town and Community groups to share the cost of construction and maintenance for protection structures.
- To manage inundation risk to assets in the foreshore, the general approach is Accommodate.
  - The inundation hazard in the shoreline areas will increase under projected sea level rise in future planning periods. To manage the risk to minor infrastructure an Accommodate approach is recommended that allows the use of respective coastal assets to continue until the asset is no longer safe or structurally sound. Minor repair would be permitted consistent with asset lifecycle and expected planning timeframe. At the point in the future where the Accommodate option becomes too difficult or expensive a Managed Retreat approach may be enacted to relocate further landward, at the time that sea level rise reaches 0.5m to 1m.
  - For the East Fremantle Yacht Club buildings the management of the risk is recommended to be addressed through planning responses (minimum finished floor levels) and building design (use of relocatable structures where appropriate, designing new structures to withstand inundation impacts).
  - For the Sea Scouts Building the inundation risk is recommended to be mitigated through planning-based recommendation on achieving a minimum finished floor level for the building consistent with the design life. This would be undertaken at the time of redevelopment of the site in the future.

Adaptation approaches are summarised in Table 15.6.

Table 15.6: Risk Treatment – Natural Zone (SMU3)

Asset / Location	Erosion	Inundation
Foreshore Reserve areas - section adjacent East Fremantle Yacht Club	Protected through maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Short term inundation in large events is acceptable (MR.1).
Coastal Pathway, access and parking - East Fremantle Yacht Club	Protected through maintenance of the existing riverwall network (Pr.4).	Design road and pathways to withstand the impacts from periodic inundation (AC.2) Incrementally raise surface level as sea level rise occurs (AC.4) Longer Term – 0.5m to 1m Sea Level Rise Short term inundation in large events is acceptable (MR.1). Remove and relocate further landward if needed (MR2) Monitor for safety following impacts (NR1)
Minor Infrastructure (BBQ.s, benches, signs etc)	Protected through maintenance of the existing riverwall network (Pr.4).	Design to withstand the impacts from periodic inundation (AC.2) Longer Term – 0.5m to 1m Sea Level Rise Short term inundation in large events is acceptable (MR.1). Remove and relocate further landward if needed (MR2) Monitor for safety following impacts (NR1)
Sea Scouts Building	Protected through maintenance of the existing riverwall (Pr.4).	Planning controls implemented through SCA and LPP. Accommodate inundation consistent with planning timeframes to 2125 through design and planning measures which outlines requirement for: • Building Design / Design to withstand impacts (Ac.2) • Appropriate Finished floor levels (Ac.3)
Jerrat Drive Foreshore Area	Examine use of Nature Based solutions to improve resilience in the shoreline areas (Pr.2). Monitor shorelines to track changes and develop further understanding of processes driving changes in the shoreline areas (NR.1).	N/A

15.5.2 Risk Management Pathways – Natural Zone SMU3

Long term adaptation pathways for the key at risk assets identified in SMU3 are summarised in Table 15.7 based on the format recommended in WAPC 2019. The long-term pathways are based on trigger points that would signal a change in management response. Trigger points and their monitoring are detailed in the Implementation Plan (Section 17.3).

The colour legend in the table is based on the general adaptation categories in the table below.

Avoid
Planned or Managed Retreat
Accommodate
Protect
No Regrets
Do Nothing

Table 15.7: Risk management pathway and triggers for the Natural Zone (SMU3)

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
Sea Level Rise projection. End of period	0.1m	0.2m	0.5m	1.05m
Assets	**Foreshore Areas - East Fremantle Yacht Club and Sea Scouts – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using Riverwalls and Revetments (Pr.4)			
Pathway	Protection Structure Audits (NR.4)			
Assets	**Jerrat Drive Escarpment Foreshore Area – Erosion Hazard**			
Pathway	Protect against Erosion Hazard using Nature Based Solutions (Pr.2)			
Pathway	Shoreline Monitoring (NR.1)			
Assets	**Carparks and Coastal Pathway adjacent East Fremantle Yacht Club – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)			Managed Retreat Remove and relocate the assets at a distance

Planning Timeframe	Now – 2035	2035 - 2050	2050 - 2075	2075 - 2125
	• Raise level in step with SLR (AC3)			appropriate for the asset design life / lifecycle (MR1, MR2).
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent			T5: Damaged/ unsafe T6: Highly Vulnerable T7: Lack public support T9: Economic feasibility
Assets	**Sea Scouts Building and East Fremantle Yacht Club Building - Inundation**			
Pathway	Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion of inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development in the SCA that can address coastal hazard.			
Trigger	Property lies seaward of 100-year planning period erosion and/or inundation extent (T4,T10)			
Assets	**Minor Infrastructure – Inundation Hazard**			
Pathway	Accommodate inundation hazard. • Design to withstand impacts (AC2)		Managed Retreat Remove and relocate the assets at a distance appropriate for the asset design life / lifecycle (MR1, MR2).	
Trigger	T4 - Asset lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent		T5: Damaged/ unsafe T6: Highly Vulnerable Next 10-yrs T9: Economic feasibility	

16. Key Recommendations

16.1 Summary of Adaptation Approaches and Recommendations

The general approaches recommended to adapt to the risk of coastal hazard in this CHRMAP include:

- Avoid development on land within the erosion hazard area over the 100-year planning period.
- Accommodate coastal hazard risk from inundation to commercial and habitable buildings through improved building design and the use of planning controls (minimum floor levels).
- Accommodate coastal hazard risk to infrastructure in the foreshore areas until such time that a managed retreat pathway may be required, as a result of sea level rise.
- Protect foreshore area and assets landward in the Walled Zone from erosion through maintaining present riverwalls and revetments.
- Accommodate flood risk to Riverside Road through periodic incremental raising of the road level in accordance with the rate of sea level rise and general road upgrade / maintenance schedule.
- Implement nature-based solutions to provide resilience to shorelines including Niergarup Reserve, Jerrat Drive foreshore, John Tonkin Reserve, supported through grant funding and local volunteer groups.
- For the Reclaimed Zone, the short to medium term adaptation pathway is to maintain existing erosion protection along the foreshore areas through traditional 'hard engineering' methods currently in place - river walls, revetments and detached groynes. Examine alternative methods of protection that can be achieved through other 'soft engineering' methods (eg Nature Based Solutions) and look for opportunities to implement as part of the asset replacement lifecycle.
- For the Reclaimed Zone the long-term adaptation pathway is expected to require a managed retreat approach, triggered by the difficulty and cost of mitigating inundation hazard with projected sea level rise of 1.05m in the 100-yr planning period. This scenario is driven by future sea level rise where the current foreshore areas are inundated regularly in the general tides and it is too difficult and/or expensive to maintain the current extent of the foreshore. There is a general presumption against using fill in the foreshore areas to address inundation risk.
- A future scenario of Managed Retreat of the foreshore area and associated infrastructure along the Reclaimed Zone should consider retreat to the area landward of Riverside Road. This decision is contingent on the future of the Leeuwin Barracks site and potential for land being made available.
- If there is a future change in the land use at the Leeuwin Barracks site to redevelop the location for residential and commercial property, then this would need to address the risk from erosion and inundation across the 100-years planning timeframe through planning-based approaches.
- For the shoreline area at the base of the Jerrat Drive escarpment use of nature-based solutions to increase resilience of the shoreline area.

16.2 Additional Studies Recommended

The following reports are recommended to support the understanding of shoreline areas for the CHRMAP:

1. A geophysical study and / or geotechnical study of the Jerrat Drive foreshore area is recommended to further understand the stability in this section of the shore. The high value of this section of coast to the community and stakeholders warrants that a detailed foreshore management plan be prepared to guide management of this location.
2. Foreshore management plans can provide a strategy to deliver the recommendations of this CHRMAP for particular foreshore reserves throughout the Town. Foreshore management plans can be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities. The Town should update the current foreshore management plan for

each of the SMU's to provide guidance for the ongoing management of foreshore reserves, monitoring of assets and the triggers for the managed retreat of assets and infrastructure at risk of erosion and inundation.

3. The City of Fremantle and the Town have established a Local Emergency Management Committee (LEMC) to oversee, plan and test the local emergency management arrangements in accordance with section 38(1) of the Emergency Management Act 2005. The LEMC has developed a Local Emergency Management Arrangement (LEMA) which includes useful information in relation to emergency preparation and response, including flooding. The LEMC shall be provided with a copy of the final CHRMAP and consider the identified risks in any subsequent reviews of the LEMA.
4. Publicly Available Information: It is recommended that the Town introduces the inundation hazard data into a publicly available mapping system, if available. This will ensure staff and the community have access to information on any affected land and can be made aware of the presence of the coastal hazards. Information on relevant coastal hazards and the implications for property, now and into the future, should also be made available to potential buyers upon making a land purchase enquiry.

16.3 Recommended Planning Controls

Planning based recommendations have been developed to address coastal hazard for existing residential and commercial property for areas outside the DCA that are controlled by the Town. These would also apply to the Leeuwin Barracks site in the Reclaimed Zone should this be released by the Department of Defence for redevelopment.

16.3.1 Local Planning Strategy

This CHRMAP will inform the next iteration of the Town's Local Planning Strategy to guide land use planning and development in areas prone to coastal hazards. There should be a general presumption against further land use intensification through rezoning or subdivision, unless specifically identified in the Local Planning Strategy. The identification of land for further intensification shall consider the risks identified in this CHRMAP alongside the precautionary principle contained in SPP 2.6.

The Local Planning Strategy has recently been adopted and endorsed by the Western Australian Planning Commission (WAPC). This references the application of SPP 2.6 and the need to consider coastal hazards identified through the preparation of the CHRMAP. Future revisions of the Local Planning Strategy must consider the coastal hazard risks identified in this CHRMAP together with other relevant planning matters including environmental, economic and social considerations to holistically inform and shape future amendments to the Town's LPS 3.

16.3.2 Structure Planning

Structure planning is considered the most effective mechanism where some degree of comprehensive redevelopment of land remains an option. Structure plans for land identified as being at risk of coastal processes over the next 100 years must include provision for a foreshore reserve to avoid unnecessary risks on future development. The foreshore reserve shall be ceded free of cost to the Crown to provide for continued coastal foreshore management, public access, recreation, conservation and landscape amenity. Structure plans shall also include provisions for all SPP 2.6 requirements to be met through subsequent approval process, including subdivision and development applications.

The Leeuwin Barracks site has been identified in the Local Planning Strategy as a potential site for future urban intensification. Amendments to the Metropolitan Region Scheme (MRS) and LPS 3 will be required to rezone the Leeuwin Barracks site to support future urban development. It is anticipated that a structure plan will be required to guide development and use of the Leeuwin Barracks site. Should a structure plan be prepared for the Leeuwin Barracks site, it will need to:

- Demonstrate how inundation risks can be appropriately managed, as outlined in the CHRMAP Local Planning Policy;
- Demonstrate how erosion risks can be appropriately managed should the existing physical barriers along Riverside Road be removed. This shall include provisions for planned or managed retreat along with the identification of alternative access and servicing arrangements; and
- Identify land for a foreshore reserve which is to be ceded free of cost to the Crown without payment of compensation. The foreshore reserve width is to include a suitable allowance for coastal processes while allowing for the continued foreshore management, public access, recreation, conservation and landscape amenity.

16.3.3 Local Planning Scheme Amendment

It is recommended that the Town initiate an amendment to LPS 3 to include the following provisions, in accordance with the CHRMAP Guidelines:

- Insert Land prone to inundation under Part 6: Special Control Areas and include the provisions outlined in Table 16.1.
- Update the Scheme Map to include the SCA which shall reflect the 100-year inundation hazard extents which affect zoned land, as identified in the CHRMAP.

The recommendations of this CHRMAP could be included as part of the next scheduled review of the Local Planning Scheme.

16.3.4 Special Control Area

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

The proposed area of the SCA is shown in Appendix E.1, with the DCA extent also shown in the mapping. The SCA covers small areas on the landward side of the DCA in the Walled Zone. For the Reclaimed zone the SCA would extend across the Leeuwin Barracks site if this were to be released by the Department of Defence for redevelopment in the future.

It is noted that some forms of development cannot be controlled by the SCA, such as works carried out by the State Government under the Public Works Act 1902 or development within the DCA. The Town will need to liaise with the relevant State agencies regarding such development to ensure it is not incompatible with the outcomes of this CHRMAP.

The planning controls for SCA1 are outlined in Table 16.1.

Table 16.1: Special Control Area (SCA1) – Area Prone to Inundation

Name of Area	Purpose	Additional Provisions
Special Control Area 1 (SCA 1) – Area Prone to Inundation	(1) To provide guidance for land use and development within areas subject to inundation. (2) To identify land within Town of East Fremantle at risk of inundation by 2125. (3) To ensure land along the Swan River foreshore is continuously available for foreshore management, public access, recreation and conservation purposes. (4) To ensure public health and safety and reduce risk associated with inundation. (5) To avoid inappropriate land use and development of land at risk of inundation. (6) To ensure land use and development does not accelerate coastal processes; or have a detrimental impact on the functions of public reserves. (7) To protect new development from the impacts of inundation. (8) To ensure coastal process considerations are taken into account in preparing strategic planning proposals and in assessing subdivision and development applications.	(1) Notwithstanding any other provision of the Scheme, all proposed development within SCA 1 requires the approval of the local government. (2) In considering any application for development approval, or its advice in relation to proposed structure plans or subdivision applications for subdivision for land within SCA 1, the local government is to have particular regard to: (a) The Town Coastal Hazard and Risk Management Adaptation Plan. (b) State Planning Policy 2.6 – State Coastal Planning Policy and Guidelines and any other relevant State planning policies. (c) The CHRMAP Local Planning Policy and any other relevant local planning policies adopted by the Town. (3) An application for development approval for development proposed within SCA 1 may be referred to any statutory, public or planning authority for advice and recommendations before being considered by the local government. (4) Where the local government decides to approve an application for development approval it may impose conditions so as to: (a) Constrain the location of the development; (b) Control the form of construction including foundations and associated works; (c) Determine the form, location and construction of access; (d) Require a minimum floor level for development; (e) Require the registration of a notification under section 70A of the Transfer of Land Act 1893 on the Certificate of Title of the subject land at the cost of the landowner advising that the lot is located in an area

		likely to be subject to coastal inundation over the next 100 years. (5) Where subdivision applications are received within SCA 1, the local government may recommend that the Commission requires a notification under section 165 of the Act to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner advising that the lot(s) is located in an area likely to be subject to coastal inundation over the next 100 years.

16.3.5 CHRMAP Local Planning Policy (LPP)

Following the introduction of SCA 1 into LPS 3, the Town shall prepare and adopt a CHRMAP Local Planning Policy in accordance with Schedule 2 of the Planning and Development (Local Planning Schemes) Regulations 2015. It is recommended that the CHRMAP Local Planning Policy includes provisions included in Table 16.2 which may be subject to further refinement by the Town following the completion of this CHRMAP.

Table 16.2: CHRMAP Local Planning Policy

CHRMAP Local Planning Policy

Policy Application

This policy applies to all land within the CHRMAP Special Control Area (SCA 1), which is that land identified as being subject to inundation over the 100-year planning timeframe.

The Town shall also have due regard to this policy in providing advice to the DBCA or WAPC for development on land within the Swan Canning DCA or the Parks and Recreation Reserve.

Policy Objectives

1. To identify land within the Town at risk of inundation by 2125.
2. To ensure land along the Swan River foreshore is continuously available for foreshore management, public access, recreation and conservation purposes.
3. To ensure public health and safety and reduce risk associated with inundation.
4. To avoid inappropriate land use and development of land at risk of inundation.
5. To protect new development from the impacts of inundation.
6. To ensure coastal process considerations are taken into account in preparing strategic planning proposals and in assessing subdivision and development applications.

Definitions

Annual Recurrence Interval (ARI) means how likely an event is to occur. For example, a 100-year ARI event is an event that occurs or is exceeded on average once every 100 years.

CHRMAP means the Town of East Fremantle Coastal Hazard Risk Management and Adaptation Plan.

Coastal means the area of water and land that may be influenced by coastal processes, including the tidal reaches of inland waters.

Coastal process means any action of natural forces on the coastal environment.

Habitable Room has the same meaning given in State Planning Policy 7.3 Residential Design Codes.

Horizontal Shoreline Datum (HSD) means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy.

MRS means the Metropolitan Region Scheme.

Net Lettable Area has the same meaning given in the Planning and Development (Local Planning Schemes) Regulations 2015.

SCA 1 means the Special Control Area 1 – Area Prone to Inundation as defined on the Scheme Maps.

Scheme means the Town of East Fremantle Local Planning Scheme No. 3 or any subsequent local planning scheme endorsed by the Minister for Planning.

SPP 2.6 means State Planning Policy 2.6 Coastal Planning Policy

Strategic Planning Proposals means a Local Planning Strategy, Local Planning Scheme, amendment to a Local Planning Scheme, Local Structure Plan or Local Development Plan.

WAPC means the Western Australian Planning Commission.

CHRMAP Local Planning Policy

Requirement for Development Approval

Notwithstanding any other provision in the Scheme, development approval is required prior to commencing or carrying out any works or use of land within SCA 1, unless specified as exempt development in this Policy.

Where development approval is required, applications will need to clearly demonstrate that the proposed development meets the objectives and requirements of this Policy and any other relevant requirements of the Town's planning framework.

Exempted Development

Notwithstanding the land being located within SCA 1, unless otherwise required by the Scheme, the provisions of this Policy do not apply to:

1. Alterations and additions to a habitable room of an existing residential building or net lettable area of commercial, retail or community building which does not exceed 50m^2 cumulatively from the date of adoption of this Policy; or
2. A change of use that does not intensify development or use of the land.

General

The inundation hazards identified in the CHRMAP must be considered during the preparation and assessment of strategic proposals, subdivision and development applications to avoid increasing the impacts of coastal processes on inappropriately located land use and development.

Notwithstanding the requirements of this Policy, the Town may exercise discretion in its consideration of proposals where a site-specific coastal hazard assessment is prepared in accordance with SPP 2.6 to demonstrate the suitability of the proposal.

Strategic Planning Proposals

1. Strategic planning proposals for land identified as being prone to inundation must demonstrate how it is proposed to plan for and appropriately manage coastal hazards, including risk to public utility infrastructure servicing the land and roads which provide public access to the land.
2. Strategic planning proposals for land adjacent to the river must include provision for a foreshore reserve which is to be ceded free of cost to the Crown without payment of compensation. The foreshore reserve width is to include a suitable allowance for coastal processes, in addition to sufficient land which is not vulnerable to coastal processes to provide for continued foreshore management, public access, recreation, conservation and landscape amenity.

