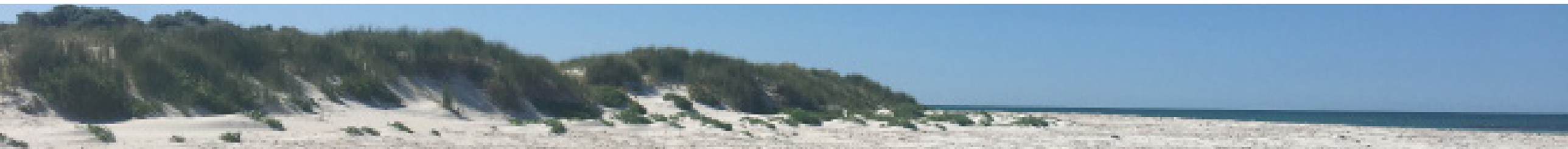
Coastal Management Plan 2021

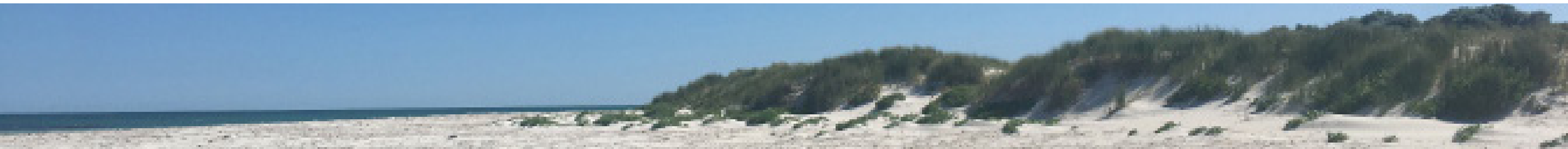
Environmental and Social Context

Document Control

Version	Modification	Justification	Author
1.0	June Draft		ZK
2.0	Final Draft		MS
3.0	Final Draft - Update	Minor Amendments	AC
4.0	Final Draft- Update	Minor Amendments	AC
5.0	Final Draft for ELM	Update of CMA terminology	ZK

Contents





1. Common Definitions

The following definitions apply to these words and phrases commonally through the report.

Physical process setback area:

The line set to show high risk of impact from erosion or inundation identified during the CHRMAP process. Development behind this line is at less risk of being impacted by erosion or inundation in the long term.

CHRMAP (Coastal Hazard Risk Management and Adaptation Plan):

A study that identifies the key hazards and assesses the risk to assets of coastal erosion and inundation.

Nodes:

Nodes are sites where recreational activities are focused. Coastal Management Plans designate nodes and rank them in a hierarchy according to their use. Specific nodes were also summarised in the Perth Coastal Recreational Use Study (Middle 2018).

Ecological Community

A naturally occurring biological assemblage that occurs in a particular type of habitat. Note: The scale at which ecological communities are defined will often depend on the level of detail in the information source, therefore no particular scale is specified.

A threatened ecological community (TEC)

is one which is found to fit into one of the following categories; “presumed totally destroyed”, “critically endangered”, “endangered” or “vulnerable”.

Possible threatened ecological communities that do not meet survey criteria are added to DEC’s Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

An assemblage

a defined group of biological entities.

Habitat

the areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (eg. substrate and topography), and the biotic factors.

Occurrence:

a discrete example of an ecological community, separated from other examples of the same community by more than 20 metres of a different ecological community, an artificial surface or a totally destroyed community.

By ensuring that every discrete occurrence is recognised and recorded future changes in status can be readily monitored.

Adequately Surveyed

“An ecological community that has been searched for thoroughly in most likelyhabitats, by relevant experts.”

Community structure

“The spatial organisation, construction and arrangement of the biological elements comprising a biological assemblage” (eg. Eucalyptus salmonophloia woodland over scattered small shrubs over dense herbs; structure in a faunal assemblage could refer to trophic structure, eg. dominance by feeders on detritus as distinct from feeders on live plants).

Modification:

“changes to some or all of ecological processes (including abiotic processes such as hydrology), species composition and community structure as a direct or indirect result of human activities. The level of damage involved could be ameliorated naturally or by human intervention.”

Destruction:

“modification such that reestablishment of ecological processes, species composition and community structure within the range of variability exhibited by the original community is unlikely within the foreseeable future even with positive human intervention.”

Threatening processes

“Any process or activity that threatens to destroy or significantly modify the ecological community and/or affect the continuing evolutionary processes within any ecological community.”

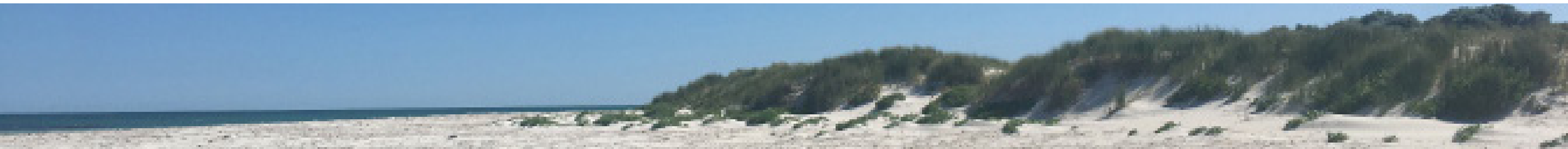
Examples of some of the continuing threatening processes in Western Australia include: general pollution; competition, predation and change induced in ecological communities as a result of introduced animals; competition and displacement of native plants by introduced species; hydrological changes; inappropriate fire regimes; diseases resulting from introduced microorganisms; direct human exploitation and disturbance of ecological communities.

Restoration

returning an ecological community to its pre-disturbance or natural state in terms of abiotic conditions, community structure and species composition.

Rehabilitation

the re-establishment of ecological attributes in a damaged ecological community although the community will remain modified



2. General Management

This section discusses those elements that are not subject to a specific action but provides guidance for those developing foreshore areas in the future. These considerations should be included as part of Structure Plan FMPs or as part of City led coastal access or management initiatives.

Access

A public road should be provided along the majority of the boundary to provide a clear delineation between the foreshore reserve and private land. Parking should be provided at strategic locations near to dedicated beach access points but avoided where access is intended to be restricted.
Emergency vehicle beach access and Universal Access should be considered where relevant and/or possible.

Paths and networks

A linear Dual-Use Path (DUP) should be provided along the length of the foreshore reserve, with a minimum 3 metre width. Opportunities for pathways to the beach or to ocean lookouts are encouraged, and elevated boardwalks or composite timber decking that is hardy and easy to maintain will be preferred.

Limiting uncontrolled access

FMPs should identify preferred access points and otherwise control access through the foreshore through the use of fencing and bollards if necessary, to avoid dune erosion and maintain the natural environment.

Security and lighting

Crime Prevention Through Environmental Design (CPTED) principles should be applied to coastal nodes and access points.

Fencing

Fencing should be provided along the foreshore reserve to restrict access in accordance with the City of Wanneroo fencing requirements.

Aboriginal heritage management

Aboriginal connections and cultural values are extensive for the whole section of coast with cultural connections identified between all CMAs. The sensitivity of these connections and sites should be explored through reference to local traditional owners to explore appropriate methods of recognition, celebration and acknowledgement.