Subdivision

The Town is responsible for providing advice to the WAPC in respect to the subdivision of land. For the subdivision of land identified as being prone to inundation, the Town will need to be satisfied that the subdivision responds to the inundation risk by ensuring:

1. The finished surface level of all new roads and lots within the subdivision area designed at or above 2.5m AHD to respond to the 500-year ARI event in the 100-year planning timeframe;
2. Public road access to the new lots is not subject to inundation to the extent that would result in difficulty providing evacuation during inundation events; and
3. Future lots can be developed for the intended purpose without the need for fill.

CHRMAP Local Planning Policy

4. The Town will recommend to the WAPC that a condition be imposed on all subdivision approvals requiring a notification under section 165 of the Planning and Development Act 2005 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner. The notification will alert prospective purchasers that the land is located within an area likely to be subject to coastal hazards within the period to 2125, except where the coastal hazard will be adequately addressed through the development works or is otherwise suitably addressed. The notification shall state the following: 'Vulnerable area – this lot is located in an area likely to be subject to inundation over the next 100 years.'

Development

The Town will be the responsible authority for development applications for land zoned under the Scheme outside of the DCA, as identified as SCA 1. For the development of land identified as being prone to inundation, the Town will need to be satisfied that the development responds to the inundation risk by ensuring:

1. Habitable rooms for residential buildings and net lettable areas for commercial, retail or community buildings provide a minimum finished floor level of at least 2.5m AHD to respond to the 500-year ARI event in the 100-year planning timeframe. The following exception may be considered below this level:

   (a) Minor additions and alterations to buildings which exist at the date of adoption of this Policy, where the minimum finished floor level is not reasonably practicable or desirable in a particular instance; or

   (b) Non-habitable buildings or floorspace such as outbuildings, carports, or the lower floor level of buildings between the natural ground level and the habitable floor level where the non-habitable purpose is noted on the application for development approval and/or building permit as such and therefore solely used for the labelled purpose.
2. The design and extent of fill and any retaining walls to achieve minimum floor levels does not create an adverse impact of inundation levels on adjacent properties or the amenity of the locality.
3. All utility service connections including power points, light switches, communications connections, sewer vents and the like are elevated and/or designed to be protected from the impacts of inundation. The Town may require information to demonstrate how this will be achieved or apply conditions to this effect.
4. The building is designed to withstand structural loads associated with inundation, including water resistant building materials and construction methods. The Town may require information from a structural engineer to demonstrate how this will be achieved or apply conditions to this effect.
5. All development approvals include a condition requiring a notification to be placed on the certificate of title of the subject land pursuant to section 70A of the Transfer of Land Act 1893, as the cost of the landowner. The notification will alert prospective purchasers that the land is located within an area likely to be subject to coastal hazards within the period to 2125, except where the coastal hazard will be adequately addressed through the development works or is otherwise suitably addressed. The notification shall state the following: 'Vulnerable area – this lot is located in an area likely to be subject to inundation over the next 100 years.'

The Town may also be required to provide comment and advice in respect to development within the DCA and/or Parks and Recreation reserve. As part of this statutory role, the Town will recommend the above requirements to be considered in the decision-making process by the relevant authority.

16.4 Management Requirements

16.4.1 Publicly Available Information

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

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

16.4.2 Emergency Response and Evacuation

The City of Fremantle and the Town have established a Local Emergency Management Committee (LEMC) to oversee, plan and test the local emergency management arrangements in accordance with section 38(1) of the Emergency Management Act 2005. The LEMC has developed a Local Emergency Management Arrangement (LEMA) which includes useful information in relation to emergency preparation and response, including flooding.

The LEMC shall be provided with a copy of the final CHRMAP and consider the identified risks in any subsequent reviews of the LEMA.

17. Short Term Implementation Plan

17.1 Implementation Actions

The short-term implementation actions over the period now to 2035 are summarised in this section. They include recommendations for:

1. Planning Actions;
2. Annual Monitoring Program;
3. Additional Technical Studies; and
4. Adaptation Actions in Shoreline Areas.

An overview of the actions is presented, with a summary of the projected timing and estimated cost. It is noted that the actions recommended in this section are the responsibility of the Town. Consultation and support from the relevant management authority (DBCA) will be required for activities in the DCA.

17.2 Planning Implementation – Short Term

The following planning and management controls should be implemented by the Town as soon as practicable given the inundation impacts identified in the CHRMAP.

Table 17.1: Short-term Implementation – Planning Actions

Planning Controls	Description	Implementation Triggers
Structure Plans	Require proponents to include coastal adaptation and management provisions into structure plans. The Leeuwin Barracks site is the only area that is likely to be subject to a future structure plan.	The submission of a structure plan containing lots being affected by coastal hazards, as identified in the CHRMAP.
Scheme Amendment	Introduce SCA into the Town's local planning scheme.	Next scheduled scheme review.
CHRMAP Local Planning Policy	Adoption of local planning policy to guide future development within the SCA.	Following the introduction of the SCA into the Town's local planning scheme.
Emergency Response and Evacuation	Review LEMA alongside the inundation mapping identified in the CHRMAP.	Next scheduled LEMA review.

17.3 Annual Monitoring Program

It is recommended that an annual monitoring program commence following the adoption of the CHRMAP. This will be used to support the CHRMAP and to further develop the understanding of the shoreline dynamics in the key locations where the risk from erosion and / or inundation has been identified.

The monitoring program would be used to target key locations in the Town's shoreline areas to improve understanding of coastal erosion and inundation impacts in the coming years. It will also provide the mechanism to assess where established triggers are being approached, to provide early indication of a change in management.

The annual monitoring program would involve collection of new information in the river shoreline areas (eg photo, survey) with discussion, analysis and comparison against previously captured data.

Desktop analysis including a review of relevant wind and water level records and summary of extreme events would be delivered. This would include analysis of the annual measured data with comparison relative to long term averages in each respective year of the program.

Current management of the coastal infrastructure assets by the Town such as structural inspections of the river walls would be summarised. The report would also note any significant extreme events that occur over the year and how these impacted the shoreline areas.

Further detail on the monitoring program is presented in the sections following.

17.3.1 Photo Monitoring and Survey Data Collection

Collection of photos and survey in the key areas to develop the understanding of the river shorelines would be undertaken at key locations of interest.

The following methods of capture are recommended:

- Photo Monitoring. Fixed monitoring locations would be established at key locations around the study area and photos would be captured at various times during the year. This method develops the understanding of how the shoreline changes seasonally.
- Capture of data using unmanned aerial vehicles (UAV). UAV data capture (drone) provides survey levels of shoreline areas as well as oblique aerial imagery. This method of capture has been used successfully in other locations around Western Australia and offers a cost-effective means of capturing this data across small areas. The data can be used to analyse the way in which shorelines evolve across different seasons and changes following large storm events.

Photo monitoring is recommended from a fixed position on the shoreline to be determined as part of the first-year annual monitoring tasks at:

1. Nieragarup Reserve foreshore
2. John Tonkin Reserve foreshore
3. Unprotected foreshore areas at Norm McKenzie Park and W. Wayman Reserve
4. Jerrat Drive escarpment foreshore

At several locations around the State this approach has been used with the installation of fixed infrastructure and signage promoting photo capture by community through the CoastSnapWA coastal monitoring program. There are several methods in practice that allow the public to take a photo of the shoreline that can be uploaded to a database that is then catalogued for analysis as part of the shoreline monitoring. This promotes citizen science and highlights the work the Town is doing in its foreshore areas. The CoastSnapWA site (https://wacoastline.org/coastsnapwa) provides a summary of the coastal

monitoring that has been undertaken at locations in Rockingham, Mandurah, Waroona, Harvey, Bunbury, Dardanup, Capel, and Busselton.

17.3.2 Asset Management and Structural Inspections

The annual monitoring program would summarise key information from the Town's management of the shoreline protection structures in its foreshore areas (eg river walls, revetments, groynes etc).

The information of interest would be structural inspections, scheduling or implementation of replacement or upgrade works undertaken as part of the East Fremantle River walls 10 Year Priority Plan (2022).

The structures of interest would include the following:

- Leeuwin Boat Ramp
- Car Parks (specifically those sited directly adjacent the river eg Public Carpark No 4 at Dome Cafe)
- River Walls and revetments through the Walled Zone
- River Walls and revetments through the Reclaimed Zone
- Offshore groyne structures at John Tonkin Reserve
- Groyne at Preston Point
- Beach access paths and stairs (John Tonkin, Nieragarup Reserve, Jerrat Drive locations)
- Beach area at John Tonkin Reserve
- River walls at East Fremantle Yacht Club

17.3.3 Projected Cost of Annual Monitoring Program

An indicative five-year program for the annual monitoring is presented in Table 17.2 with the following noted:

- In the first year the photo monitoring sites would be established with approximately six sites determined for repeat capture in the years to follow. These would be in the Reclaimed Zone and the Natural Zone. In subsequent years the collection of photos from these sites could be managed through a community led platform where members of the public could upload photos to a database (eg CoastSnapWA). An estimate of $3,000 annually to manage this process has been included in Table 17.2. Alternatively, the Town could elect to undertake the photo-monitoring through the year using its own personnel to reduce cost.
- In the first year of the program an independent verification of the accuracy of the UAV survey collection would be undertaken using a local surveyor. This activity would provide an independent comparison of the UAV survey accuracy and would not be repeated in subsequent years. This has been applied in similar monitoring programs in WA.

The cost for the monitoring activities in Table 17.2 is estimated at approximately $15,500 (ex GST) annually, with a five-year total of $77,500 ex GST. Co-funding of up to 50% of the cost of the program could be made available if the Town is successful in application for the DoT's annual Coastal Adaptation and Protection (CAP) grants.

- The annual cost could be reduced if the Town was to undertake the photo-monitoring through the year using its own personnel.

Table 17.2: Indicative five-year program for Annual Monitoring activities

Task	Description	Budget
Year 1	2024 Activities	$ 15.5k
1.1	UAV survey and oblique imagery capture – Reclaimed Zone	$ 4,000
1.2	Inspection / Asset management of shoreline structures	Town Internal
1.3	Transect Surveys (UAV Independent Accuracy Verification)	$ 1,500
1.4	Photo Monitoring. Establish Site Locations in Year 1 (estimate 6)	$ 1,500
1.5	Desktop Analysis, Annual Monitoring Report	$ 8,500
Year 2	2025 Activities	$ 15.5k
2.1	UAV survey and oblique imagery capture – Natural Zone	$ 4,000
2.2	Inspection / Asset management of shoreline structures	Town Internal
2.3	Photo Monitoring – Community Capture / On-line Platform	$ 3,000
2.4	Desktop Analysis, Annual Monitoring Report	$ 8,500
Year 3	2026 Activities	$ 15.5k
3.1	UAV survey and oblique imagery capture – Reclaimed Zone	$ 4,000
3.2	Inspection / Asset management of shoreline structures	Town Internal
3.3	Photo Monitoring – Community Capture / On-line Platform	$ 3,000
3.4	Desktop Analysis, Annual Monitoring Report	$ 8,500
Year 4	2027 Activities	$ 15.5k
4.1	UAV survey and oblique imagery capture – Natural Zone	$ 4,000
4.2	Inspection / Asset management of shoreline structures	Town Internal
4.3	Photo Monitoring – Community Capture / On-line Platform	$ 3,000
4.4	Desktop Analysis, Annual Monitoring Report	$ 8,500
Year 5	2028 Activities	$ 15.5k
5.1	UAV survey and oblique imagery capture – Reclaimed Zone	$ 4,000
5.2	Inspection / Asset management of shoreline structures	Town Internal
5.3	Photo Monitoring – Community Capture / On-line Platform	$ 3,000
5.4	Desktop Analysis, Annual Monitoring Report	$ 8,500
	TOTAL Cost for Five-Year Program	**$77,500**

17.4 Additional Technical Studies

The following technical studies are recommended over the next 5-years:

1. Analysis of flood risk for local catchment flooding in extreme events using the existing drainage network.

The CHRMAP does not assess catchment-based flooding in extreme events. A dedicated hydrological and hydraulic model to assess the flood risk for the study area under severe rainfall events with consideration of local catchment flooding, the existing stormwater drainage network and the connection to the Swan River would be required. Joint occurrence of the river level and catchment-based events would be considered. This would provide a greater understanding of the flood risk and recommendations for potential upgrades to manage the risk. It is expected that this study would be led by the Town, though potential for joint ownership with the DBCA could be examined.

An estimate of the cost of the study is $60,000 (ex GST).

2. Jerrat Drive escarpment foreshore stability study

The Jerrat Drive foreshore area is a location which is highly valued by the community in the Natural Zone. The study will summarise the current condition of the foreshore and assess the risks to the location in future with consideration of the local site survey, vegetation, geotechnical information, drainage and local access pathways. Recommendations for the management of the location to inform future foreshore management approaches which include consideration of revegetation of the foreshore and use of nature-based solutions in the shoreline to improve resilience.

An estimate of the cost of the study is $35,000 (ex GST)

3. Study to determine appropriate Nature Based Solutions for target shoreline areas.

A study of the methods to be used for shoreline stabilisation in the target shoreline areas which can reference the general guidance from SRT (2009) and deliver site specific recommendations. This will guide the nature-based approaches in the subsequent years.

An estimate of the cost of the study is $30,000 (ex GST)

17.5 Additional Planning Based Studies

In addition, the following planning-based studies are recommended in the next 7 years (by 2030):

- Update to current Foreshore Management Plan.
- Publicly Available Information
- Emergency Response and Evacuation.
- CHRMAP Review.

17.5.1 Foreshore Management Plans

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

The Town should update its foreshore management plan, in conjunction with relevant stakeholders, to provide guidance for the ongoing management of foreshore reserves, monitoring of assets and the triggers

for the managed retreat of public assets and infrastructure at risk of coastal processes. The priority actions under the East Fremantle River walls 10 Year Priority Plan (2022) would be included as part of this process.

An estimate of the cost of the study is less than $40,000 (ex GST).

17.5.2 Publicly Available Information

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

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

17.5.3 Emergency Response and Evacuation

The City of Fremantle and the Town have established a Local Emergency Management Committee (LEMC) to oversee, plan and test the local emergency management arrangements in accordance with section 38(1) of the Emergency Management Act 2005. The LEMC has developed a Local Emergency Management Arrangement (LEMA) which includes useful information in relation to emergency preparation and response, including flooding.

The LEMC shall be provided with a copy of the final CHRMAP and consider the identified risks in any subsequent reviews of the LEMA.

An update to the LEMA in the next 5 years based on the revised hazard mapping from the CHRMAP is anticipated with an estimated cost of $15,000 (ex GST).

17.5.4 CHRMAP Review

Approximately every five-years a general review of the CHRMAP should be undertaken by the Town. As part of the review the following should be covered (as a minimum):

- The improved knowledge of coastal hazards in the shoreline areas from the annual monitoring and additional studies should be incorporated into the review and where this may impact any of the recommendations in the CHRMAP.
- The guidance on sea level rise projections by the DoT (DoT 2010) should be reviewed for any updates. Any change to the projected sea level rise allowances would require assessment of updates to the CHRMAP.
- Review of changes in the SPP2.6 advice (WAPC 2013) or updates to the CHRMAP guidelines (WAPC 2019) would be assessed as part of the review process.
- Engagement with the community to provide an overview of learnings from the annual monitoring program and outline how these are captured in the CHRMAP review process. A review of the community values to determine if they are consistent with values collected in the previous version of the CHRMAP would be sought as part of the engagement activities.

The monitoring and review process will ensure that the management and adaptation actions remain relevant. In conjunction with annual monitoring activities, a general review of the CHRMAP approximately every 5-years would be used to implement the findings from the monitoring program and address updates to the CHRMAP recommendations where required.

An estimate of the cost of the study is less than $35,000 (ex GST).

17.6 Adaptation Actions - Shoreline Areas

To improve the resilience of the natural shoreline areas through the Reclaimed Zone and the Natural Zone, the implementation of nature-based solutions is recommended. An example of the revegetation of shoreline at John Tonkin Reserve foreshore is shown in Figure 17.1.

For indicative budget planning purposes, the key shoreline areas where adaptation approaches are recommended along with the approximate cost and timing are summarised in Table 17.3.

Table 17.3: Indicative Timing and Cost of Adaptation Actions in the Short term (present day to 2035)

SMU	Location and Approach	Approximate Cost [1, 2]	Indicative Timing
Reclaimed Zone	Niergarup Reserve application of nature-based revegetation and foreshore stabilisation techniques	$25k	2024
Reclaimed Zone	John Tonkin Reserve application of nature-based revegetation and foreshore stabilisation techniques	$50k	2025 -2026
Natural Zone	Jerrat Drive escarpment - application of nature-based revegetation and foreshore stabilisation techniques	$60k	2027 - 2028
Reclaimed Zone	Norm McKenzie Park and W. Wayman Reserve application of nature-based revegetation and foreshore stabilisation techniques	$25k	2029

Notes:
[1] Nature based solutions for revegetation and foreshore stabilisation estimated at $200/m.
[2]. Costs are rounded to nearest $5,000.

Figure 17.1: Example of nature-based stabilisation technique - revegetation of foreshore at John Tonkin Reserve shoreline

17.7 Short Term Implementation Plan and Estimated Cost

A proposed short-term implementation plan with indicative costs for the period over the first 5-years 2024 to 2028 inclusive is presented in Table 17.4.

The budget is estimated at $427,500 for studies and monitoring ($77,500 annual monitoring, $215,000 for technical studies and planning studies). Additionally, a budget estimate of $135,000 is forecast to fund nature-based adaptation approaches.

Table 17.4: Short-term implementation plan and estimated budget. First five years 2024 – 2028.

Task	Description	Budget
Year 1	2024 Activities	
Annual Monitoring	Year 1 Monitoring Activities	$ 15,500
Technical Studies	Jerrat Drive escarpment foreshore stability study	$ 35,000
Technical Studies	Nature Based Solutions in Target Shoreline Areas	$ 30,000
Planning	Introduce SCA into the Town's LPS 3. Prepare local planning policy to guide future development within the SCA.	Town Internal
Adaptation	Niergarup Reserve – Nature Based Solutions in Shorelines	$ 25,000
Year 2	2025 Activities	
Annual Monitoring	Year 2 Monitoring Activities	$ 15,500
Planning	Prepare Foreshore Management Plans	$ 40,000
Adaptation	John Tonkin Res (Yr1) Nature Based Solutions in Shorelines	$ 25,000
Year 3	2026 Activities	
Annual Monitoring	Year 3 Monitoring Activities	$ 15,500
Planning	Update Emergency Response Plan (LEMA)	$ 15,000
Adaptation	John Tonkin Res (Yr2) Nature Based Solutions in Shorelines	$ 25,000
Year 4	2027 Activities	
Annual Monitoring	Year 4 Monitoring Activities	$ 15,500
Technical Studies	Catchment Based Flooding Study	$ 60,000
Adaptation	Jerrat Drive (Yr1) Nature Based Solutions in Shorelines	$ 30,000
Year 5	2028 Activities	
Annual Monitoring	Year 5 Monitoring Activities	$ 15,500
Adaptation	Jerrat Drive (Yr2) Nature Based Solutions in Shorelines	$ 30,000
Planning	CHRMAP Review	$ 35,000
	TOTAL Cost for Five-Year Program	**$427,500**

17.8 Funding Opportunities

It is noted that the Town would be eligible for up to 50% of the cost of the planning and technical studies presented in Table 17.4. Additionally for the adaptation approaches (nature-based solutions), there are opportunities to also co-fund these activities through grant schemes outlined in more detail in Section 19.

The implementation budget over the 12-year short-term period from 2024 to 2035 is estimated at approximately $596,000 (ex GST) as shown in Table 17.5. This will cover the cost of annual monitoring, completion of the additional technical / planning studies recommended including two reviews of the CHRMAP (2028, 2033) and undertake nature-based work in the shoreline areas summarised in Table 17.3.

As previously noted, there are grant schemes that would allow the Town to co-fund this commitment by up to 50% over the period (covered in more detail in Section 19). The costs in Table 17.5 show the estimated costs without any co-funding and with co-funding of 50%.

Table 17.5: Estimated Implementation Budget over short term (12-year period 2024 – 2035)

Item	Cost	Cost if co-funded 50%
Annual Monitoring Cost (2024 to 2035)	$ 186,000	$ 93,000
Technical and Planning Studies	$ 180,000	$ 90,000
Nature Based Work in Shorelines	$ 160,000	$ 80,000
Review of CHRMAP x 2	$ 70,000	$ 35,000
TOTAL	**$ 596,000**	**$ 298,000**

18. Medium and Long-Term Implementation Plan

The medium-term implementation actions cover the period of 2035 to 2075. The long-term plan covers the period 2075 to 2125. Summary advice to the Town for its management strategy and adaptation response is provided in this Section.

18.1 Medium-Term Actions (2035 to 2075)

18.1.1 Planning Implementation

A Planned or Managed Retreat Policy would be developed and implemented over this timeframe. The findings from the annual monitoring program and the Town's asset management would be considered in future CHRMAP review to inform this process. The future of the Leeuwin Barracks site will also be a key driver of the future decision on adaptation pathways for the Reclaimed Zone. The recommendations and actions would be subject to engineering advice and local planning recommendations in accordance with the applicable policy.

The planning and management controls Table 18.1 should be implemented in the medium-term, as deemed appropriate by the Town.

Table 18.1: Medium term Implementation. Planning Actions

Planning Controls	Description	Implementation Triggers
Planned or Managed Retreat Policy	Adoption of a policy of planned or managed retreat in response to the impacts of erosion.	Once it has been determined that the physical barriers along Riverside Road are to be removed. This will be confirmed through future iterations of this CHRMAP.
MRS Amendment	Request rezoning of retreated land to 'Parks and Recreation' reserve under the MRS.	Once land has been retreated in accordance with the adopted Planned or Managed Retreat Policy.

18.1.2 Adaptation Actions

A summary of the medium-term adaptation actions is presented in Table 18.2.

Table 18.2: Medium Term Adaptation Actions

Item	Description	Trigger	Projected Timing
Minor infrastructure in the foreshore (SMU1, SMU2, SMU3)	Replacement of Town assets in the foreshore as part of asset lifecycle. Replacement to consider the projected planning timeframes and associated coastal hazard from erosion and inundation.	Annual monitoring and CHRMAP review process to be used as basis for confirming future allowances for erosion and inundation in development requirements.	2035 – 2075

Item	Description	Trigger	Projected Timing
Riverwalls in the Walled Zone (SMU1)	Maintain shoreline revetments and river walls to ensure erosion protection of Riverside Road. As part of asset lifecycle, raise the height of river walls at the shoreline in response to future sea level rise.	Regular structural condition assessments in the Walled Zone to determine the maintenance requirements / replacement schedule as part of asset management ().	2035 – 2075
Riverside Road in SMU1	As part of asset lifecycle, incrementally raise the height of Riverside Road to accommodate future sea level rise.	Sea level rise[1] of +0.5m	2050-2075
Walled Zone - Dome Café and Marine Education Boatshed (SMU1)	Under guidance in adopted local Planned or Managed Retreat policy either: • Accommodate the risk through building design (raise floor levels, use of suitable building materials) or • remove the assets under a managed retreat approach (remove to higher ground or completely)	Sea level rise[1] of +0.5m	2050-2075

Note 1. Calculation of sea level rise increase is to be determined based on the analysis of the nearest available tide gauge data (Fremantle Harbour) accounting for annual, inter-annual and longer-term water level influences.

18.2 Long Term Implementation (2075 – 2125)

A summary of the Long-Term adaptation actions is presented in Table 18.3.

It is noted that cost estimates are not provided at this stage, as this requires further assessment, evaluation and agreement on the long-term future strategy of managed retreat / protect approaches in SMU1 and SMU2 between the DBCA and the Town. This task should be included in future CHRMAP revision.

Table 18.3: Long Term Adaptation Actions (2075 – 2125)

Item	Description	Trigger	Projected Timing
Minor infrastructure in the foreshore (SMU1, SMU2, SMU3)	Prepare for Managed retreat from shoreline areas once inundation risk is too high (frequent)	Sea level rise[1] of +0.5m to 0.75m	2075 - 2125

Item	Description	Trigger	Projected Timing
Riverwalls in the Walled Zone (SMU1)	Maintain shoreline revetments and river walls to ensure erosion protection of Riverside Road. As part of asset lifecycle, raise the height at the shoreline in response to future sea level rise.	Regular structural condition assessments in the Walled Zone to determine the maintenance requirements / replacement schedule as part of asset management.	2075 – 2125
Riverside Road in SMU1	As part of asset lifecycle, incrementally raise the height of Riverside Road to accommodate future sea level rise.	Sea level rise[1] of +0.5m to 1.05m	2075-2125
Carparks (SMU1 and SMU2)	When inundation risk is too high because of sea level rise either: • Accommodate the risk through raising level; or • remove the assets under a managed retreat approach	Sea level rise[1] of +0.5m to 0.75m	2075 – 2125
Foreshore Area Assets in SMU1 between Riverside Rd and River edge	Prepare for Managed Retreat from shoreline areas once inundation risk is too high	Sea level rise[1] of +0.5m to 1.05m	2075 – 2125
Foreshore and assets SMU2 between Riverside Rd and River edge	Prepare for Managed Retreat from shoreline areas once inundation risk is too high	Sea level rise[1] of +0.5m to 1.05m	2075 – 2125

Note 1. Calculation of sea level rise increase is to be determined based on the analysis of the nearest available tide gauge data (Fremantle Harbour) accounting for annual, inter-annual and longer-term water level influences.

19. Funding

19.1 Grant Funding

The grant funding options that could apply for to support the funding of coastal management activities is summarised in Table 19.1. These funding mechanisms generally require a co-funded approach whereby 50% of the funding is matched. The grant programs are designed to support outcomes that support public benefit.

Table 19.1: Summary of Funding Mechanisms

Grant	Brief Description	Potential Application
Coastal Management Plan Assistance Program (CMPAP) Coastal Management Plan Assistance Program (CMPAP grants) (www.wa.gov.au)	CMPAP grants support eligible coastal land managers to develop and implement adaptation and management plans and strategies for coastal areas that are, or are predicted to become, under pressure from a variety of challenges. CMPAP grants are administered by the Department of Planning, Lands and Heritage. CMPAP grants provide up to 50% of the budget for planned projects (co-funded with 50% contribution by the Town). Applications are invited for grants of up to $200,000 Note - the Town is eligible for CMPAP grants for coastal land vested to them for care, control or management. DBCA would not be eligible as they are State Government, however they can be a project partner.	• Funding of future CHRMAP review (every 5-years). • Funding of additional studies to develop management strategy for shoreline areas eg Foreshore Management Plans • Review/update of a planning scheme and local planning strategy, and inclusion of a Special Control Area covering the vulnerable coastal land • Develop/review a local planning policy to help guide development in a vulnerable coastal area • Detailed assessment of economic or adaptation options.
Coastal Adaptation and Protection (CAP) grants Coastal Adaptation and Protection (CAP) Grants and H-CAP Major Project Fund (transport.wa.gov.au)	CAP grants provide financial assistance for local projects that identify and manage coastal hazards. The program seeks to preserve and enhance coastal assets for the community. It aims to build partnerships with local coastal managers and help them understand and adapt to coastal hazards. CAP grants are available for the coastline immediately adjacent to the oceans of WA. Estuarine shorelines are also included as an area of secondary focus.	• Annual Monitoring Program. • Funding for shoreline restoration / revegetation programs. • Funding of additional studies to develop management strategy for shoreline areas • Jerrat Drive escarpment foreshore stability study).

Grant	Brief Description	Potential Application
	CAP grants provide up to 50% of the budget for planned projects (co-funded with 50% contribution by the Town). The minimum CAP grant limit is $15,000 (excluding GST) and the maximum CAP grant limit is $400,000 (excluding GST)	
Coastwest Grants Coastwest grants (www.wa.gov.au)	Coastwest grants support eligible coastal land managers and community organisations to undertake projects that manage and enhance WA's coastal environments through rehabilitation, restoration and preventative actions. Coastwest grants are administered by the Department of Planning, Lands and Heritage. Grants provide up to 50% of the budget for planned projects (co-funded with 50% contribution by the Town). Applications are invited for grants of $5,000 - $60,000. Note - the Town is eligible for Coastwest grants for coastal land vested to them for care, control or management. DBCA would not be eligible as they are State Government, however they can be a project partner.	• Funding for shoreline restoration / revegetation programs with input from community organisations. • Projects which aim to protect and rehabilitate sensitive coastal areas, enhance coastal landscapes and biodiversity including near shore marine habitats.
National Disaster risk Reduction (NDRR) Grant Program Apply for a National Disaster Risk Reduction grant (www.wa.gov.au)	The Western Australian Government has a National Partnership Agreement (NPA) for Disaster Risk Reduction with the Commonwealth to fund disaster reduction activities that are specifically intended to deliver the outcomes of the National Disaster Risk Reduction Framework (NDRRF). The NPA is the primary funding mechanism for the National Disaster Risk Reduction (NDRR) Grants Program. The NDRR supports projects that: 1. Reduce existing disaster risk. 2. Minimise creation of future disaster risk.	• Funding for shoreline restoration / revegetation programs which provide public benefit. • Funding for coastal Protection Structures which offer a public benefit. •

Grant	Brief Description	Potential Application
	3. Equip decision-makers with the capabilities and information they need to reduce disaster risk and manage residual risk. In the 2023 NDRR grant round $2.5 million was made available. Projects with local outcomes could apply for between $10,000 and $250,000 grant funding. Applicants must contribute at least 50 per cent of the total project cost in cash or in-kind.	
Disaster Ready Fund https://nema.gov.au/disaster-ready-fund	The Australian Government has established the Disaster Ready Fund (DRF) to provide up to $200 million per financial year, over five years from 1 July 2023 ($1 billion in total). Proponents will need to provide a 50 per cent co-contribution (cash or in-kind). The minimum and maximum funding amounts are not currently available at time of writing.	• projects that build resilience to, prepare for, or reduce the risk of, future natural hazard impacts, and help to build the long-term sustainability of communities at risk of being affected by future disasters. • Projects may include direct investment in grey and green-blue infrastructure, for example levees, floodways, seawalls, firebreaks, constructed wetlands and reefs.

References

Baird (2023), Town of East Fremantle, Data Review and Coastal Hazard Assessment. Report prepared for the Town of East Fremantle, Report Number 13668.101.R1_Rev0.

BMT (2017), Swan and Helena Rivers Flood Study and Floodplain Management Plan, Hydraulic Modelling Final Report. November 2017

Breunig R., Hasan, S. & Whiteoak [Breuning et al] (2018). *Impact of playgrounds on property prices: evidence from Australia*, Australian National University [Funded by Melbourne Water], March 4

Department of Transport Coastal Infrastructure, Coastal Engineering Group (2010). Sea Level Change in Western Australia, Application to Coastal Planning. Available at http://www.planning.wa.gov.au/dop_pub_pdf/sea_level_change_in_wa_rev0_final.pdf

Department of Environment and Climate Change (2007), Residential Flood Damages. Residential Flood Damages (nsw.gov.au)

Department of Defence 2023, Factsheet for Leeuwin Barracks accessed from https://www.eastfremantle.wa.gov.au/major-projects/leeuwin-barracks-update

element (2023a), East Fremantle Coastal Hazard Risk Management and Adaptation Plan, Community and Stakeholder Engagement Plan. Prepared for Town of East Fremantle. Report Number 21-601, November 2023

element (2023b), Town of East Fremantle CHRMAP, Engagement Outcomes Report. Report 21-388, February 2023.

Ecoscape (2016), Town-of-East-Fremantle-Foreshore-Masterplan-(Final), Report prepared by Ecoscape for the Town of East Fremantle, Report Number 10078-3362-14R, 2 March 2016.

Fugro (2008), Metadata Report for Department of Water WA, J221571 Armadale – Dunsborough, North Metro and three Town's Lidar Survey, used under license from Department of Water.

Lemon Light Productions (2022), Drone Capture of aerial obliques through the Town of East Fremantle Shoreline Areas collected for the Town of East Fremantle.

NCARF (2017), National Climate Change Adaptation Research Facility Coast Adapt, https://coastadapt.com.au/

Rhelm (2023), Town of East Fremantle Coastal Hazard Risk Management and Adaption Plan – Economic assessment, Prepared by Rhelm for Town of East Fremantle. Memo number RM-01-J1606, September 1 2023

Smith G.P, Davey E.K, Cox R.J, Flood Hazard. WRL Technical Report 2014/07. September 2014. Accessed from https://knowledge.aidr.org.au/media/2334/wrl-flood-hazard-techinical-report-september-2014.pdf

Swan River Trust (2009), Best management practices for foreshore stabilisation Approaches and decision-support framework. December 2009

Standards Australia (2013) AS 5334-2013: Climate change adaptation for settlements and infrastructure - A risk-based approach, SAI Global Limited Standards Australia Ltd Sydney

Western Australian Planning Commission: WAPC. (2006) State Planning Policy 2.9: Water Resources. Prepared under Section 26 of the State Planning and Development Act 2005, Perth.

Western Australian Planning Commission (WAPC, 2013). State Planning Policy No. 2.6 State Coastal Planning Policy. Gazettal Date: 30 July 2013.

Western Australian Planning Commission (WAPC, 2019). Coastal Hazard Risk Management and Adaptation Planning Guidelines. July 2019. https://www.dplh.wa.gov.au/information-and-services/state-planning/coastal-planning-and-management/coastal-hazard-risk-management-and-adaptation-plan

Appendix A

Community and Stakeholder Engagement

A.1 Engagement Outcomes Report

21-388 Town of East Fremantle CHRMAP

Engagement Outcomes Report

February 2023

element.

the art and science of place

Document ID: 21-601 Documents / 04 Reports						
Issue	Date	Status	Prepared by		Approved by	
			Name	Initials	Name	Initials
1	29.09.2022	Draft	Misha White	MW	Cath Blake-Powell	CBP
2	10.02.2023	Draft	Misha White	MW	Cath Blake-Powell	CBP

Contents

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Executive Summary

In 2021, the Town of East Fremantle engaged the project team of Baird Australia, **element**, and Rheum to provide specialist land use planning, community engagement and coastal engineering consultants to produce a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). The CHRMAP will be prepared in accordance with the CHRMAP Guidelines and State Planning Policy 2.6, adopted by the Town of East Fremantle and used to guide future decision making for vulnerable assets in its riverine foreshore zone.

An important part of this study is speaking with the community and key stakeholders to identify their values and aspirations for the foreshore. The engagement for this project will be primarily spread across two key stages in the project lifecycle: Stage 1: Establish the Context and Stage 5: Risk Treatment.

In Stage 1 of the project, we engaged with over 150 people across 3 activities and promoted the project through an awareness campaign. The purpose of engagement in Stage 1 was to understand coastal values, aspirations, visitation and usage of the coastline. Below is a summary of the key findings.

- The community valued the ‘natural environment’ most about their foreshore, with ‘opportunities for health and well-being’ and ‘access to land-based activities’ also highly valued.
- The East Fremantle foreshore is well utilised with a range of land and water-based activities occurring frequently in the area.
- Whilst only a small proportion of respondents noted that they were undertaking activities in the area because ‘I can’t do this activity elsewhere, it is unique to this area’, many felt that their lives would be impacted adversely if they were unable to undertake these along the East Fremantle foreshore.
- The community were concerned about erosion and inundation along the foreshore, including flooding of carparks and pathways during storms and high tides as well as erosion of the existing river walls.

This report will be updated after the Community Workshops in Stage 5, which will be held in late 2022.

1. Introduction

1.1 Project Overview

In 2021, the Town of East Fremantle appointed the project team of Baird Australia, **element and** Rhelm to produce a Coastal Hazard Risk Management Adaptation Plan (CHRMAP) consistent with Western Australian Planning Commission (WAPC) 2019 guidelines. The East Fremantle CHRMAP is the first riverine CHRMAP conducted in the Perth metropolitan area.

A Stakeholder and Community Engagement Strategy (SCEP) was prepared to guide the engagement process and ensure that the community and stakeholders were effectively and actively involved in the CHRMAP preparation process.

The SCEP outlines how the community and stakeholder participation, and engagement process aligns within the inform, consult and involve levels of IAP2 Public Participation Spectrum. The goals of each level of engagement are described in the table below.

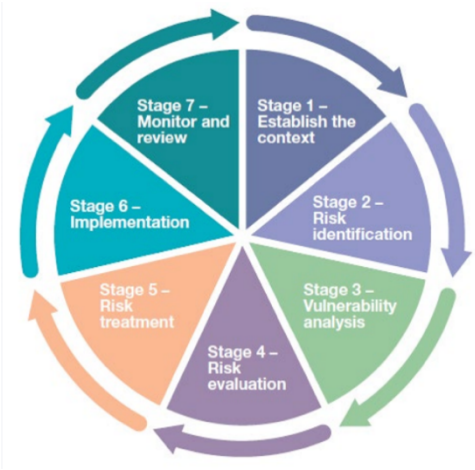
Table 3.1: Levels of Engagement for the Project (based on IAP2 Public Participation Spectrum)

Level	Inform	Consult	Involve
Goal	To provide balanced and objective information in a timely manner.	To obtain feedback on analysis, issues, alternatives and decisions.	To work with the public to make sure that concerns and aspirations are considered and understood.
Promise	"We will keep you informed."	"We will listen to and acknowledge your concerns."	"We will work with you to ensure your concerns and aspirations are directly reflected in the decisions made."