Bushfire management

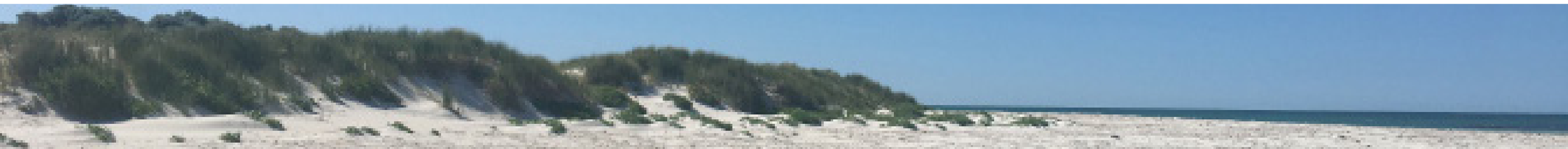
Planning for Bush Fire Protection (WAPC 2010) and the recently released draft Planning for Bushfire Risk Management Guidelines (WAPC 2014) should be used as a guideline in the subdivision approval process and/or during development planning.

Implementation, Developer Maintenance and Handover

Any FMP should also include details of implementation, developer maintenance and handover, including management of any leases and provision of any bonds.

Coastal hazard risk adaptation

Coastal assets such as paths and shelters can be approved as temporary development in accordance with the State Coastal Planning Policy Guidelines (WAPC 2013). FMPs should clearly identify those structures that are temporary and provides an adaptation or retreat plan for the asset life cycle.



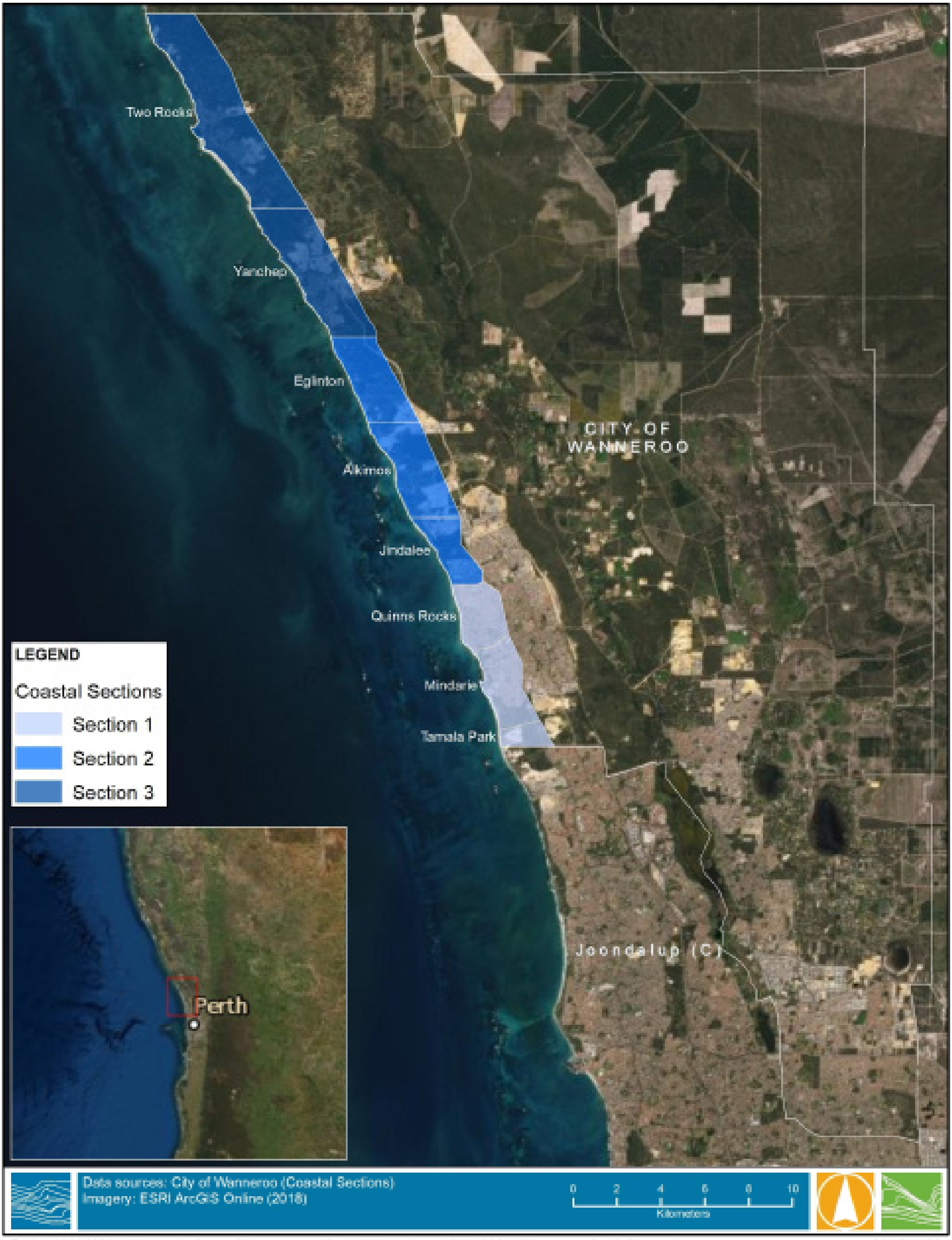


Figure 5.1 – City of Wanneroo Coastal Sectors

4. Introduction

Aim

The City of Wanneroo (City) is undertaking an analysis of the coastal foreshore's environmental, social, and cultural heritage context to support coastal planning and management activities for 2020-2035. The review will guide decision making around future infrastructure development and environmental management of the coastline. The resulting Coastal Management Plan 2020 (CMP) comprises two Sections:

- CMP 2020 - focusing on the strategy and action plan that is to address the key issues and opportunities identified along the City's coastal reserves – (undertaken internally by City).
- Technical Summary - focusing on background information of the coastline's environmental and social environment (assisted by a coastal consultancy team) – the focus of this document.

Objectives

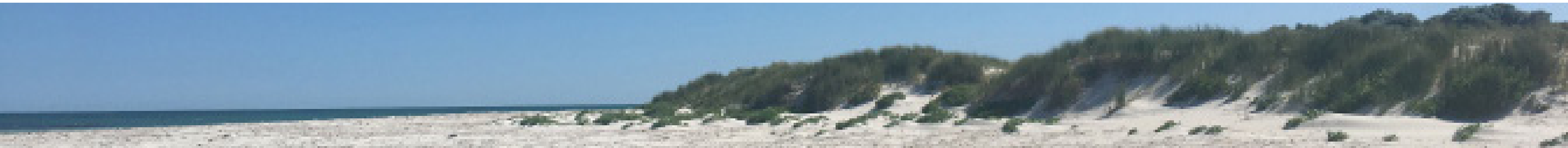
The objectives of Technical Summary of the Coastal Management Plan are to:

- Identify key coastal risk issues, values and physical characteristics that may impact coastal planning and management.
- Review and understand available information and identify key coastal processes for each of the management CMAs: Mindarie to Quinns Rocks; Jindalee to Eglinton; and Yanchep to Two Rocks.
- Provide advice on coastal hazard risk, potential knowledge gaps, future data collection requirements and ongoing actions.

Study Area

The study area for the Coastal Management Plan is the City's 32km of coastline extending from Mindarie to Two Rocks as shown in Figure 5.1. The three CMAs are further split into eight subSections:

- Mindarie to Quinns Rocks (Mindarie, Quinns Rocks);
- Jindalee to Eglinton (Jindalee, Alkimos, Eglinton); and
- Yanchep to Two Rocks (Yanchep, Two Rocks).