The engagement objectives and the engagement tools are summarised in the sections that follow based on the information in the SCEP.

The CHRMAP process is being completed in 7 stages, where the community will review the draft prepared at the end of each stage. In this way, community and stakeholder involvement will guide the preparation process. See the diagram overleaf for a breakdown of the 7 stages.

Figure 1 Diagram of the CHRMAP stages



This report is a summary of the community engagement undertaken during Stage 1 of the CHRMAP process. This report will be updated as the engagement progresses throughout the CHRMAP project.

1.2 Project Scope

The subject area for the East Fremantle CHRMAP is located on Whadjuk Noongar land within of the Town of East Fremantle. The Swan River riverine foreshore features some 3km in length lies between Petra Street to the north-east and East Street to the south. Bordered by the residential suburb of East Fremantle the area has interactions with many landmarks and recreational features including the John Tonkin Reserve, Swan Yacht Club, East Fremantle Yacht Club, several outdoor sporting grounds, hospitality venues and several boating moorings and jetties. The significant Leeuwin Barracks site (closed to the general public) is a nearby land area currently undergoing a divestment process by Department of Defence.

The study area was split into 3 zones shown in the Figure 2 overleaf;

- The Natural Zone;
- The Reclaimed Zone and;
- The Walled Zone

Figure 2 CHRMAP study area

1.3 Project Objectives

The objectives of the CHRMAP are to:

- improve understanding of coastal and riverine features, processes and hazards in the study area;
- identify significant vulnerability trigger points and respective timeframes to mark the need for immediate or medium-term risk management measures;
- identify assets (natural and man-made) and the services and functions they provide situated in the coastal zone;
- gain an understanding of asset vulnerability;
- identify the value of the assets that are vulnerable to adverse impacts from coastal hazards;
- determine the consequence and likelihood of coastal hazards on the assets, and assign a level of risk;
- identify possible (effective) risk management measures (or 'actions') and how these can be incorporated into short and longer-term decision-making; and
- engage stakeholders and the community in the planning and decision-making process.

2. Engagement Methodology

2.1 Purpose and Objectives of Engagement

The purpose of the engagement during Stage 1 of the CHRMAP process was to raise project awareness, engage a community and business reference group and collect community coastal values including social, economic and environmental values, including which foreshore assets the community hold important.

As such, the objectives of the engagement were to:

- Utilise reliable communication channels to ensure information is shared with interested stakeholders.
- Identify stakeholders and understand the nature of their interest and potential to contribute towards success of the project or otherwise.
- Establish early in the project opportunities to have authentic conversations with people. Particularly those most affected by potential change from future coastal adaptation measures.
- Inform key community member and stakeholders to develop understanding and alignment with the goals of coastal hazard risk assessment within the East Fremantle community.
- Ensure adjacent neighbours (residents and businesses) to the project site are kept informed and are invited to undertake targeted engagement as required, giving sufficient notice to do so.
- Inform, consult and involve the community in identifying suitable adaptation options
- Collect and collate the community and stakeholders' coastal values and aspirations for the long term.
- Understand the level of tolerance of specific risks within the community for specific assets, or groups of assets.
- Develop a shared vision between the Town, landowners and surrounding community for the future CHRMAP recommendations.

A number of communication channels and engagement tools have been used throughout Stage 1 of the CHRMAP project process, these are identified below.

2.2 Engagement Tools

2.2.1 Community and Business Reference Group

A Community and Business Reference Group was established (CBRG) to occur for the duration of the engagement activities and delivery of the draft CHRMAP. By engaging the local knowledge and insights of the CBRG, the project demonstrates a greater level of transparency, collaboration and willingness to take on board concerns, values and ideas of local businesses and the community, via selected representatives. The CBRG members were selected via an Expression of Interest process which aimed to ensure a diverse mix of local business and community members.

The CBRG will meet at key milestones in the project to provide feedback of the engagement approach prior to implementation as well as an additional point of review of each chapter report. The CBRG will help to

generate community buy-in and good will and help in the dissemination of key information through their networks.

The CBRG will be ongoing for the remainder of the CHRMAP project.

2.2.2 Pop-up Information Sessions

Two pop-up information sessions were held to introduce the CHRMAP process and provide information about the project including;

- Why does a CHRMAP need to be prepared
- Outline of foreshore zones to be included in the study
- Identification of coastal assets
- Explanation of coastal hazards
- Overview of management options

These were attended by the project team and Town staff who were available to explain the process and answer any questions

2.2.3 . Foreshore Values Survey

The Foreshore Values survey ran was composed of 21 questions and considered the East Fremantle foreshore as 3 separate zones; the Walled Zone, the Reclaimed Zone and the Natural Zone (see Figure 2) and was hosted online via the Town's webpage.

An outline of the questions in the Coastal Values survey is shown in Table 1 below.

Table 1 Coastal Values Survey Questions Overview

No.	Question
About you – Respondent Demographic Information	
1	Please tell us your current residential suburb
2	What is your connection to the East Fremantle foreshore project area (between Petra Street and East Street)?
3	Are you of Aboriginal and/or Torres Strait Islander descent?
CHRMAP Awareness and Interactions with the Foreshore	
4	Before taking this survey, how familiar are you with the CHRMAP project currently being undertaken by the Town of East Fremantle?
5	Thinking about your interactions and experiences with the East Fremantle Foreshore (between Petra Street and East Street) what are three words that come to mind?
Values and Activities	
6	Below is a list of values that can apply to a variety of coastline and foreshore environments. Please tell us how important each value is to you in the context of the East Fremantle foreshore.
7	Roughly how close do you live to the East Fremantle Foreshore project area?
8	Please indicate below whether you personally undertake any of these activities and where you undertake them.
Activities in the Walled Zone	

9	How often do you participate in these activities in the Walled Zone?
10	Why do you choose to undertake these activities in the Walled Zone as opposed to other areas? (You may select more than one option)
Activities in the reclaimed Zone	
11	How often do you participate in these activities in the Reclaimed Zone?
12	Why do you choose to undertake these activities in the Reclaimed Zone as opposed to other areas? (You may select more than one option)
Activities in the Natural Zone	
13	How often do you participate in these activities in the Natural Zone?
14	Why do you choose to undertake these activities in the Natural Zone as opposed to other areas? (You may select more than one option)
Impact of Hazards	
15	If you were unable to do these activities along the East Fremantle foreshore, how much would this impact your life?
16	From your experience, within the project area have you noticed any areas along the foreshore that may be affected by, or increasingly impacted by, inundation and/or erosion hazards over the past 5 years. Please tell us more below, including the location/s of concern
Other demographics and comments	
17	Please tell us how you heard about this survey
18	How young are you?
19	What is your gender?
20	Would you like to receive project updates via email?
21	Please let us know if you had any further questions or comments about the project for the CHRMAP Team here:'

2.3 Communication Channels

Project information, updates and invitations to participate in engagement opportunities were distributed to the community in the following ways.

Table 2 Communications Methods

Communication Method	Description
Project website	A project webpage was created website was hosted on the ToEF consultation webpage, https://www.eastfremantle.wa.gov.au/consultations/ To contain all project information including; FAQ's, project background, engagement event information and project contact.
Project flyer / postcard	A project postcard was distributed to nearby residents and businesses.
Project emails/ e-newsletters	Emails were sent out via the TOEF to registered community members as a call to action for engagement opportunities.
Posters and signage	Posters were erected at local businesses and signage at key locations along the foreshore directing people back to webpage.
Social media	Established social media channels for the TOEF were used to provide information and direct people to the webpage

3. Key Findings

3.1 Community and Business Reference Group

The initial CBRG meeting occurred on 24 August 2022, with 13 of the 15 attending.

Some of the questions and comments raised during this meeting were;

- Is the health of the river and water quality considered within the CHRMAP project.
- Pollution of the river and foreshore is a hazard and affects the use of the river.
- Water based fish, marine life and plants should be considered as an asset.
- Need to consider the effect of human activity and particularly boat wake on the foreshore.
- The effect of inundation due to rainfall also needs to be considered.
- Who was the East Fremantle CHRMAP steering committee comprised of.
- Is there connectivity across LGA's.
- What are the implications of a riverine rather than coastal CHRMAP.

A second CBRG meeting occurred on the 23rd November, 2022. The meeting delivered the results of the studies and survey to date to attendees. The new format for community engagement for Asset Priorisation and Adaptation Options being via the George Street Festival was discussed. Potential activities were tested with the CBRG and the feedback from the group was provided.

3.2 Pop-up Information Sessions

Two pop-up information sessions were held on Wednesday 31 August 2022 from 5pm to 7pm and 2 October 2022 from 10am to 12pm at the East Fremantle town Hall, 135 Canning Highway. The 2 sessions were visited by 14 people who came to view the information and chat to the project team to gather more information about the project.

The information session included a static information display, coastal flooding maps and a rotating presentation and was attended by the following project team members:

- Baird coastal engineering specialists
- element, planning and engagement specialists
- Town of East Fremantle officers

A summary of the feedback and questions asked are below.

- Stormwater discharge along the river needed to be considered
- Some of the breather pipes in the area caused water to overflow and flood the surrounding land-based area

- Several people were concerned about the impact of inundation on their properties close to the foreshore area.

3.3 Foreshore Values Survey

The main tool for collecting community feedback was through a Foreshore Values survey which ran from 1 August to 6 September 2022. A total of 152 respondents undertook the Foreshore Values survey.

3.3.1 Who did we reach

The majority of respondents were residents from within the Town of East Fremantle (n=101) whilst most of the remaining respondents were from nearby suburbs, particularly Bicton. A smaller number of respondents were from a variety of other metropolitan suburbs.

Approximately 7% owned property in East Fremantle but did not live in the area, whilst 14.5% worked in East Fremantle. A significant amount attended a sporting or community group (35%) while 65% used the area for recreational purposes.

Well over half (58%) lived within 1km of the site, while a further (31.5%) lived up to 5km away. The remainder lived more than 5km away.

The majority of respondents (60%) were over 55 years of age, with 27% aged 35-54 and 10% 34 years or below. Most respondents were male (56%).

3.3.2 Awareness of East Fremantle CHRMAP project and survey

Well over a quarter (28%) were not aware of what a CHRMAP was before answering the survey. A further 62% were somewhat aware and had heard of it or knew the basics, whilst only 10% felt that they were highly aware of the project.

For those that indicated how they had heard of the survey well over half (53%) received a direct email or e-newsletter from the Town of East Fremantle or an organised club in the area. Nearly a quarter became aware via the Town's website with a further 10% and 12% from posters/flyers and word of mouth.

3.3.3 Perceptions of the foreshore area

Respondents were asked about what three words they associated with the East Fremantle foreshore based on their experiences and interactions. Almost a quarter of respondents (22%) described the foreshore using beautiful (or beauty). Peaceful/tranquil/serene (15%) and nature/natural (13%) were almost mentioned often, along with recreation (9%), walking (9%) and relaxing (8%).

The image overleaf shows a graphical representation of the word descriptions that were used

Figure 3: Q5. Thinking about your interactions and experiences with the East Fremantle Foreshore (between Petra Street and East Street) what are three words that come to mind?

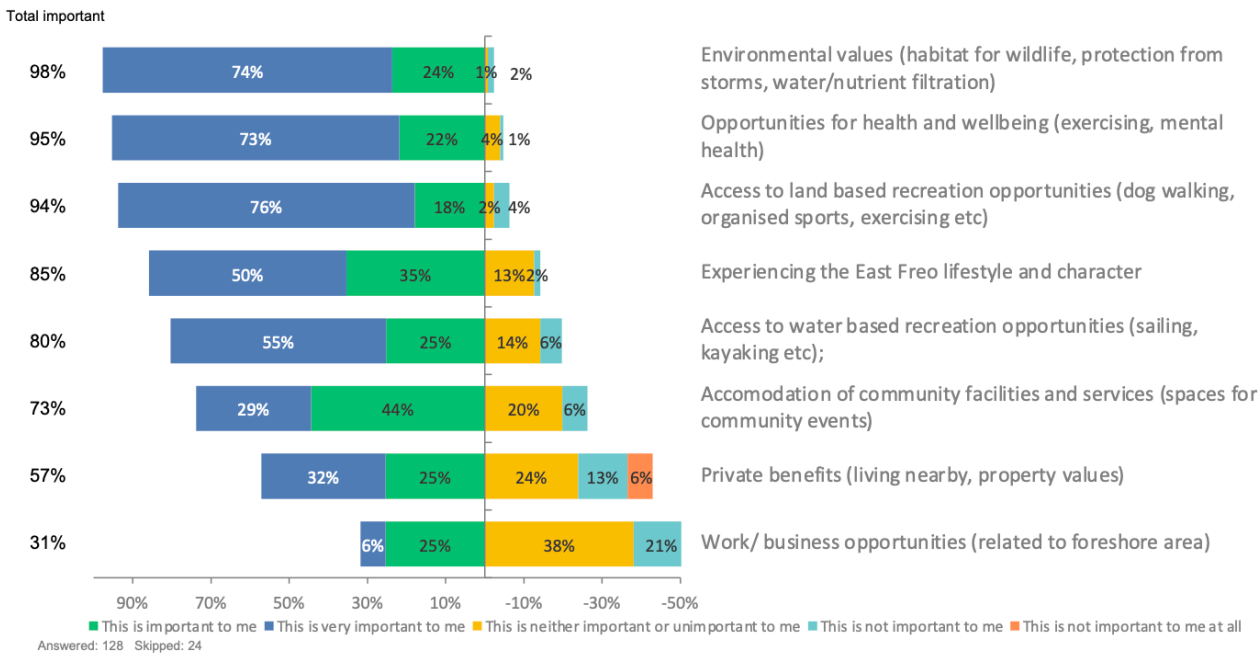
3.3.4 Values

There are a range of values that can apply to the riverine foreshore within East Fremantle. Respondents were asked to rate the following values to determine which were most important to them. A full list of the values is shown in Figure 4 below.

Whilst almost all were viewed as important, the most highly rated values were ‘Environmental’ (98% combined importance), ‘Opportunities for health & well-being' (95% combined importance) and ‘Access to Land-based recreation opportunities’ (94% combined importance).

‘Work/ business opportunities were seen as the least important value (31% overall importance).

Figure 4: Q5. Please tell us how important each value is to you in the context of the East Fremantle foreshore



3.3.5 Activities

As illustrated in the Figures below and overleaf; walking, visiting a restaurant or café, being in nature and visiting a restaurant were the top 4 activities respondents engage in along the East Fremantle foreshore.

There were some differences noted between the zones

- Outdoor socialising/picnics were more likely to occur in the Reclaimed Zone than other zones (67% vs 48% and 47% for the Reclaimed and Walled Zones)
- Sporting or community group activities were more likely to occur in the Natural Zone than other zones (40% vs 26% and 16% for the Natural and Walled Zones)
- Visiting a restaurant or café were least likely occur in the Natural zone (37% vs 72% and 73% for the Reclaimed and Walled Zones)

Figure 5: Q8. Please indicate below whether you personally undertake any of these activities and where you undertake them – all zones

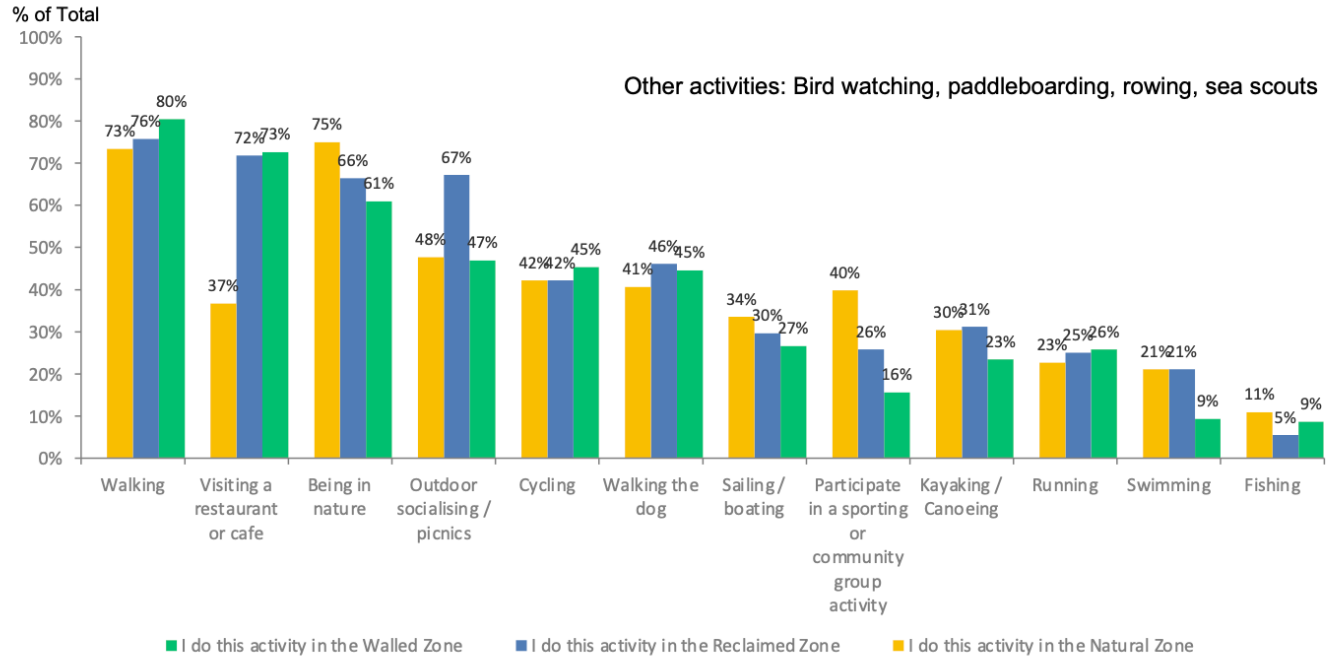


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Figure 6: Q8. WALLED ZONE - Please tell us how important each value is to you in the context of East Fremantle foreshore

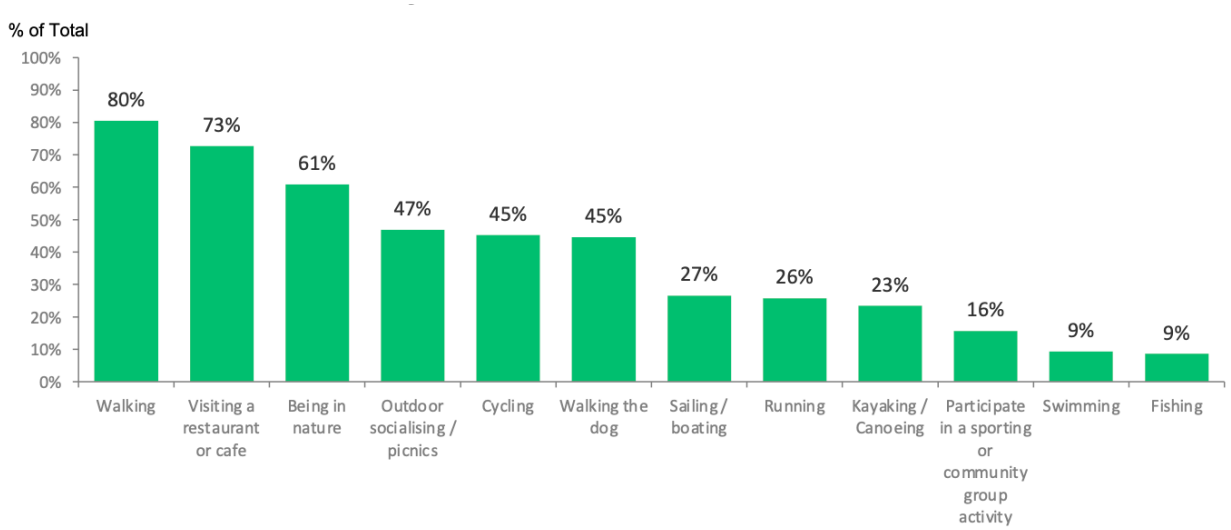


Figure 7: Q8. RECLAIMED ZONE - Please tell us how important each value is to you in the context of Fremantle foreshore

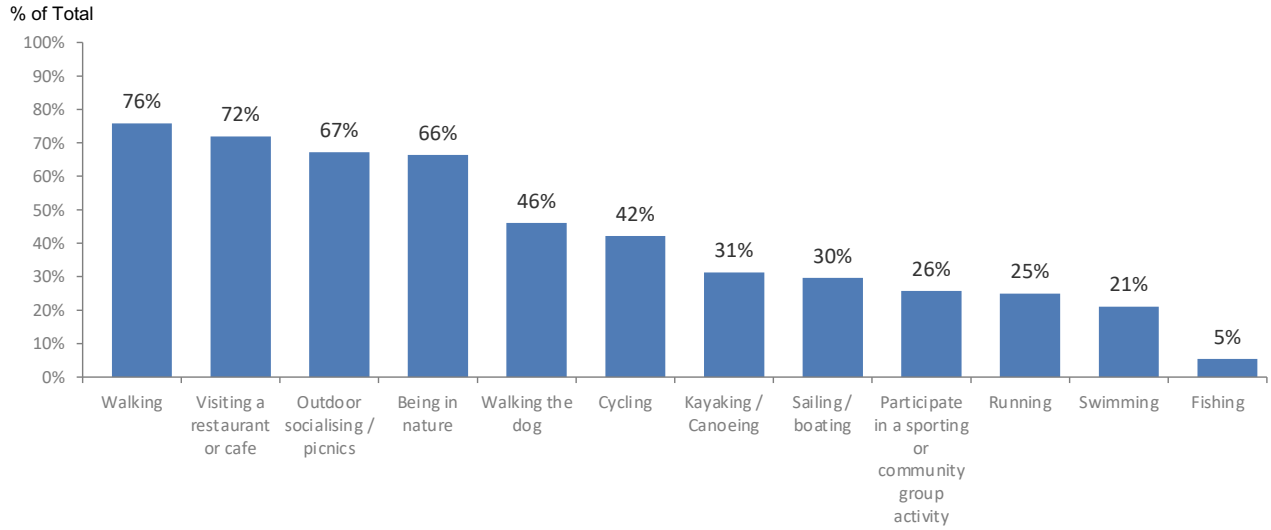
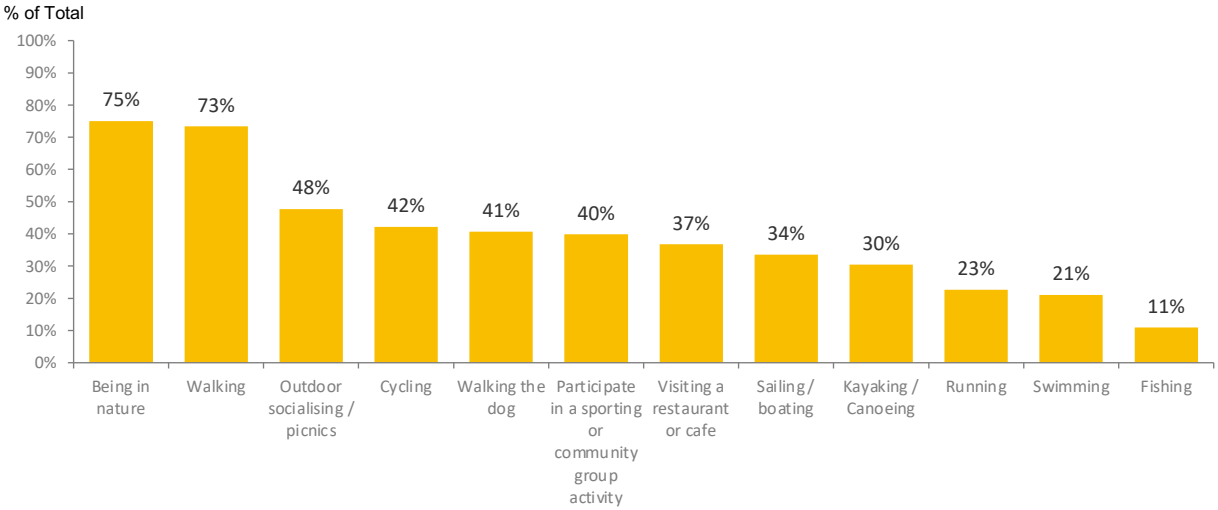


Figure 8: Q8. NATURAL ZONE - Please tell us how important each value is to you in the context of East Fremantle foreshore



For each zone, respondents that participated in an activity were asked how frequently they did that. In terms of the frequency of activities, those that occurred at least once a week for each of the zones are shown in the table below.

The proportion of those who participated in the activity for the zone is expressed as a %, with the number of people shown in brackets.

Table 3: Proportion of respondents participating in Activities at least weekly

Activities	Walled Zone	Reclaimed Zone	Natural Zone
Walking	75%	66% (58)	68% (54)
Running	71% (20)	60% (15)	52% (13)
Walking the dog	71% (39)	70% (35)	71% (32)
Being in nature	64% (49)	53% (41)	57% (48)
Participate in a sporting or community group activity	56% (9)	43% (12)	67% (28)
Cycling	42% (24)	42% (21)	39% (19)
Sailing / boating	42% (13)	24% (7)	39% (12)
Visiting a restaurant or cafe	38% (34)	34% (29)	42% (16)
Swimming	33% (4)	21% (5)	27% (6)
Kayaking / Canoeing	29% (8)	27% (9)	29% (10)
Outdoor socialising / picnics	24% (14)	15% (12)	18% (9)
Fishing	22% (2)	17% (1)	18% (2)

Walking and walking the dog were some of the most frequently occurring activities across the zones.

Those activities that occurred less often were outdoor fishing and outdoor socialising/picnics.

Some the differences across the zones were;

- Walking, running and being in nature occurred more frequently in the walled zoned.
- Most activities occurred less frequently in the reclaimed zone in comparison to other zones.
- Sporting and community group activities occurred more often in the natural zone.

Detailed graphs outlining the frequency of activity for each of the zones are contained in Appendix A.

3.3.6 Reasons for undertaking activities

People were asked to choose why they undertook an activity in an area, rather than elsewhere based on a following choices;

- I can't do this activity anywhere else, it is unique to this area
- I've always done the activity here, it's what I know and like
- I live nearby so it is more convenient for me
- I like the quality of the public facilities
- I feel a social connection with others who do this same activity
- Proximity to an attractive, natural setting

More than one reason could be provided for each activity in each zone.

For most activities across the zones the most common reasons were 'I live nearby so it is more convenient for me' and 'Proximity to an attractive, natural setting'.

There were relatively few respondents that indicated 'I can't do this activity anywhere else, it is unique to this area' for activities. This is shown in the table below for each activity across the zones, in terms of proportion of those participating in the activity and the actual numbers of people (n).

Table 4: Proportion (and number) of respondents participating in Activities by Zone who indicated that 'I can't do this activity anywhere else, it is unique to this area'.

Activities	Zones		
	Walled Zone	Reclaimed Zone	Natural Zone
Walking	10% (n=10)	12% (10)	11% (9)
Running	7% (2)	15% (4)	17% (4)
Walking the dog	2% (1)	8% (4)	16% (7)
Visiting a restaurant or cafe	8% (7)	10% (8)	11% (4)
Sailing / boating	7% (2)	11% (3)	18% (6)
Swimming	9% (1)	0	19% (4)
Outdoor socialising / picnics	5% (3)	5% (4)	8% (4)
Participate in a sporting or community group activity	12% (2)	15% (4)	30% (12)
Kayaking / Canoeing	11% (3)	15% (5)	9% (3)
Being in nature	11% (8)	9% (7)	14% (11)
Fishing	10% (8)	0	9% (1)
Cycling	9% (1)	2% (1)	4% (2)

More respondents were likely to feel that they were unable to do the same activities elsewhere in the natural zone. This was particularly true for participating in sporting or community activities and being in nature.

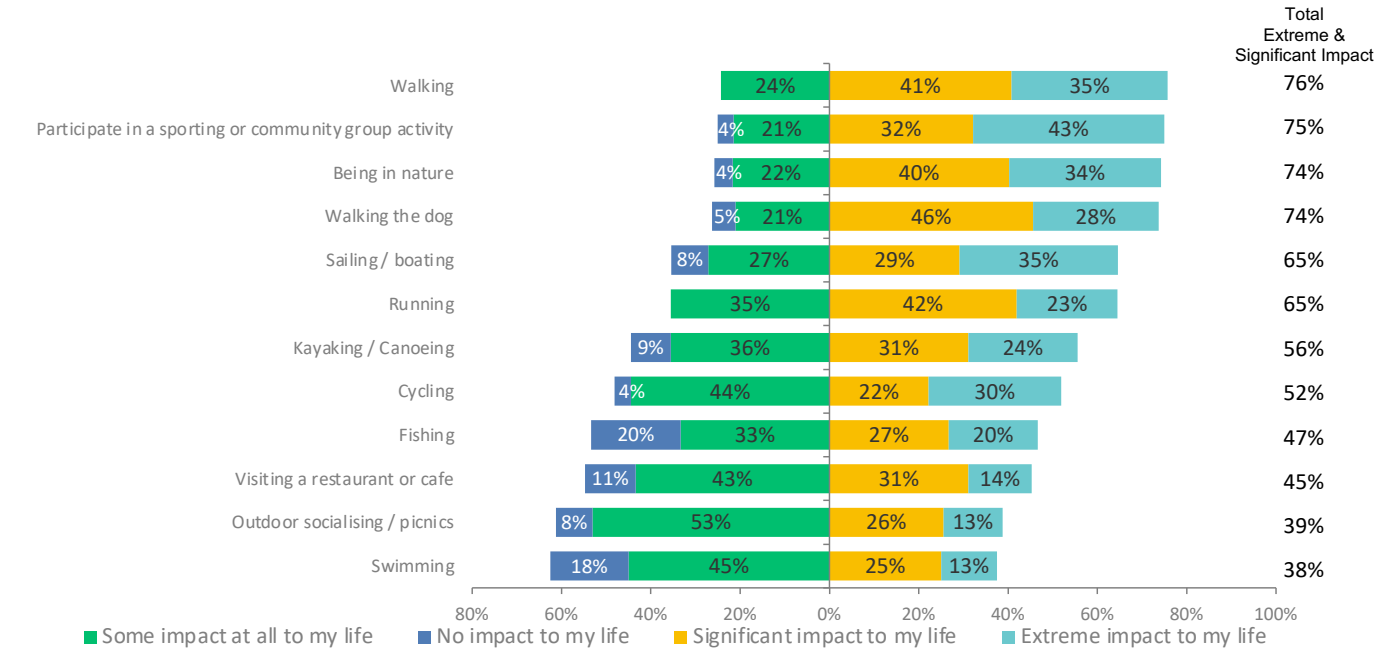
Detailed graphs and tables outlining the reasons for participating in an activity for each of the zones are contained in the Appendix B.

3.3.7 Impact if unable to participate in activities

Each of the respondents that indicated they participated in a particular activity in a specific zone, were subsequently asked 'If you were unable to do these activities along the East Fremantle foreshore, how much would this impact your life?'. Respondents then rated the impact on their lives from no impact, some impact, significant impact and extreme impact.

Those who engaged in walking, participating in sporting or community group activities, being in nature and walking the dog indicated that being unable to do this would have the highest impact with approximately three quarters of participants indicating that this would have an extreme or significant impact as shown in Figure 8 overleaf.

Figure 9: Q15. If you were unable to do these activities along the East Fremantle foreshore, how much would this impact your life?



Answered: 114 Skipped: 38

3.3.8 Erosion and Inundation Noticed

Respondents were asked 'Have you noticed any areas along the foreshore that may be affected by, or increasingly impacted by, inundation and/or erosion hazards over the past 5 years?'

A total of 46 respondents provided comments about the type and location of erosion and inundation.

The comments and number of mentions are shown in the table below

Table 5: Comments on locations /types of erosion and inundation noticed in the vicinity of the East Fremantle foreshore.

Comments	Number of mentions
Cycle and walking paths can be affected	9
Concerns about boat wash	6
East Fremantle Yacht Club	6
River walls	6
Foreshore area near rowing club	4
Area near Dome (carpark)	6
Walled Zone	4
Beach area near Zephyrs	3
Cliff areas near Jerat Drive	4
The Groynes at Zephyrs are working	2
Natural area	2
Stirling bridge area	2
Beach areas (general)/ unwalled sections	2

Fremantle bridge	2
Reclaimed zone	2
Jetty infrastructure /Navy cadet boat ramp	2
EG Chapman Reserve	1
Scouts area	1

3.3.9 Other Questions and Comments

Respondents were asked if there was any further questions or comments. Eleven people responded with the following comments:

- Would like to be involved (n=2)
- Consider the interests of cyclists (n=2)
- Don't over-vegetate the river and cut of views (n=1)
- Include higher walls to limit inundation in urban areas (n=1)
- Thanks for seeking input from the community (1)
- You cannot forecast for 100 years (n=1)
- Include additional images of foreshore erosion (n=1)

3.4 Asset Prioritisation and Adaptation Pathways

3.4.1 Festival Methodology

The initial methodology for this was to have two community workshops. However, it was decided that the annual George Street Festival offered a good opportunity to canvas a broader and greater amount of community members due to good attendance numbers. The George Street Festival is an outdoor event that incorporates the length of George Street. It is a free event that features a range of stalls, music and activities. The event occurred on the 4 December, 2022 from 11am – 6pm. An East Fremantle CHRMAP stall was set up for the day and a total of 92 people attended the CHRMAP stall.

The purpose of the stall was to share information about the CHRMAP and to encourage attendees to participate in activities to identify important community assets, prioritise these assets and understand the preferred adaptation options for them. This also allowed information sharing to occur with community members who were not already aware of the East Fremantle CHRMAP.

The utilisation of the George Street Festival to obtain feedback meant that the number of community members exposed to the information and involved in the process was maximized. However, the stall format also meant that the time available to explain the CHRMAP concept and obtain feedback was reduced in comparison to a workshop. To accommodate this, the tasks that participants undertook were split into two sessions for the day.

The new format for activities was tested with the CBRG and the feedback from the group helped to refine the final activities that were undertaken with the community at the 2022 George Street Festival.

Display Boards were utilised during the day to provide information about the CHRMAP, outline the instructions for the activities and gather feedback from the community.

3.4.2 Session One: Coastal Assets Identification and Prioritisation

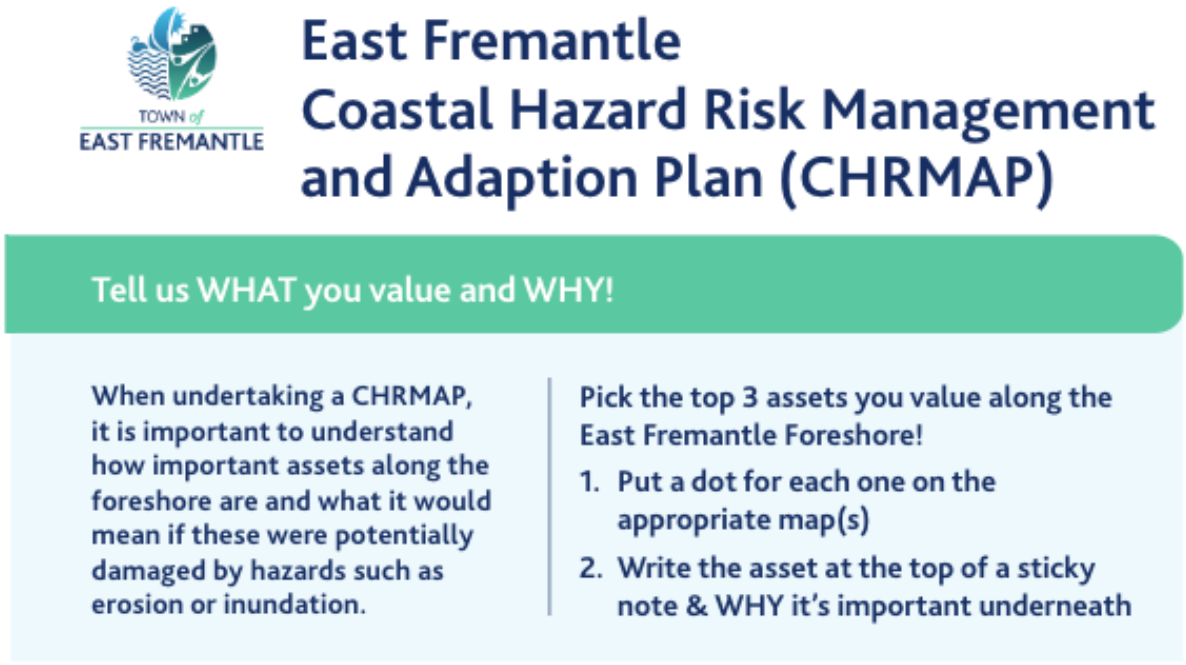
The tasks that occurred during session one were undertaken between 11am – 2.30pm. These tasks required participants to identify the assets along the foreshore that were of importance to them by placing 3 dots on the

maps displayed to indicate their top 3 assets. (Participants from session 2 of the day were also asked to provide input for this)

Participants from session one were also required to state why these assets were important to them.

The instructions for the session one participants are shown in Figure 10 below.