5. Coastal Processes

5.1 Key Documents

The following is a summary of key documents reviewed for the Technical Summary of the Coastal Management Plan (CMP), with a focus on information regarding physical coastal processes. The geographical relevance of each document is also shown in Table 5.1 below. All of these documents have been reviewed during the preparation of the CMP and consist of regional studies and policies, Foreshore Management Plans (FMPs – both regional and local) and Structure Plans (district and local) as well as other relevant reports.

City-wide Coastal Studies

- CoW – CHRMAP 2018
- CoW – CMP Part 1
- CoW – Strategic Community Plan 2017/18 – 2026/27
- CoW – Local Environmental Strategy 2019
- CoW – Local Planning Policy 4.21 Coastal Assets

Regional FMPs

- Mindarie – Quinns Rocks FMP
- Two Rocks – Yanchep FMP

Local FMPs

- Catalina Estate
- Lot 1 Mindarie
- Lot 12 Jindalee
- Lot 9 Jindalee
- North Alkimos
- Amberton Estate
- Capricorn

Structure Plans

- Alkimos Eglinton District Structure Plan (DSP)
- Butler – Jindalee DSP
- Yanchep – Two Rocks DSP
- Jindalee North - Local Structure Plan 88
- Jindalee Coastal Village Agreed - Local Structure Plan
- Eglinton - Local Structure Plan 82
- Capricorn Coastal Node – Structure Plan 75
- Lot 12 Jindalee Coastal Village – Agree Local Structure Plan
- North Alkimos – Local Structure Plan 73
- South Alkimos – Local Structure Plan 72
- Two Rocks – Local Structure Plan
- Two Rocks Town Centre Structure Plan
- North Two Rocks - Local Structure Plan 91 – Part 1 Statutory Report
- Yanchep South – Local Structure Plan 19
- South Yanchep Local Structure Plan 66

Additional Data and Information

The list below summarises all other additional data sets, and information that was utilised in compiling the document:

- City of Wanneroo – Coastal Management webpage text, photos, and linked documents were reviewed and some documents subsequently review in detail.
- Quinns Beach Long Term Coastal Management: Stage One
- Quinns Beach Long Term Coastal Management: Stage Two
- Quinns Beach Long Term Coastal Management: Stage Three
- Quinns Foreshore Master Plan
- Other Quinns Beach documents regarding coastal management
- City of Joondalup Coastal Infrastructure Adaptation Plan 2018-2026
- Two Rocks Coastal Management Reports
- Two Rocks Geophysical infill survey Western Australia
- Two Rocks – Wrack monitoring Program
- Two Rocks Marina Master Plan
- GIS layers of Sediment cells
- CHRMAP erosion and inundation hazard lines from CHRMAP Part 1: Coastal Vulnerability Study & Hazard Mapping report
- Coastal structures asset management information
- Rottnest wave data summary analyses
- Perth Metropolitan coastal sediment cell information
- Coastal hazard risk management and adaptation planning guidelines
- Assessment of coastal erosion hotspots in Western Australia

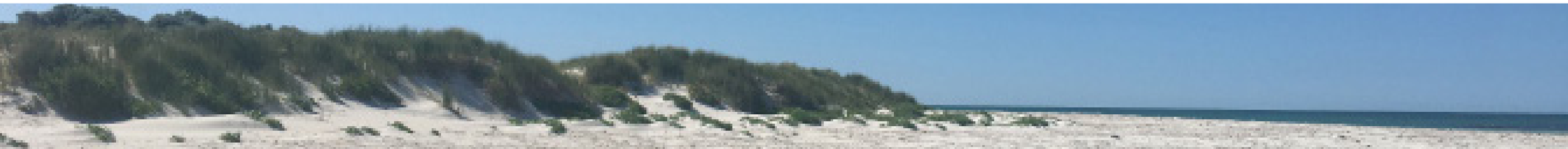
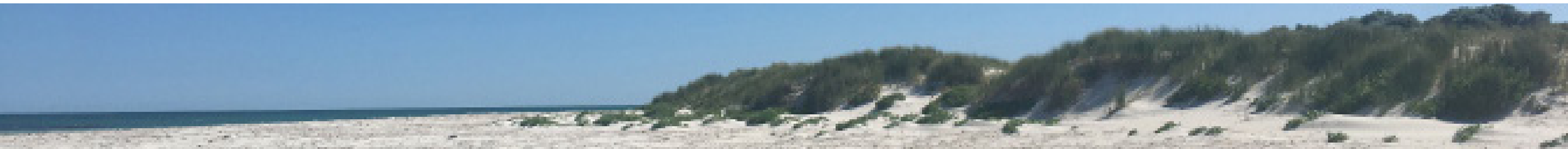


Table 5.1 summarry of relevant and available coastal documents by the geographical area they apply to. Organised by coastal CMA, subSection, and sediment cell, as well as areas beyond City's coastline.

Primary Section	SubSection	Sediment cells	Documents
Yanchep / Two Rocks	Two Rocks	R06H 30b & 31a & R06I 32a, 32b &32c	Two Rocks – Yanchep FMP Two Rocks Geophysical infill survey Western Australia Two Rocks Coastal Management (several documents) Yanchep – Two Rocks DSP Two Rocks – Wrack Monitoring Program North Two Rocks - Local Structure Plan 91 Two Rocks – Local Structure Plan Two Rocks Town Centre Structure Plan
Yanchep / Two Rocks	Yanchep	R06H 30a & 30b	Two Rocks – Yanchep FMP Capricorn Yanchep FMP Yanchep – Two Rocks DSP Capricorn Coastal Node – Structure Plan 75 South Yanchep Local Structure Plan 66 Yanchep South – Local Structure Plan 19
Jindalee / Eglinton	Eglinton	R06G 29d	Amberton Estate FMP Alkimos Eglinton DSP Eglinton - Local Structure Plan 82
Jindalee / Eglinton	Alkimos	R06G 29c & 29d	North Alkimos FMP Alkimos Eglinton DSP North Alkimos – Local Structure Plan 73 South Alkimos – Local Structure Plan
Jindalee / Eglinton	Jindalee	R06G 29c	Lot 12 Jindalee FMP Lot 9 Jindalee FMP Butler – Jindalee DSP Jindalee North – Local Structure Plan 88 Jindee Coastal Village Agreed - Local Structure Plan Lot 12 Jindalee Coastal Village – Agree Local Structure Plan
Mindarie / Quinns Rocks	Quinns Rocks	R06G 29b	Mindarie – Quinns Rocks FMP Quinns Beach Coastal Management (several documents) Pool Location Assessment – Quinns Beach Ocean Pool Feasibility Study
Mindarie / Quinns Rocks	Mindarie	R06G 29a	Mindarie – Quinns Rocks FMP Lot 1 The Wharf, Mindarie FMP
Mindarie / Quinns Rocks	Mindarie	R06G 29a	Catalina Estate FMP
Whole of City's coastline	n/a	R06I R06H R06G	Coastal Management Plan Part 1 City CHRMAP (several documents) Strategic Community Plan 2017/18 – 2026/27 Local Environmental Strategy 2019 Local Planning Policy 4.21 Coastal Assets Coastal Feasibility Studies
Perth Metro Area	n/a	R06I to R06C	City of Joondalup Coastal Infrastructure Adaptation Plan 2018-2026 Rottnest wave data summary 1994-2008
W.A. Coast	n/a	n/a	State Planning Policy 2.6 – State Coastal Planning Policy State Coastal Planning Policy Guidelines Sea Level Change in Western Australia – Application to Coastal Planning Coastal Sediment Cells for the Vlamingh Region between Cape Naturaliste and Moore River, Western Australia



5.2 COASTAL PROCESSES

5.2.1 Context Introduction

The City's coast consists of sandy beaches and Tamala limestone rock outcrops backed by coastal dune systems and land development, primarily residential. The nearshore coastal zone is characterised by rocky limestone reefs supporting macroalgae (seaweed communities) and associated areas of shallow sand-based benthic habitats dominated by seagrass communities. The limestone reef chains provide significant, but inconsistent wave sheltering to the coastline. Seasonal weather patterns drive changes to beach width, being wider in summer and narrowing in winter due to storm erosion. Sediment transport processes are complex due to the highly variable bathymetry associated with variable nearshore reef chains.

5.2.2 Metocean Climate

Metocean climate refers to the atmospheric and oceanic processes that influence the active coastal zone and associated land formations, both nearshore and onshore. The tides, winds and storms drive changes in water level, wave energy, wave directions and local currents, which interact with local bathymetry to mobilise sand and erode rock to create the coastal landforms both under and above the sea surface. A desktop review of the local metocean climate for the City's coast has been undertaken and is summarised below.

Tides and Water Levels

The City coastline is subject to a micro-tidal climate, having a maximum tidal range of 1.16m (DPI, 2007). This is a small range in global terms and means that non-tidal drivers of sea level change are much more important here than at locations with larger tidal ranges.

Variations in water level are caused not only by the astronomical tides, but also by phenomena such as wind setup, wave setup and atmospheric pressure. Wind blowing over the surface of the water causes water to "pile up" against the coast towards which the wind is blowing (wind setup). Wave dissipation and breaking also causes water to "pile up" against the coast (wave setup). Atmospheric pressure leads to local changes in sea level, with high pressure lowering the sea level and low pressure increasing sea level, a process referred to as the inverse barometric effect.

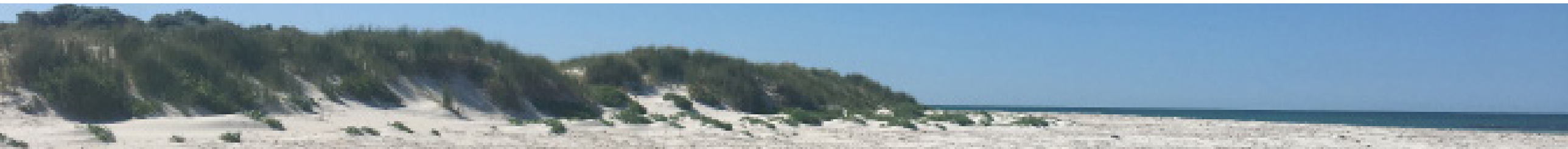
Table 5.2 – Summary of astronomical tide ranges at Two Rocks Marina (DoT, 2018).

AHD (m)	Tidal Plane	Chart Datum (m)
0.52	Highest Astronomical Tide (HAT)	1.39
0.27	Mean Higher High Water (MHHW)	1.14
0.17	Mean Lower High Water (MLHW)	1.04
0	Australian Height Datum (AHD)	0.87
-0.07	Mean Sea Level (MSL)	0.80
-0.31	Mean Higher Low Water (MHLW)	0.56
-0.41	Mean Lower Low Water (MLLW)	0.46
-0.63	Lowest Astronomical Tide (LAT)	0.24

Table 5.3 – Summary of astronomical tide ranges at Fremantle Fishing Boat Harbour (DoT, 2010).

AHD (m)	Tidal Plane	Chart Datum (m)
0.6	Highest Astronomical Tide (HAT)	1.36
0.22	Mean Higher High Water (MHHW)	0.98
0.04	Mean Lower High Water (MLHW)	0.8
0	Australian Height Datum (AHD)	0.76
0	Mean Sea Level (MSL)	0.76
-0.09	Mean Higher Low Water (MHLW)	0.67
-0.21	Mean Lower Low Water (MLLW)	0.55
-0.55	Lowest Astronomical Tide (LAT)	0.21

There are numerous other oceanic processes that can cause local variations in sea level at the coast. All these mechanisms combine, resulting in observed water level deviations from astronomical tides. They are often grouped under the term "storm surge" since their combined effects are greatest during a storm event (Cardno, 2013). The City's small tidal range means that non-tidal drivers of sea level change (storm surge) are much more important drivers of coastal processes than at locations with larger tidal ranges.



In the Perth region, the majority of storm surges arise in relation to strong winter storms moving out of the Southern Ocean. Significant summer storms and tropical cyclones, while possible, are very rare. Only two of the most severe events in the last 20 years have occurred outside of the May to July period. One of these, the equal fifth largest storm surge event (at Hillarys), was tropical cyclone Bianca, which crossed the coast near Perth as a tropical low on the 30th of January 2011 (Cardno, 2013). The higher water levels associated with winter storms are significant because they allow high-energy waves from the same storms to propagate into the foredunes and erode them away.

Water level records from both Two Rocks and Hillarys Marinas have been analysed for extreme events and values for various return intervals are presented in Table 5.4.

Table 5.4 Summary of extreme water level analysis for Two Rocks and Hillarys Marinas based on the observed records from 1999 to December 2018 (Water Technology, 2020)

Average Return Interval (years)	Water Level (m AHD) at Two Rocks Marina	Water Level (m AHD) at Hillarys Marina
1	0.74	7.83
10	0.93	1.02
50	1.04	1.13
100	1.09	1.15

Sea level rise will be another significant contributor to local water levels along the city's coastline and is discussed separately in Section 5.3.

Winds, Waves and Currents

Winds

At the synoptic scale, the wind regime is largely determined by the seasonal position of the Subtropical High-Pressure Belt. During summer, the Belt is centred between 35 and 40 degrees south (i.e. south of the study area). During this time, the study area experiences winds largely from the southwest and east as a result of winds rotating anticlockwise around high-pressure cells (Ecoscape, 2004).

During winter, the Subtropical High Pressure Belt is situated between 25 and 30 degrees south (i.e. north of the study area). This results in storm force winds from the northwest, west and southwest being experienced in the region under the influence of low pressure cells (Ecoscape, 2004).

Cardno (2013) reviewed wind data from the Bureau of Meteorology (BoM) for Swanbourne and Ocean Reef. The data extended from December 1993 to December 2012 for Swanbourne, and October 1996 to December 2012 for Ocean Reef. A wind rose for both these sites is displayed in Figure 5.2. For both sites, the dominant wind direction is from the east through to the south-southwest quadrants. Wind speeds generally range from 3.6 - 7.7 m/s but can be up to 24.2 m/s. Summer is dominated by strong southerlies and easterlies, with minimal wind coming from the west to the northeast. Winter consists of light north to north-easterlies and very strong winds from the west associated with winter storm events. Autumn and spring are generally a transition between the two wind patterns, with strong winter easterlies continuing to a lesser extent in spring (Cardno, 2013).

The strong westerly winds from winter storms create high-energy erosive sea-waves and high storm surge induced water levels which can significantly erode beaches and dunes.