Figure 10: Foreshore Asset Display Board instructions



3.4.3 Session Two: Coastal Asset Adaptation Options

Session two was undertaken between 2.30pm – 6.00pm. Similarly to session one, participants were required participants to identify the assets along the coast that were of importance to them by placing 3 dots on the maps.

Participants were then also asked to decide on the preferred adaptation option for each of their priority assets. Relevant adaptation approaches and examples were shown on Display Boards and each participant had the adaptation options explained to them individually. They then wrote their top three assets on a piece of paper and allocated them to an adaptation option by placing them in the appropriately labelled container. Additional descriptions of the adaptation options were next to the containers for each of the options.

Participants were also able to suggest other adaptation strategies if desired, however no one did this.

The instructions for the session one participants and the adaptation containers are shown in Figure 11 and 12 overleaf.

Figure 11: Adaptation Options Display Board instructions

Figure 12: Adaptation Options Display Board and Containers

3.4.1 Results

The following table shows the assets that were identified as important to participants. The higher the number of dots allocated to the assets the greater the priority. This number is a record of all participants who attended the East Fremantle stall and took part. It should be noted that while participants could record a maximum of 3 assets, a few recorded less than this.

The table is divided up into each of the zones; Walled, Reclaimed and Natural. The assets are then ranked according to the number of dots allocated as important. If an asset did not receive a dot (recorded as important) it was not included in the table.

In terms of articulating why this asset was important to them, only those who participated during the first session provided reasons and these are recorded in the table below. Those who participated in the second session did not record this information, therefore not all assets will have reasons for importance included in the table.

Based on the information shown below, the most important asset for the community within the area was the multi use/walking path (13) which stretched along the entire foreshore (including the walled area). The main reasons that this feature was seen as important related to its use for exercise, the enjoyment that people had from using it and the accessibility or the potential lack thereof to the river foreshore.

The detached groyne field and the beaches adjacent to it stretching from Preston Point to the Boat Ramp in the reclaimed zone (7) were also deemed a priority. Again, access to the water and the enjoyment its use gave people were the main reasons it was seen as important.

Other key assets the community indicated were particularly important to them were; 8 Knots Tavern (6), Cool Beans (5), John Tonkin Reserve (5), Preston Point (5), Zephyrs Café (5) and the East Fremantle Yacht Club (EFYC) (5).

In addition to this, the natural foreshore area between the Defence Building and the EFYC (in front of the Jerrat Drive escarpment) in the Natural Zone was also noted as an important asset to the community. (5)

Table 6: Asset Priority and Importance

Map No.	Asset	No. of dots (priority)	Why is it important
	Low lying areas	2	• Public use areas
	Multi-use Path/ Walking path (all zones)	13	• It often gets flooded and I run there every day. • Exercise and vista • Accessing the whole river foreshore which belong to the people and connects all of Freo • Cannot use them when the tides are high • I walk dog often • Daily exercise for all along foreshore through to Fremantle • Because I walk every day and it is a pleasant thing to do • Parks for dogs • Can't use the space to enjoy the area
	Parks	3	• Public space • For children to play in • Outdoor activities and outings with children & family
Walled Zone			
10	Riverside Road	4	

5	Left Bank	3	• Social setting, employment area, family gathering area
4	J Dolan Park	2	• It's at risk
6	Marine Education Boatshed	2	
7	Merv Cowan Park	1	
9	Niergarup Trail	1	
11	Steve Swan Walk	1	
n/a	Beach area in front of wall	1	• Becoming flooded - not able to walk along
n/a	Bon Scott head mural	1	
	Reclaimed Zone		
5	Detached Groyne Field and adjacent foreshore beach areas	7	• Dolphins, pelicans • Beach areas between groynes are easy to access • Dogs allowed to go off the lead and swim in the river - go for nice walks – wildlife
1	8 knots tavern	6	• River proximity landscape • 8 Knots is a lovely place to go
4	Cool Beans	5	• Herons roost there • Relaxed communication - Trees • Healthy community based activities
6	John Tonkin Reserve	5	• Love the work at the John Tonkin. More projects like this would be great! • Fauna that lives in the area
	Preston Point and adjacent beach	5	• Affects the rest of the river and the flow that goes through • Birds nest on it
17	Zephyrs Cafe	5	• The view and visit • Community meeting place
7	Leeuwin Barracks	3	• Will use for something else • No more development near or at Leeuwin Barracks
14	Swan Yacht Club	4	• Very close to the water's edge
3	Boat Launching area	2	• Where people keep their dinghy and access their boats • Being accessible and natural
8	Leeuwin Boat Ramp	1	
10	Niergarup reserve	1	
15	W Wayman Reserve	1	
13	Rowing /Boat Club	1	• Healthy community based activities and dwellings need to be preserved including rowing, strength conditioning - imperative for the culture
	Natural Zone		
n/a	Natural foreshore area	5	• It will be the first to go • Keep it accessible • So you can walk along the sand area

			• Leave as natural as possible
9	East Fremantle Yacht Club	5	• Access to wider part of the river
2	Camp Waller Scout hall	3	• Family gathering area, walking my dog along the river and in the river
4	Defence Jetty	3	
14	Wauhop Park	2	
11	Jerrat Drive Escarpment	2	
3	Defence Building	1	• Will use for something else
6	East Fremantle Junior Cricket Club	1	
7	East Fremantle Junior Football Club	1	
10	EJ Chapman reserve	1	

During the second session people identified the assets that were important to them and then decided their preferred adaptation option. The adaptation options were identified by Baird as those most suitable to the unique East Fremantle riverine environment.

Overall, a total of 49 assets were prescribed adaption options to mitigate risk. Based on this, building design was the preferred adaptation option for a third (33%) of assets. Further to this, nature-based designs were preferred for 31% of assets.

Table 7: Adaptation Option Types

Adaptation Option	Total Number of Assets	Walled Zone	Reclaimed Zone	Natural Zone	General
Building Design	16	3	4	4	5
Nature Based	15	3	8	3	1
Groynes	8	2	5	-	1
Sea Walls	6	4	1	1	
Sand Nourishment	3	-	3	-	
Retreat	1	1	-	-	

The table overleaf outlines the priority assets and corresponding adaptation options in more detail.

Table 8: Adaptation Options by Asset

Asset	Preferred Adaptation option					
	Building Design	Nature Based	Groynes	Sea Walls	Sand nourishment	Retreat
Pathways / Multiuse Pathway	3		1			
Jetties should be floating	1					
Buildings on Piles	1					
Erosion protection from storm surge		1				
Walled Zone						
Dome Café	1					
J Dolan Park		1				
Left Bank	2					
Marine Education Boatshed	1	1				
Riverside Road/ Inundation of foreshore road & underground infrastructure			1	2		1
Niergarup Trail		1				
Steve Swan Walk			1			
Bon Scott Head Mural	1					
Reclaimed Zone						
8 Knots	1	1	1			
Cool Beans		1		1		
4 Groynes			1			
Beaches near groynes/ Preston Point Beach/ Preston Pt Dog Beach		2			2	
Foreshore Leeuwin Area		1				
John Tonkin Reserve		1			1	
Leeuwin Boat Ramp			1			
Plausible SLR Projections built into Leeuwin Barracks redevelopment	1					
Niergarup Reserve		1				
Swan Yacht Club	2					
Zephyr Café		1	2			
Natural Zone						
Jerrat Drive Foreshore/ Escarpment		2				
East Fremantle Yacht Club	4					
EJ Chapman Reserve		1				
Wauhop Park				1		

4. Success Criteria

As a result of the engagement findings, we can deduce a preliminary set of criteria which will be used to guide the success of the CHRMAP report. The 'success' of the CHRMAP will be determined by the assets identified through the CHRMAP process continuing to provide their present function, services and values (or an accepted version of it as determined by community and stakeholders).

Therefore, the success criteria will be determined by the values collected in this part of the engagement process. The preliminary success criteria are outlined below and will be updated as the engagement progresses.

- Ensure the natural environment is protected and sustained in its current condition or an improved condition. In line with this the use of nature-based adaptation solutions were viewed as being preferable by the community, especially in the reclaimed zone.
- Preserve the function and opportunity for land-based health & well-being and recreation activities along the foreshore and access to water-based activities such as walking (the dog), sailing and kayaking. This multi-use pathways throughout the zones were seen as crucial to enabling these activities.
- Preserve the existing hospitality and recreation venues along the coastline and access to them. In general, the preferred adaptation option for these assets was for via building design either retrospectively or in the future to withstand and manage flooding and raised water levels.
- Maintain services that maximise community benefit for all.
- Consider foreshore areas that have current inundation and erosion issues and are at particular risk of water level rise.
- Develop solutions to riverine processes that are sustainable (financially, socially and built form) and locally responsive.
- Revisit regularly with community and key stakeholders their values in relation to development adjacent the foreshore.

5. Next Steps

With most of the engagement complete, Baird will incorporate the findings from the engagement into the draft CHRMAP. The draft CHMRAP report will then be presented to the CBRG for consideration.

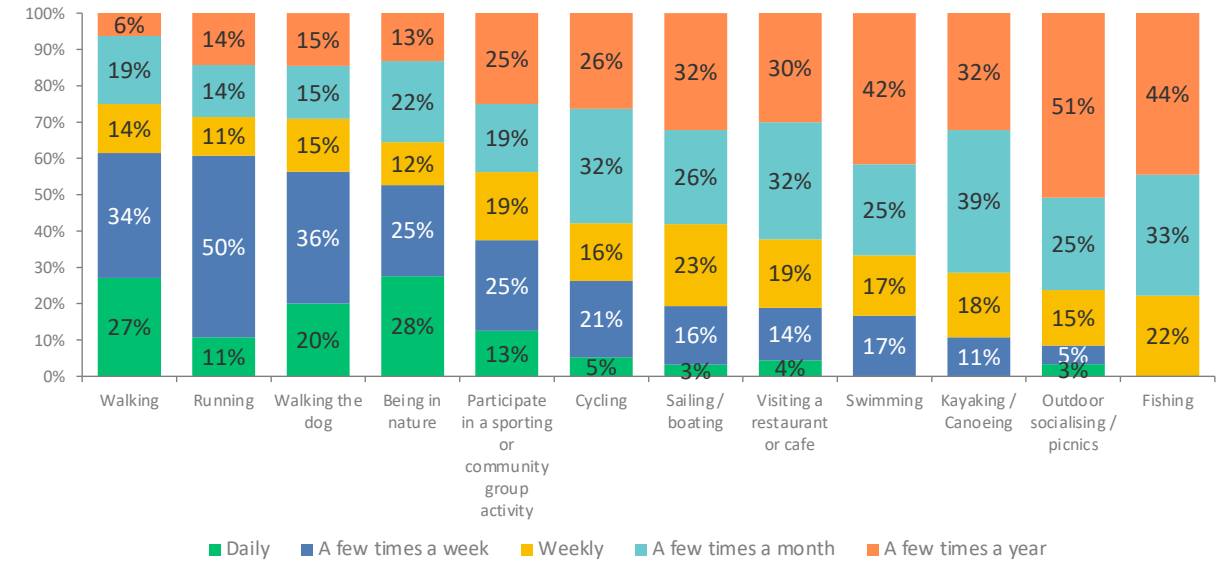
Following this there will be a public comment period for a minimum of 4 weeks will be hosted via the Town of East Fremantle's website. At this time communications will be sent to community members that participated in the CHRMAP process and key stakeholders.

The draft CHRMAP report will then be finalised based on feedback in mid-2023.

Appendix A. Frequency of Activities

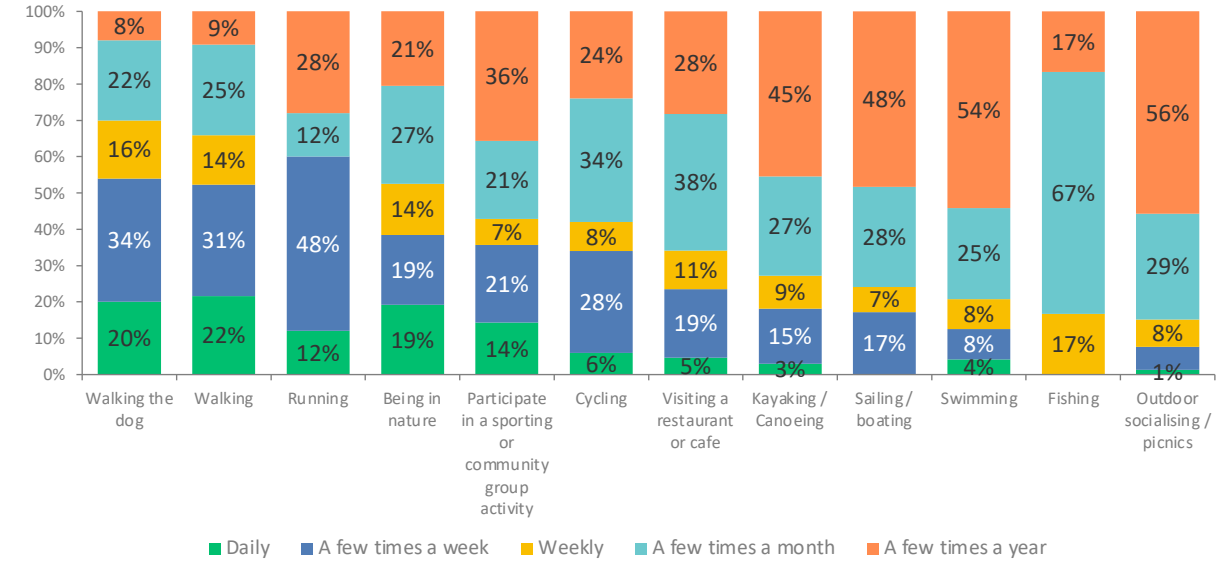
Q9: How often do you participate in these activities in the Walled Zone?

Answered: 114 Skipped: 38



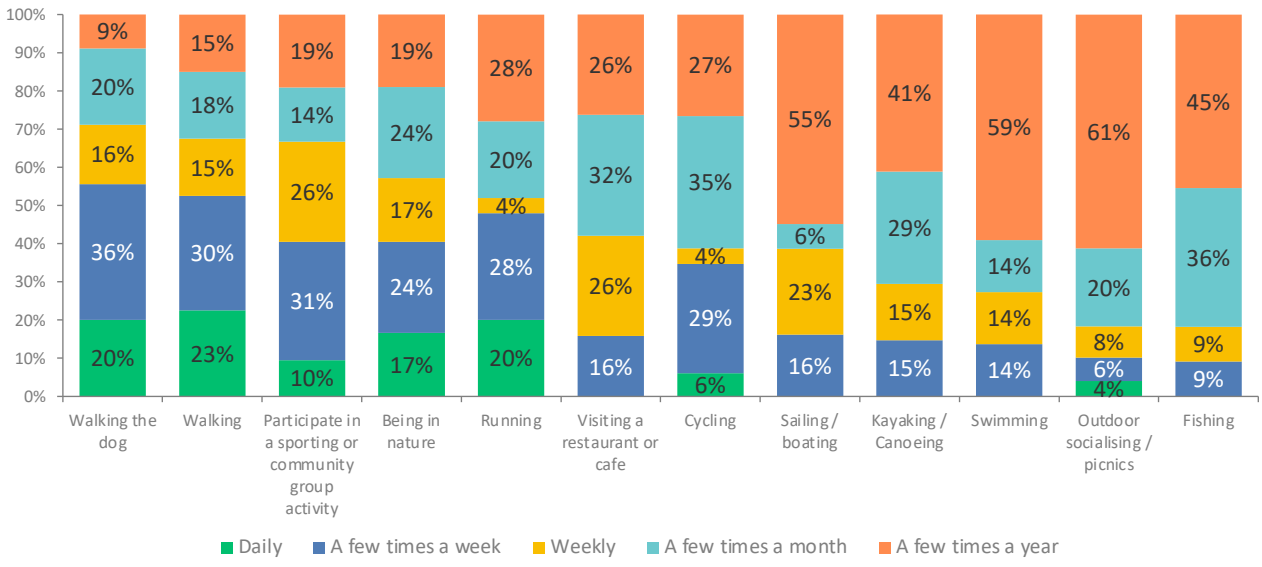
Q9: How often do you participate in these activities in the Reclaimed Zone?

Answered: 105 Skipped: 47



Q13: How often do you participate in these activities in the Natural Zone?