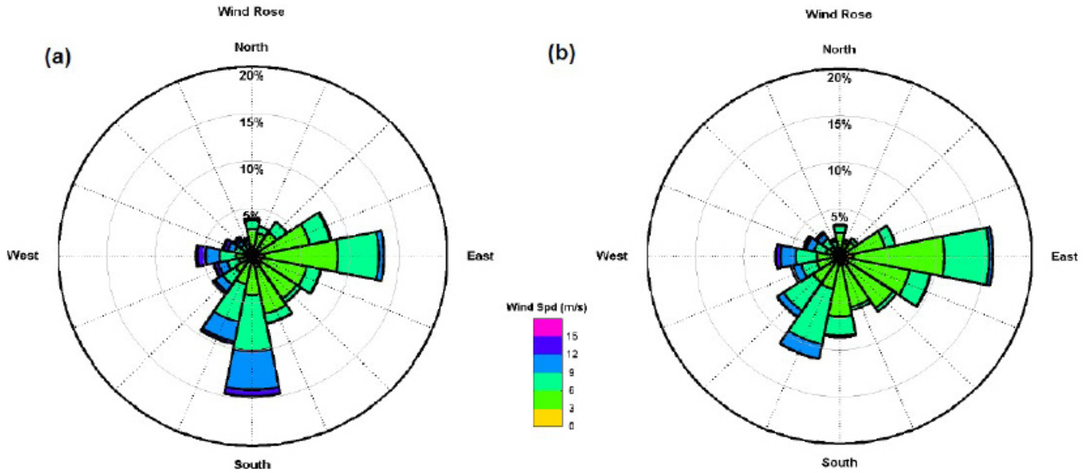
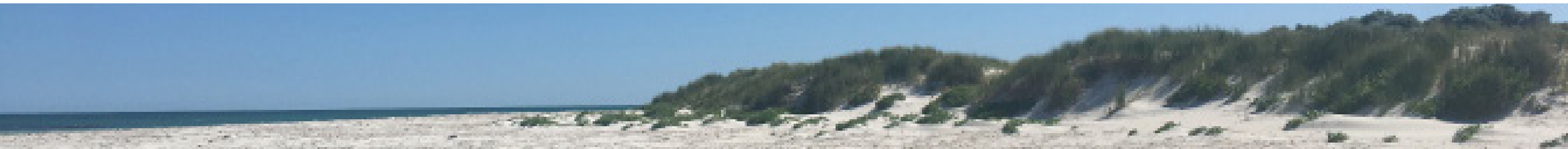


Figure 5.2 – (a) Ocean Reef wind rose (1996-2012) and (b) Swanbourne (1993-2012) – from Cardno (2013).

Waves and Currents

Offshore wave data collected west of Rottnest Island in a location with 50m water depth is presented in Figure 5.3 (DoT, 2009). Typically, offshore wave heights are around 0.5 to 3.0m, but maximum wave heights greater than 9.0m have been observed. Similarly, Figure 5.4 displays a summary of offshore wave period (the time between two wave crests) with typical values between 10s and 16s.



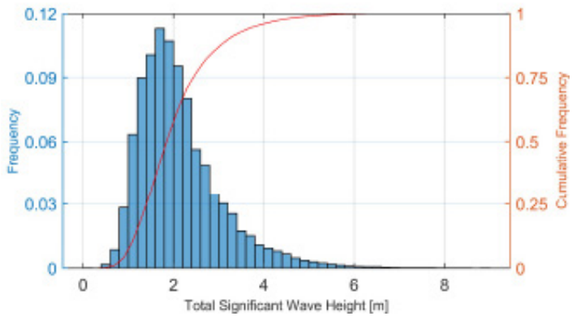


Figure 5.3 – Total significant wave height occurrence and exceedance distribution for 1999-2020 .from Rottnest wave buoy (Water Technology, 2020).

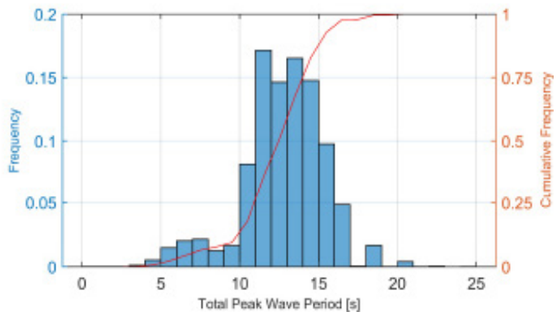


Figure 5.4 – Peak period occurrence and exceedance distribution for 1999-2020 from Rottnest wave buoy (Water Technology, 2020).

Figure 5.5 summarises the offshore wave direction of swell waves (greater than 8s period) with most waves coming from the west-southwest. Figure 5.6 shows similar information for sea waves (less than 8s period) with most waves from the southwest and south-southwest directions. Both figures summarise the significant wave height, Hs, which is the average wave height of the highest third of measured waves in a given period.

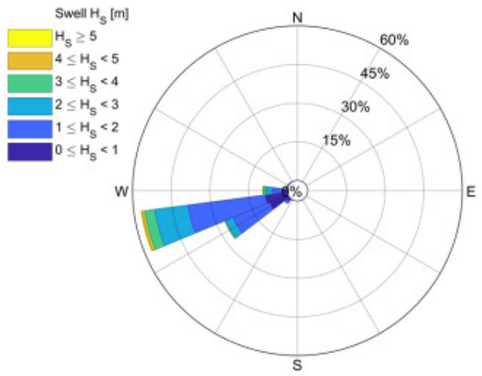


Figure 5.5 – Wave rose summary for significant wave height (Hs) and direction of swell waves for 2004 to May 2020 from Rottnest wave buoy (Water Technology, 2020).

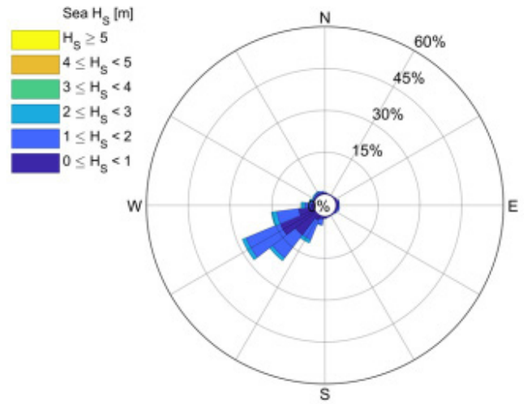


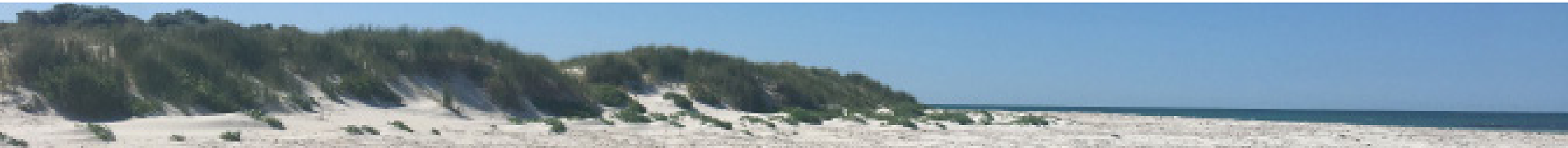
Figure 5.6 – Wave rose summary for significant wave height (Hs) and direction of sea waves for 2004 to May 2020 from Rottnest wave buoy (Water Technology, 2020).

The offshore wave climate at Rottnest applies to the whole Perth metropolitan area because there are no significant features for incoming ocean waves to interact with west of 50m depth. The waves observed offshore interact with the local bathymetry of the city's coastline, reef chains and seagrass beds, etc., to result in a complex nearshore wave climate which can transport sand and drive changes to beach morphology and rock formations.

Table 5.5 summarises extreme wave height analysis of the Rottnest wave buoy record from 1999-2018, presenting values for various return intervals.

Table 5.5 Summary of extreme wave analysis for Rottnest wave buoy based on the observed wave records from 1999 to December 2018 (Water Technology, 2020).

Average Return Interval (years)	Wave Height (m) at Rottnest wave buoy
1	7.1
10	8.3
50	9.1
100	9.4



Cardno (2015) analysed nearshore wave and current data collected by the City at two locations in the proximity of Quinns Beach (Figure 5.7). Although this is only a small dataset from one part of the city's coast it is representative of the complexity of the nearshore bathymetry and metocean conditions which work shape the coastline.

The instruments were deployed for a summer period (22 January 2014 – 30 April 2014) and a winter period (28 June 2014 – 16 October 2014). The 'Offshore' instrument was located approximately 3.4km west of Quinns Beach at a depth of approximately -14 m AHD, between Staggie Reef Ridge and Marmion Reef Ridge. The 'Inshore' instrument was located approximately 650m offshore at a depth of approximately -5.5 m AHD, midway between Quinns Rocks and the shoreline.

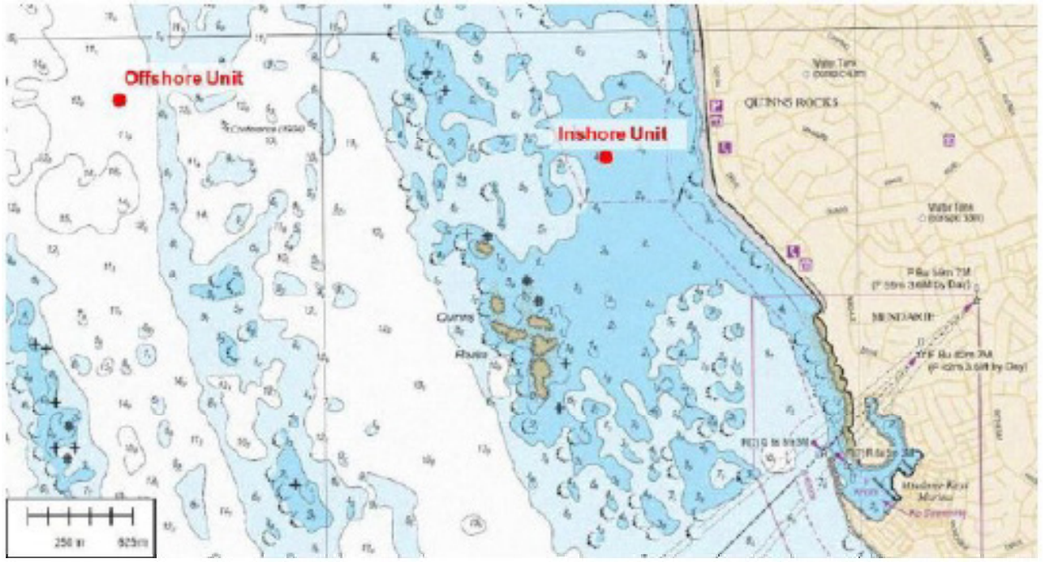


Figure 5.7 - Metocean data collection locations for summer and winter 2014.

Figures 5.8, 5.9, 5.10 and 5.11 present the results of the wave and current data analyses (Cardno 2015). The wave directionality at the inshore location mirrors that of the offshore location, but the wave heights were noticeably reduced. This is because of the wave sheltering provided by the fringing reefs which cause larger waves to shoal and often break before they reach the nearshore zone.

One noticeable feature of the data is the slight transformation of winter wave direction to the southwest between the offshore and inshore observations. This is a result of the waves interaction with the shallow reefs via the processes of refraction and diffraction.

Currents at the offshore location were typically less than the inshore location in summer, with both from similar north-westerly directions. In winter, the offshore location experienced stronger currents and directions at both sites were highly variable.

As waves approach the shoreline, they undergo a process of transformation whereby their energy is reduced and prevailing directional modified by the seabed. These wave transformation processes include (Ecoscape, 2004):

- Reflection off shallow reefs and emergent rocks, such as Quinns Rock;
- Depth limited breaking on reefs and in shallow areas;
- Diffraction through gaps in the reefs;
- Attenuation due to turbulence induced by the reefs and shallow sand; and
- Refraction and shoaling as bathymetry shallows.

It is clear from the data how complicated and variable the nearshore wave and current conditions can be, which is what makes prediction of wave behaviour at the coastline a complicated undertaking. Subsequently, it is very difficult to predict which foreshore areas will erode or accrete during certain weather events, or which areas may change significantly over future decades.

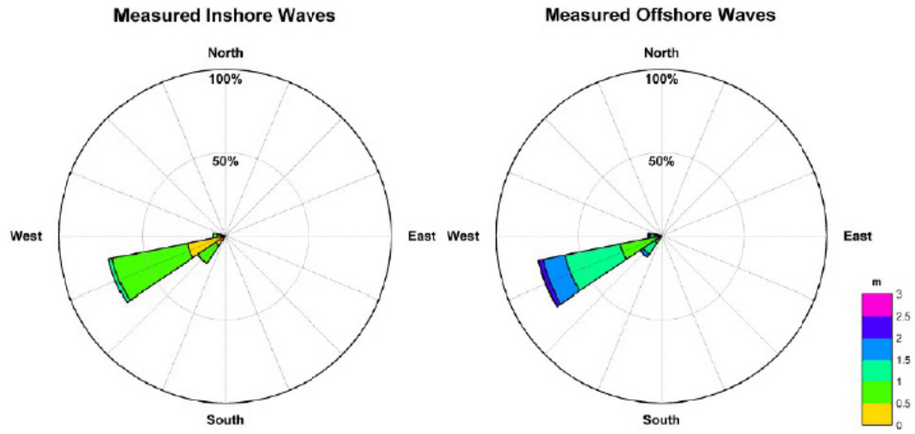
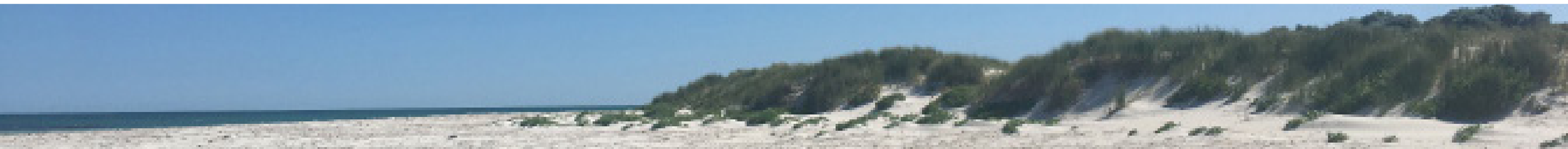


Figure 5.8 - Wave rose plots of the measured wave height (in metres) and wave direction for the summer data collection period at the Inshore and Offshore AWAC locations.



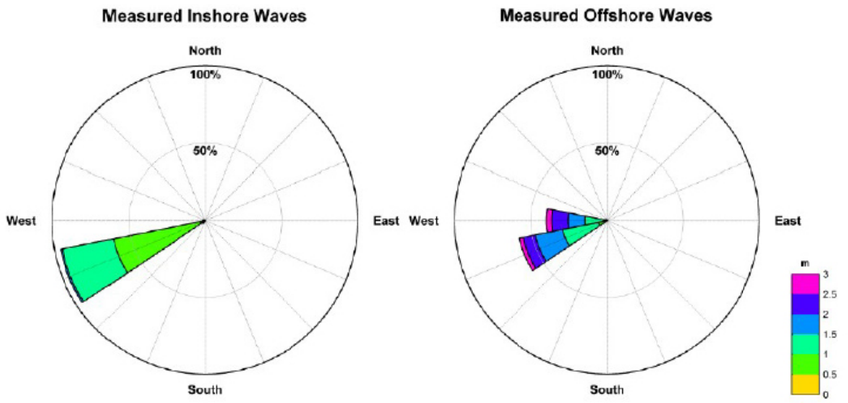


Figure 5.9 - Wave rose plots of the measured wave height (in metres) and wave direction for the winter data collection period at the Inshore and Offshore AWAC locations.