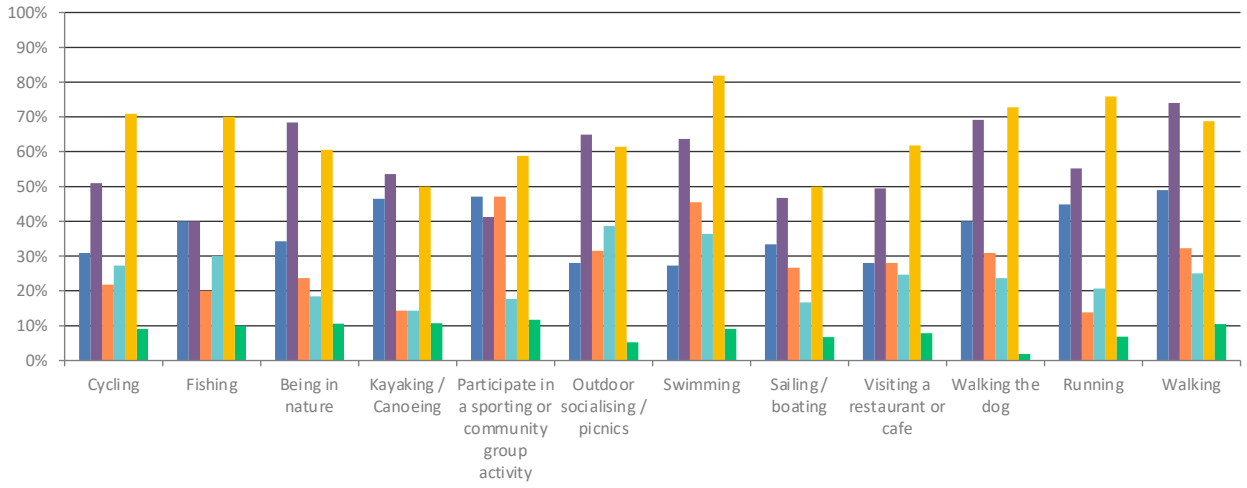
Answered: 103 Skipped: 49



Appendix B. Reason for Activities

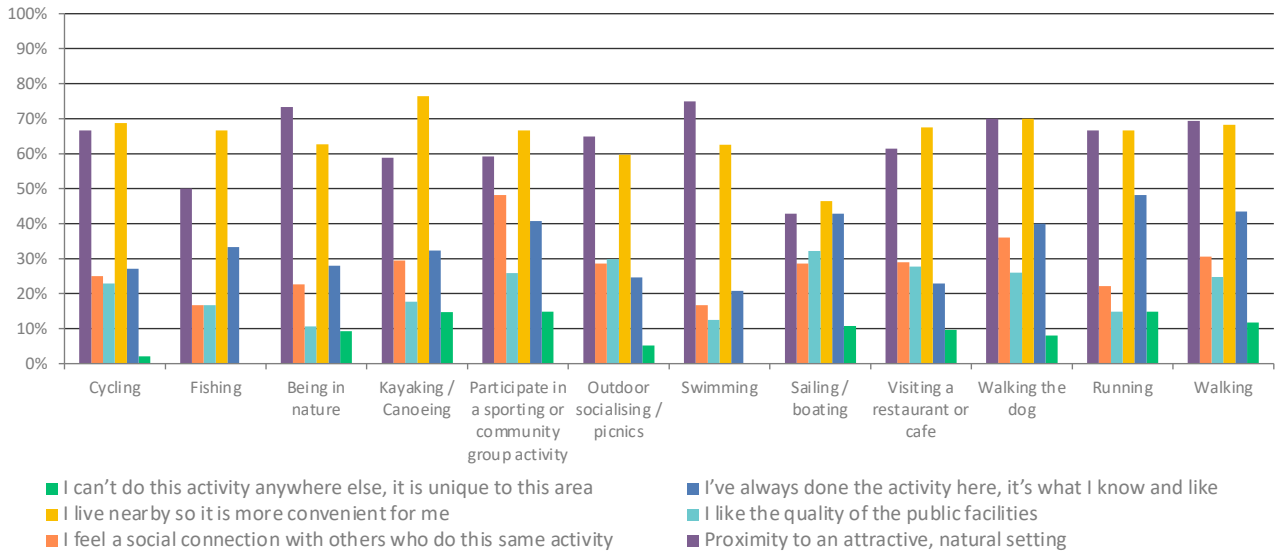
Q10: Why do you choose to undertake these activities in the Walled Zone as opposed to other areas? (You may select more than one option)

Answered: 112 Skipped: 40



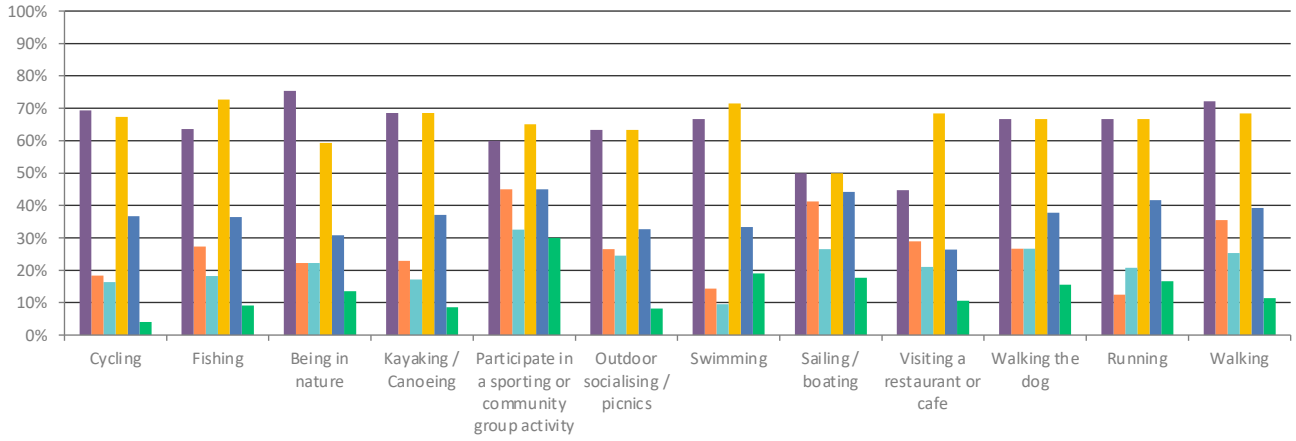
Q12: Why do you choose to undertake these activities in the Reclaimed Zone as opposed to other areas? (You may select more than one option)

Answered: 103 Skipped: 49



Q14: Why do you choose to undertake these activities in the Natural Zone as opposed to other areas? (You may select more than one option)

Answered: 102 Skipped: 50



- I can't do this activity anywhere else, it is unique to this area
- I've always done the activity here, it's what I know and like
- I live nearby so it is more convenient for me
- I like the quality of the public facilities
- I feel a social connection with others who do this same activity
- Proximity to an attractive, natural setting

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Appendix B

Coastal Processes Allowances

Baird.

B.1 Structures in the Shoreline

B.1.1 Walled Zone

N:\Projects\13668.101_TOEF_CHRMAP\09_GIS\10 QGIS\Figures\TOEF_StudyArea_WalledZone.png

Baird.

B.1.2 Reclaimed Zone

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Baird.

B.1.3 Natural Zone

B.2 Coastal Processes Allowances – Assumption that Protection Structures in the Shoreline are Maintained

Baird.

B.2.1 Walled Zone

N:\Projects\13668.101_TOEF_CHRMAP\09_GIS\10 QGIS\Figures\TOEF_StudyArea_WalledZoneSetbackLines_Structures.png

Note HSD: Horizontal Shoreline Datum (used as benchmark)

Baird.

B.2.2 Reclaimed Zone

N:\Projects\13668.101_TOEF_CHRMAP\09_GIS\10 QGIS\Figures\TOEF_StudyArea_ReclaimedZoneSetbackLines_Structures.png

Note HSD: Horizontal Shoreline Datum (used as benchmark)

Baird.

B.2.3 Natural Zone

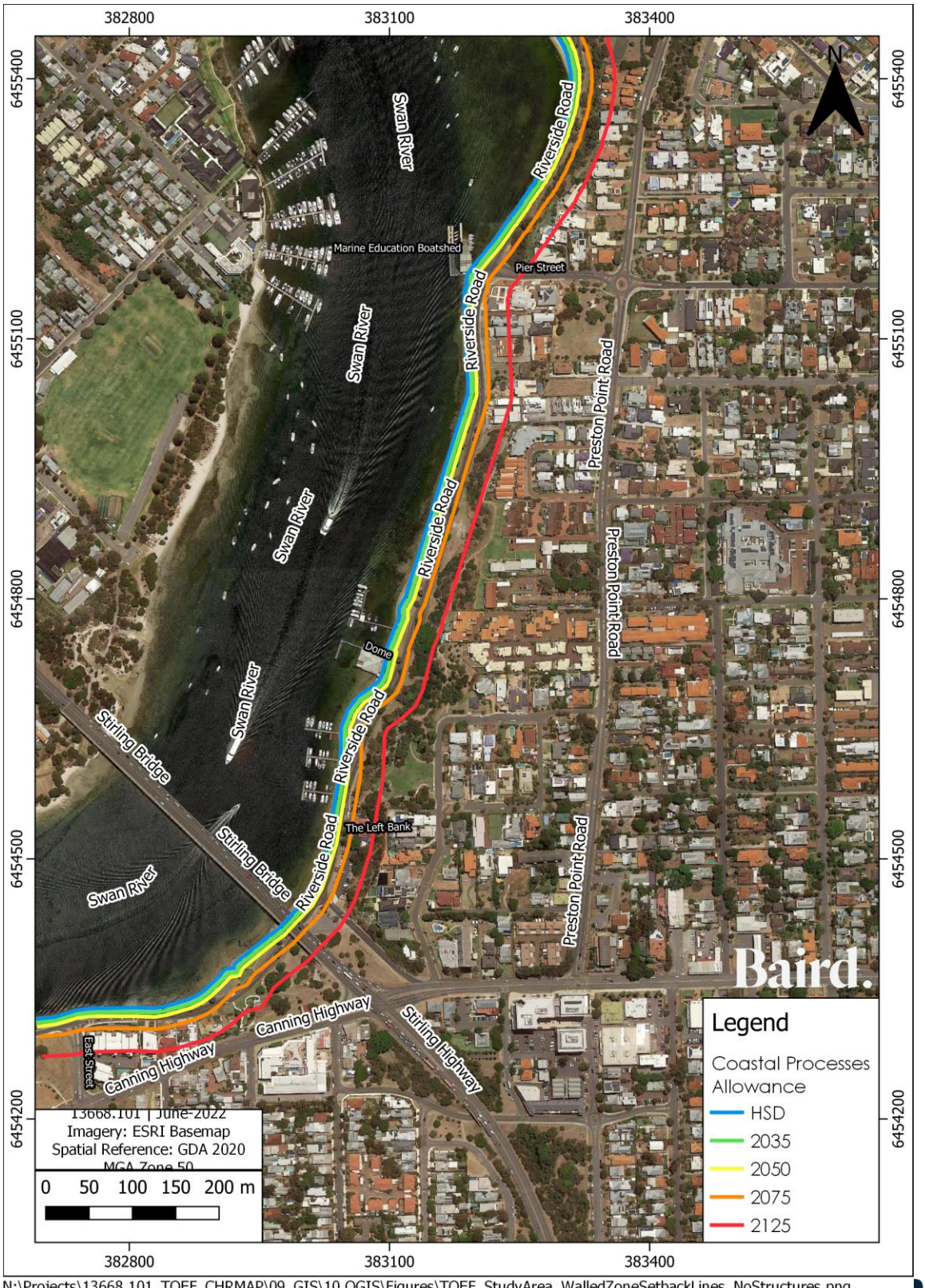
Note HSD: Horizontal Shoreline Datum (used as benchmark)

Baird.

B.3 Coastal Processes Allowances – Assumption of No Protection Structures in the Shoreline.

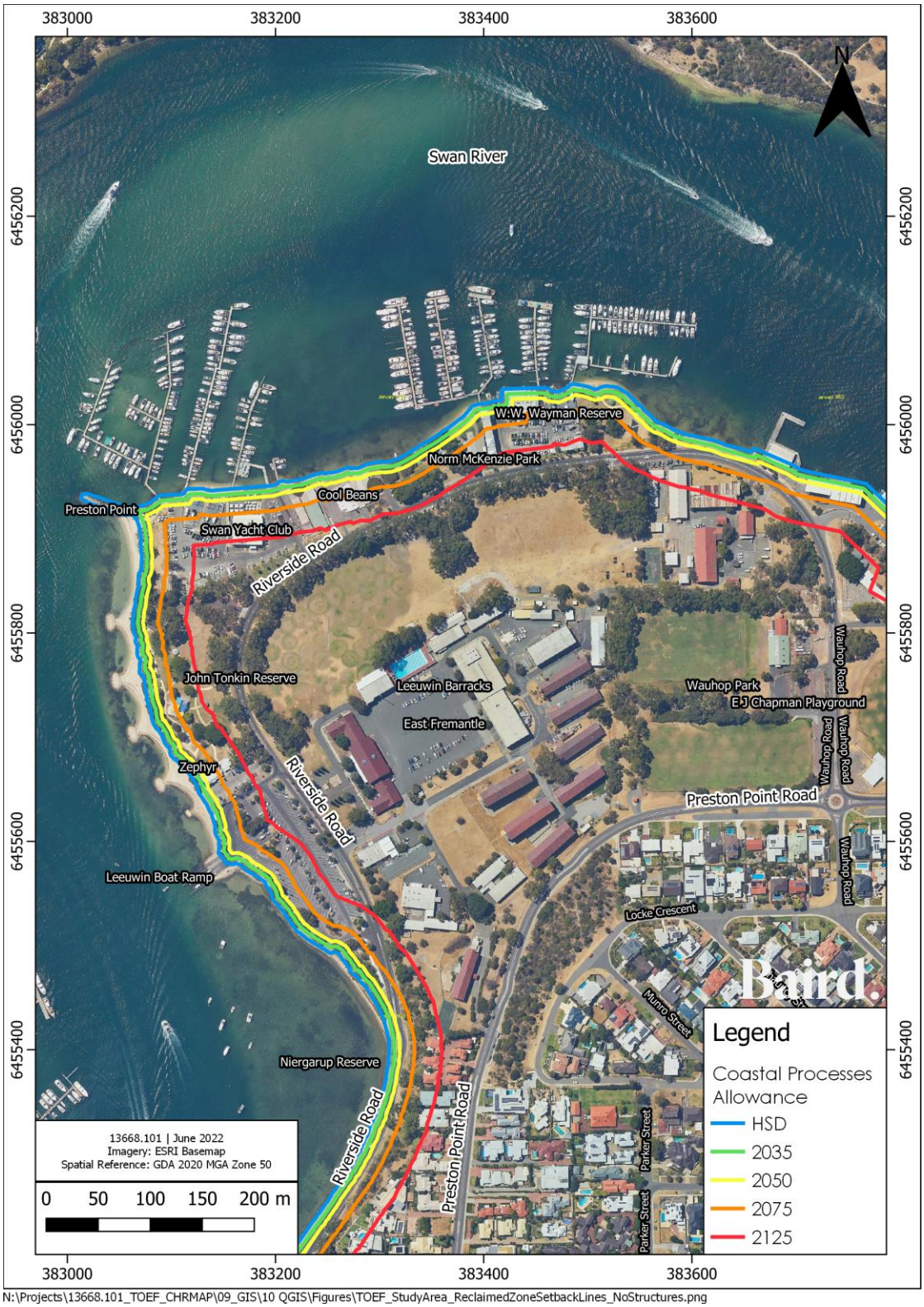
Baird.

B.3.1 Walled Zone



Note HSD: Horizontal Shoreline Datum (used as benchmark)

B.3.2 Reclaimed Zone



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Note HSD: Horizontal Shoreline Datum (used as benchmark)

Baird.

B.3.3 Natural Zone

Note HSD: Horizontal Shoreline Datum (used as benchmark)

Appendix C

Inundation Mapping

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C.1 Inundation Hazard (S4)

C.1.1 500yr ARI Scenario. Peak Depth. Present Day

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Baird.

C.1.2 500yr ARI Scenario. Peak Depth. Planning Year 2035

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Baird.

C.1.3 500yr ARI Scenario. Peak Depth. Planning Year 2050

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Baird.

C.1.4 500yr ARI Scenario. Peak Depth. Planning Year 2075

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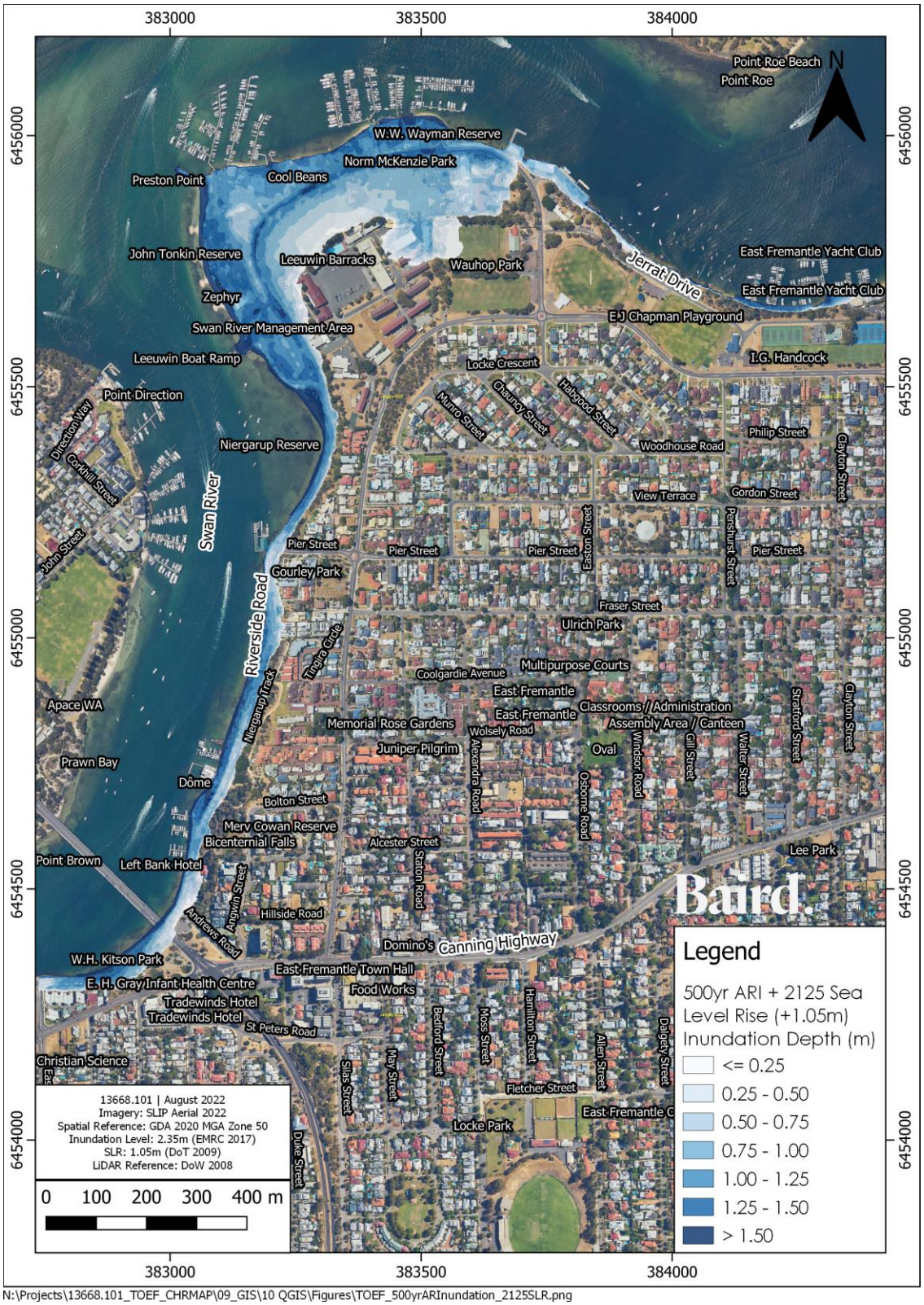
Baird.

C.1.5 500yr ARI Scenario. Peak Depth. Planning Year 2125



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Baird.