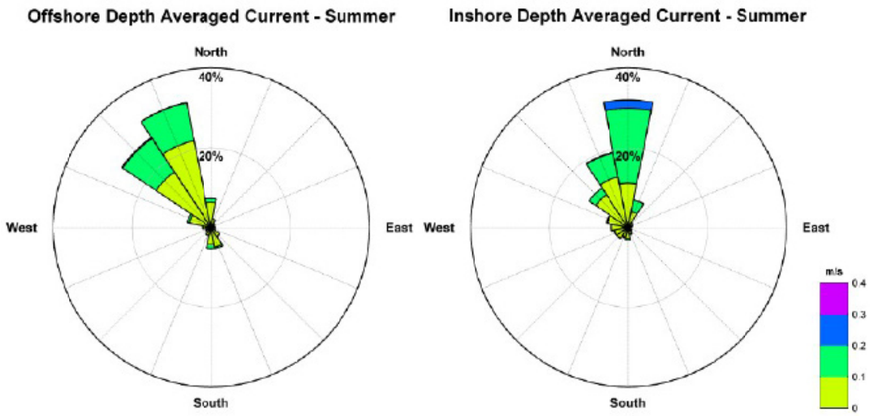


Figure 5.10 - Summer depth averaged current roses for the Offshore and Inshore AWAC locations.

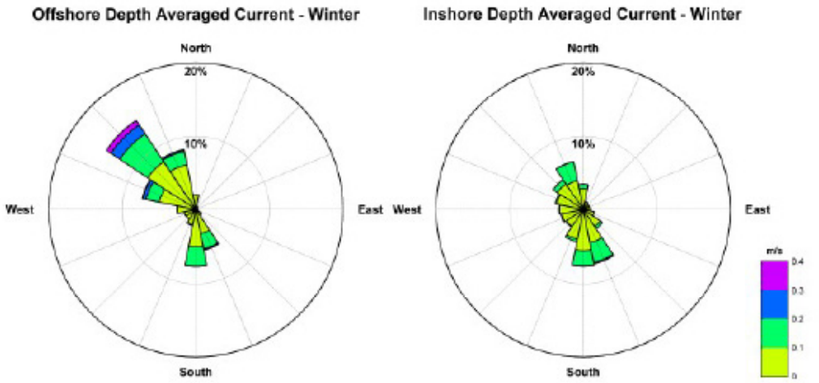
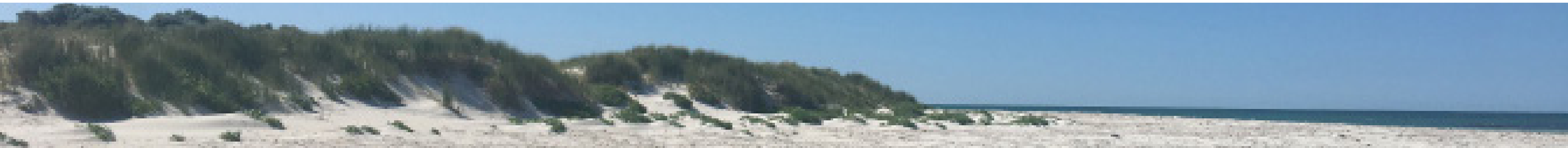


Figure 5.11 – Winter depth averaged current roses for the Offshore and Inshore AWAC locations.

The City has also undertaken the collection of wave and water level data just offshore of the Quinns Rocks dog beach and Mindarie Marina:

- The dog beach measurements were recorded approximately 200 m offshore in 7.9 m water depth from 1/7/2015 to 9/10/2015 to help inform coastal management works in the area (Cardno, 2017).
- Data at Mindarie Marina were collected as part of a study to investigate potential maintenance and upgrade options for the marina breakwater. The data were collected from 14/5/2019 to 26/7/2019, approximately 300 m west of the Marina in 9.2 m of water (Water Technology, 2020).



5.2.3 Surface Water and Groundwater Resources

Hydrometeorology

The City of Wanneroo experiences a Mediterranean climate, within the southwest of Western Australia, classified for its typically hot, dry summers and mild, wet winters. The majority of rainfall occurs in winter months (May to September) as cold fronts associated with low pressure systems bring heavy rain to the region. In the warmer months (October to April) the Subtropical High Pressure Belt moves south and significantly reduces rainfall in the region. Occasionally, during summer and autumn, tropical cyclone systems may migrate southward and bring strong winds and rainfall to the study area.

The Wanneroo rainfall station opened in 1905 and has a long-term average rainfall of 792 mm. In more recent years the station average is 705 m (1995 to 2019). For comparison average annual rainfall at Swanbourne (south of study area) is 728 mm (1993 to 2019) and at Gingin it is 620 mm (1996 to 2016) [Bureau of Meterorology, 2020]. Winter rainfall often exceeds 100 mm in a month while monthly summer rainfall is often 0 mm. Monthly summer rainfalls of over 50 mm are possible. Average annual rainfall over the Perth region has declined by over 10% since the mid-1970's [IOCI, 2009].

The weather station at Gingin, approximately 30 km inland of the study area, provides good long-term climate and rainfall records, which demonstrate the strong seasonality in rainfall patterns (Figure 5.12).

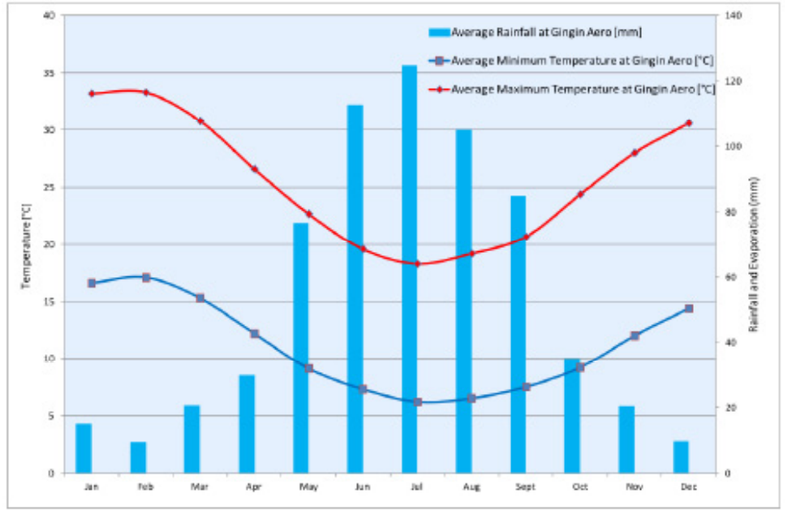


Figure 5.12 – Monthly average temperature and rainfall data for BoM weather station Gingin Aero (1996 – 2018). Image from Capricorn Yanchep Foreshore Management Plan (Strategen Environmental, 2018).