Appendix D

Vulnerability Assessment by Shoreline Management Unit

D.1 Vulnerability – Erosion

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU			Consequence	Adaptive Cap.	2035	2050	2075	2125	2035	2050	2075	2125	2035	2050	2075	2125
1	Road Reserve - Lower Merv Cowan (East Riv Drv)	Environmental	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Toilet Block - Lower Merv Cowan (East Riv Drv)	Environmental	Minor	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Riverside Road - Niergarup Reserve to Pier Street	Environmental	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Riverside Road - Pier Street to Dome Café	Environmental	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Riverside Road Dome Café to Stirling Bridge	Environmental	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Riverside Road - Stirling Bridge to J Dolan Park	Environmental	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	J Dolan Park	Environmental	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Riverwalls protecting shoreline	Environmental														
1	Coastal Pathways - Niergarup Reserve to Pier Street	Social	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Coastal Pathways - Pier Street to Dome Café	Social	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Coastal Pathways - Dome Café to Stirling Bridge	Social	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Coastal Pathways - Stirling Bridge to J Dolan Park	Social	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Boat ramps, moorings, jetties	Economic	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
1	Residential Properties - Riverside Rd / East St	Economic	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Residential Properties - Riverside Rd / Pier St	Economic	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Marine Education Boatshed	Economic	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Dome Café	Economic	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Minor Infrastructure (bins, signage, shelters, fencing)	Economic	Insignificant	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Carpark - Public Carpark No 4 (Dome Cafe)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Carpark - J Dolan Park	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Left Bank	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Playground Equipment – north of Dome Cafe	Economic	Minor	Good	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Shelters, seating and picnic tables – J Dolan Park	Economic	Insignificant	Good	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Shelters, seating and picnic tables – North of Dome Cafe	Economic	Insignificant	Good	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Drainage features (pits, pipes, culverts, stormwater outlets)	Economic	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU		General Cat.	Consequence	Adaptive Cap.	2035	2050	2075	2125	2035	2050	2075	2125	2035	2050	2075	2125
1	Niergarup Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
2	Coastal Pathway - John Tonkin Reserve	Environmental	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
3	Coastal Pathway - Norm McKenzie Park	Environmental	Moderate	Average	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	M	H	H	E
4	Norm McKenzie Park Foreshore Reserve Area	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
5	Norm McKenzie Park - Playground	Environmental	Minor	Average	Rare	Unlikely	Likely	Almost Certain	L	L	M	H	L	L	M	H
6	Norm McKenzie Park - Roadside Shelter and BBQ	Environmental	Minor	Average	Rare	Rare	Possible	Likely	L	L	M	M	L	L	M	M
7	W Wayman Reserve - Foreshore Reserve Area	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
8	W Wayman Reserve - Pathway	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
9	W Wayman Reserve - Shelter	Social	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	H	L	M	M	H
10	W Wayman Reserve - Exercise Equipment	Social	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
11	Detached groyne field	Environmental	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
12	John Tonkin Reserve - Playground	Environmental	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
13	John Tonkin Reserve - Gazebos	Environmental	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
14	Riverwalls protecting shoreline	Environmental														
15	Navy Cadets	Social	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
16	Beach access pathways	Social	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
17	Leeuwin Barracks - Existing Carpark / Builings	Economic	Moderate	Good	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
18	Leeuwin Barracks -Park Area Adjacent Riv Drv	Economic	Moderate	Good	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
19	Aquarama Marina (CarPark East Side)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
20	Aquamarina Bulding (adj Riv Drv)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
21	8 Knots Tavern	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
22	Rowing Club	Economic	Moderate	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	L	L	M	H
23	Minor Infrastructure (bins,signage, shelters, fencing)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
24	Moorings	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
25	Cool Beans Café	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
26	Swan Yacht Club	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
27	Zephyr Cafe	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
28	Boat Ramp	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
29	Dinghy Storage	Economic	Minor	Average	Possible	Likely	Almost Certain	Almost Certain	M	M	H	H	M	M	H	H
30	Riverside Road	Economic	Major	Poor	Rare	Unlikely	Possible	Likely	L	M	H	E	M	H	E	E
31	Car parks – Public Car Park No 1 (Boat Ramp)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
32	Car parks – Public Car Park No 2 (John Tonkin North)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
33	Car parks – Public Car Park No 5 (Cool Beans)	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
34	Car parks - Public Car Park No 3 – Zephyr Café	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
35	Car parks – Swan Yacht Club	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
36	Car parks – Fremantle Rowing Club	Economic	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
37	Drainage features (pits, pipes, culverts, outlets)	Economic	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	General Cat.	Consequence	Adaptive Cap.	2035	2050	2075	2125	2035	2050	2075	2125	2035	2050	2075	2125
3	Riverwalls	Environmental														
3	Foreshore along Jerrat Drive	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
3	Beaches within Jerrat Drive escarpment	Environmental	Major	Average	Possible	Likely	Almost Certain	Almost Certain	H	E	E	E	H	E	E	E
3	Fremantle Sea Scouts building	Social	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
3	Beach access stairs to Jerrat Drive escarpment Beach	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
3	Department of Defence wharves	Economic														
3	East Fremantle Yacht Club Building	Economic	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
3	East Fremantle Yacht Club Lower Car Park, Boat Access Pathway	Economic	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
3	Jerrat Drive and road network	Economic	Moderate	Average	Rare	Rare	Unlikely	Possible	L	L	M	H	L	L	M	H
3	Boat ramps, moorings and jetties	Economic	Moderate	Good	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	M	H	H	H
3	Minor Infrastructure (bins, signage, shelters, fencing	Economic	Insignificant	Good	Possible	Likely	Almost Certain	Almost Certain	L	L	M	M	L	L	L	L
3	Carpark at Jerrat Drive	Economic	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
3	Drainage features (pits, pipes, culverts, stormwater outlets)	Economic	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E

D.2 Vulnerability – Inundation

		m AHD				Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence.	Adaptive Cap.	2035	2050	2075	2125	2035	2050	2075	2125	2035	2050	2075	2125
1	Road Reserve - Lower Merv Cowan (East Riv Drv)	1.5	Environmental	Minor	High	Rare	Unlikely	Likely	Almost Certain	L	L	M	H	L	L	L	M
1	Toilet Block - Lower Merv Cowan (East Riv Drv)	1.9	Environmental	Minor	Moderate	Rare	Rare	Rare	Likely	L	L	L	M	L	L	L	M
1	Riverside Road - Niergarup Reserve to Pier Street	1.2	Environmental	Moderate	High	Possible	Likely	Likely	Almost Certain	H	H	H	E	M	M	M	H
1	Riverside Road - Pier Street to Dome Café	1.4	Environmental	Moderate	High	Unlikely	Unlikely	Likely	Almost Certain	M	M	H	E	L	L	M	H
1	Riverside Road Dome Café to Stirling Bridge	1.4	Environmental	Moderate	High	Unlikely	Unlikely	Likely	Almost Certain	M	M	H	E	L	L	M	H
1	Riverside Road - Stirling Bridge to J Dolan Park	1.2	Environmental	Moderate	High	Possible	Likely	Likely	Almost Certain	H	H	H	E	M	M	M	H
1	J Dolan Park	1.0	Environmental	Insignificant	Moderate	Likely	Likely	Almost Certain	Almost Certain	L	L	M	M	L	L	M	M
1	Riverwalls protecting shoreline	1.0	Environmental	Minor	High												
1	Coastal Pathways - Niergarup Reserve to Pier Street	1.0	Social	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Coastal Pathways - Pier Street to Dome Café	0.9	Social	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Coastal Pathways - Dome Café to Stirling Bridge	0.8	Social	Minor	High	Likely	Almost Certain	Almost Certain	Almost Certain	M	H	H	H	L	M	M	M
1	Coastal Pathways - Stirling Bridge to J Dolan Park	0.9	Social	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Boat ramps, moorings, jetties	0.7	Social	Minor	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	M	M	M	M
1	Residential Properties - Riverside Rd / East St	2.3	Economic	Moderate	Moderate	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
1	Residential Properties - Riverside Rd / Pier St	2.8	Economic	Moderate	Moderate	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Marine Education Boatshed	1.1	Economic	Moderate	Moderate	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
1	Dome Café	1.5	Economic	Moderate	Moderate	Rare	Unlikely	Likely	Almost Certain	L	M	H	E	L	M	H	E
1	Minor Infrastructure (bins, signage, shelters, fencing)	1.0	Economic	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Carpark - Public Carpark No 4 (Dome Cafe)	0.8	Economic	Moderate	High	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	M	H	H	H
1	Carpark - J Dolan Park	0.9	Economic	Moderate	High	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	M	M	H	H
1	Left Bank	2.1	Economic	Moderate	Moderate	Rare	Rare	Rare	Likely	L	L	L	H	L	L	L	H
1	Playground Equipment – north of Dome Cafe	1.0	Economic	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Shelters, seating and picnic tables – J Dolan Park	1.1	Economic	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Shelters, seating and picnic tables – North of Dome Cafe	1.0	Economic	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
1	Drainage features (pits, pipes, culverts, stormwater outlets)	1.0	Economic	Minor	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M

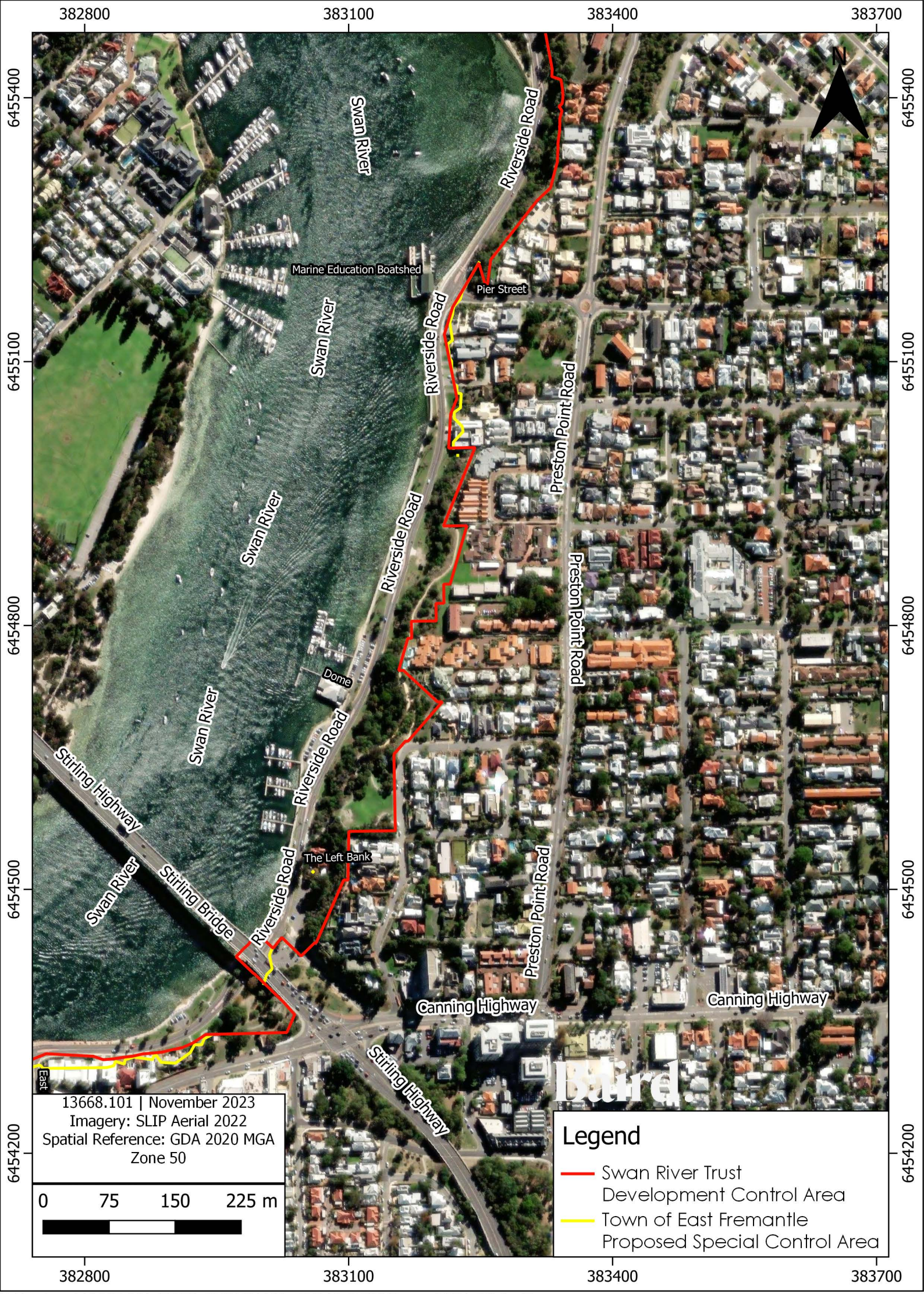
		m AHD					Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	Adaptive Cap.	2035	2050	2075	2125	2035	2050	2075	2125	2035	2050	2075	2125
2	Niergarup Reserve	0.8	Environmental	Minor	Good	High	Likely	Almost Certain	Almost Certain	Almost Certain	M	H	H	H	L	M	M	M
2	Coastal Pathway - John Tonkin Reserve	1.0	Environmental	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	Coastal Pathway - Norm McKenzie Park	1.1	Environmental	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	Norm McKenzie Park Foreshore Reserve Area	1.0	Environmental	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	Norm McKenzie Park - Playground	1.1	Environmental	Minor	Average	Moderate	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	M	M	H	H
2	Norm McKenzie Park - Roadside Shelter and BBQ	1.3	Environmental	Minor	Average	Moderate	Unlikely	Possible	Likely	Almost Certain	L	M	M	H	L	M	M	H
2	W Wayman Reserve - Foreshore Reserve Area	0.7	Environmental	Minor	Good	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	M	M	M	M
2	W Wayman Reserve - Pathway	1.1	Social	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	W Wayman Reserve - Shelter	1.1	Social	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	W Wayman Reserve - Exercise Equipment	1.3	Social	Minor	Average	Moderate	Unlikely	Possible	Likely	Almost Certain	L	M	M	H	L	M	M	H
2	Detached groyne field	0.2	Environmental	Minor	Good	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	M	M	M	M
2	John Tonkin Reserve - Playground	1.1	Environmental	Minor	Average	Moderate	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	M	M	H	H
2	John Tonkin Reserve - Gazebos	1.1	Environmental	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	Riverwalls protecting shoreline	1.0	Environmental	Minor	Good	High												
2	Navy Cadets	1.6	Social	Moderate	Average	Moderate	Rare	Rare	Possible	Almost Certain	L	L	H	E	L	L	H	E
2	Beach access pathways	0.7	Social	Minor	Good	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	M	M	M	M
2	Leeuwin Barracks - Existing Carpark / Builings	1.6	Economic	Moderate	Average	Moderate	Rare	Rare	Possible	Almost Certain	L	L	H	E	L	L	H	E
2	Leeuwin Barracks -Park Area Adjacent Riv Drv	1.4	Economic	Minor	Good	High	Unlikely	Unlikely	Likely	Almost Certain	L	L	M	H	L	L	L	M
2	Aquarama Marina (CarPark East Side)	1.1	Economic	Moderate	Good	High	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	M	M	H	H
2	Aquamarina Bulding (adj Riv Drv)	1.6	Economic	Moderate	Average	Moderate	Rare	Rare	Possible	Almost Certain	L	L	H	E	L	L	H	E
2	8 Knots Tavern	1.1	Economic	Moderate	Average	Moderate	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	E	E
2	Rowing Club	1.5	Economic	Moderate	Average	Moderate	Rare	Unlikely	Likely	Almost Certain	L	M	H	E	L	M	H	E
2	Minor Infrastructure (bins,signage, shelters, fencing)	1.0	Economic	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
2	Moorings	0.8	Economic	Minor	Good	High	Likely	Almost Certain	Almost Certain	Almost Certain	M	H	H	H	L	M	M	M
2	Cool Beans Café	1.5	Economic	Moderate	Average	Moderate	Rare	Unlikely	Likely	Almost Certain	L	M	H	E	L	M	H	E
2	Swan Yacht Club	1.6	Economic	Moderate	Average	Moderate	Rare	Rare	Possible	Almost Certain	L	L	H	E	L	L	H	E
2	Zephyr Cafe	1.8	Economic	Moderate	Average	Moderate	Rare	Rare	Unlikely	Likely	L	L	M	H	L	L	M	H
2	Boat Ramp	0.7	Economic	Minor	Good	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	M	M	M	M
2	Dinghy Storage	0.4	Economic	Minor	Good	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	M	M	M	M
2	Riverside Road	1.0	Economic	Moderate	Good	High	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	M	M	H	H
2	Car parks – Public Car Park No 1 (Boat Ramp)	1.1	Economic	Moderate	Good	High	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	M	M	H	H
2	Car parks – Public Car Park No 2 (John Tonkin North)	1.3	Economic	Moderate	Good	High	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	L	M	M	H
2	Car parks – Public Car Park No 5 (Cool Beans)	1.3	Economic	Moderate	Good	High	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	L	M	M	H
2	Car parks - Public Car Park No 3 – Zephyr Café	1.2	Economic	Moderate	Good	High	Possible	Likely	Likely	Almost Certain	H	H	H	E	M	M	M	H
2	Car parks – Swan Yacht Club	1.3	Economic	Moderate	Good	High	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	L	M	M	H
2	Car parks – Fremantle Rowing Club	1.2	Economic	Moderate	Good	High	Possible	Likely	Likely	Almost Certain	H	H	H	E	M	M	M	H
2	Drainage features (pits, pipes, culverts, outlets)	1.0	Economic	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M

		m AHD					Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	Adaptive Cap.	2035	2050	2075	2125	2035	2050	2075	2125	2035	2050	2075	2125
3	Riverwalls (Sea Scouts, East Fremantle Yacht Club)	1.0	Environmental	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
3	Foreshore along Jerrat Drive	1.0	Environmental	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
3	Beaches within Jerrat Drive escarpment	0.5	Environmental	Insignificant	Good	High	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Fremantle Sea Scouts building	1.6	Social	Moderate	Average	Moderate	Rare	Rare	Possible	Almost Certain	L	L	H	E	L	L	H	E
3	Beach access stairs to Jerrat Drive escarpment Beach	1.0	Social	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
3	East Fremantle Yacht Club Building	1.5	Economic	Moderate	Average	Moderate	Rare	Unlikely	Likely	Almost Certain	L	M	H	E	L	M	H	E
3	East Fremantle Yacht Club Lower Car Park, Boat Access Pathway	1.0	Economic	Moderate	Good	High	Likely	Likely	Almost Certain	Almost Certain	H	H	E	E	M	M	H	H
3	Jerrat Drive and road network	14.0	Economic	Minor	Good	High	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
3	Boat ramps, moorings and jetties	0.8	Economic	Minor	Good	High	Likely	Almost Certain	Almost Certain	Almost Certain	M	H	H	H	L	M	M	M
3	Minor Infrastructure (bins, signage, shelters, fencing, beach access stairs)	1.5	Economic	Minor	Good	High	Rare	Unlikely	Likely	Almost Certain	L	L	M	H	L	L	L	M
3	Carpark at Jerrat Drive	10.7	Economic	Moderate	Average	Moderate	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
3	Drainage features (pits, pipes, culverts, stormwater outlets)	1.0	Economic	Minor	Good	High	Likely	Likely	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M

Appendix E

Proposed Special Control Area

E.1 Proposed Special Control Area



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