Surface Water

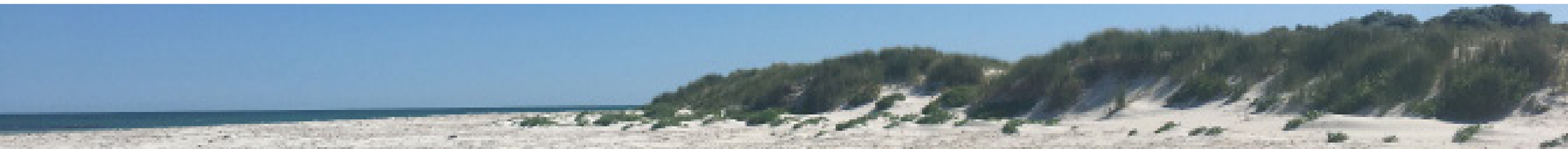
There are no known significant surface water features within the City of Wanneroo CMP study area.

Groundwater

The Wanneroo foreshore is characterised by sandy, unconsolidated fine to coarse grained calcareous soils of the Quindalup Dune system, overlying Tamala limestone. The soil is highly permeable and karst features are known to occur within the local limestone. On undeveloped land a very high proportion of rainfall infiltrates into the sandy soils, with approximately 10 to 20% of total rainfall converted to groundwater recharge (Davidson, 1995). Infiltration testing conducted in 2013 and 2015 within the Amberton Estate foreshore indicated high levels of infiltration, ranging from 19.3 – 62.2 m per day (typically above 38 m per day) [Emerge Associates, 2016].

The Wanneroo foreshore is a discharge area for the Gnangara Mound, the superficial (unconfirmed groundwater system that is bounded to the north by Gingin Brook, to the south by the Swan River to the east by Gingin Scarp and Ellen Brook and west the Indian ocean. The Gnangara Mound (North and South) covers an area of approximately 2140 km2.

Regional groundwater mapping on the Perth Groundwater Atlas indicates groundwater heights ranging from 0 m AHD (mean sea level) at the coastal boundary up to 1-2 m AHD on the inland boundary of the study area (DoW, 2020). Groundwater flow is in a westerly direction towards the ocean, with salinity increasing with proximity to the coast. The Perth Groundwater Atlas indicates groundwater with high salinity within the foreshore study area close to the coast (7000 mg/l total dissolved salinity).



5.2.4 Coastal Geomorphology & Sediment Cells

Geomorphology overview

The City's coastal geomorphology can generally be characterised by its:

- Complex response to the spatially variable nearshore wave climate. The presence of discontinuous offshore reefs/rocks modifies waves as described above, leading to variable shoreline morphology.
- Numerous structural controls that punctuate the shoreline, including Mindarie Marina, Two Rocks Marina and particularly along Quinns Beach - which contains groynes, an artificial headland and long-term management requirements (sand nourishment, dune maintenance etc.).

Most of the City's shoreline is comprised of Safety Bay Sands overlaying Tamala limestone, which can outcrop inconsistently along coastline resulting in pocket perched beaches and small areas of rocky shoreline (Cardno, 2012). The older Pleistocene Tamala limestone and associated surface solids are covered inconsistently, most prominently in the west by a series of younger Holocene sand dune deposits (EDC et al., 2015). The sand dune systems are Spearwood and Quindalup dune complexes. The coastline has numerous salients and cuspate forelands associated with prominent Sections of reef (Cardno 2015).

The City's coast features a range of distinctive geomorphic landforms that run in a north to south direction roughly parallel to the coast. These landforms contribute to distinct landscapes, varied native vegetation types, and distinct 'sense of place' (CoW, 2019). They include:

- The Quindalup Dunes – located adjacent to the coast across most of the City's length. These dunal soils are mainly young, infertile sandy soils lying over older Tamala Limestone. Soils of the Quindalup dunes are free draining and easily eroded by wind.
- The Spearwood Dunes – located further inland, are older than the Quindalup Dunes. Soils here tend to be more fertile, consisting of yellow to brown sands overlying limestone. They feature limestone ridges, with distinct native vegetation cover.

Parabolic dunes occur frequently along the City's coastline. They are sand dunes that appear u-shaped from above and are convex in the downwind direction. The arms of the dunes can develop subsidiary smaller blowouts and parabolic dunes (CoW, 2007).

Table 5.6 – Summary of relevant geomorphological information by coastal CMA.

Primary Section	Notable geomorphic features
Yanchep / Two Rocks	Parabolic dunes are common. Shore parallel dune ridges common in areas of sediment accretion driven by wave and wind action.
Jindalee / Eglinton	Boreholes suggest suitably continuous elevated limestone rock is present under foreshore dunes to provide long-term protection of the shoreline, if sand is eroded in future (EPCAD, 2013).
Mindarie / Quinns Rocks	Quinns Beach is a cuspate foreland that has formed as a result of the presence of Quinns Rocks in combination with shallower Sections of the Staggie and Marmion Reef Ridges.

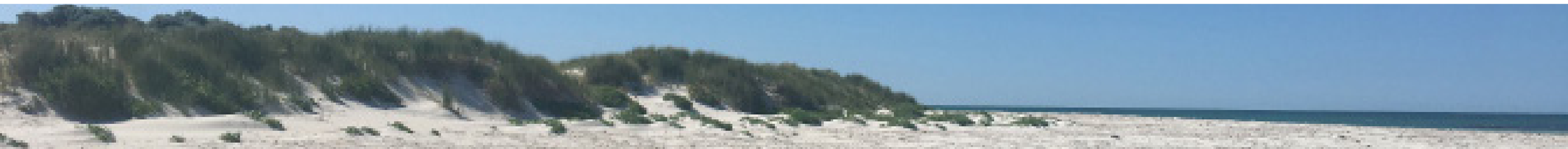
Sediment cells

A hierarchy of sediment cells is used to assist coastal planning, management, engineering, science, and governance along the coast. Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange, often described using sediment budgets. They include areas of sediment supply (sources), sediment loss (sinks), and the sediment transport processes linking them (pathways). Sediment transport pathways include both alongshore and cross-shore processes, and therefore cells are best represented in two-dimensions. They are natural management units with a physical basis and commonly cross jurisdictional boundaries (Stul et al., 2015). Figure 5.13 depicts a typical display of sediment cell layout.

Sediment cells provide a summary of coastal data in a simple format and can be used to (Stul et al., 2015):

- Identify the geographical context for coastal evaluations;
- Provide a visual framework for communicating;
- Support coastal management decision-making;
- Support other technical uses; and
- Reduce problems caused by selection of arbitrary or jurisdictional boundaries.

Sediment cells were defined in three steps through the selection of points along the shoreline, offshore and onshore boundaries, and alongshore boundaries connecting the beach face points to the offshore and onshore boundaries. The cells have been mapped as a hierarchy of primary, secondary and tertiary levels to incorporate three spatial and temporal scales. This hierarchical representation of cells gives a basis for implementation of integrated planning and management at a range of planning scales, from small-scale engineering works, through to large-scale natural resource management.



Primary cells are related to large landforms and are most relevant to potential change in large landform assemblages or land systems over longer coastal management timescales of more than 50 years. Secondary cells incorporate contemporary sediment movement on the shoreface and potential landform responses to inter-decadal changes in coastal processes (Stul et al., 2015). Tertiary cells are defined by the reworking and movement of sediment in the nearshore and are most relevant for seasonal to inter-annual changes to the beach face. Therefore, Tertiary cells are considered to be the most relevant for the City's preparation of this Coastal Management Plan.

Sediment cells provide an indication of a spatial area within which marine and terrestrial landforms are likely to be connected through the process of sediment exchange. This implies that either natural or imposed changes at any point in the cell may affect any other part, recognising such relationships are strongly bound by proximity. A fundamental use of sediment cells is therefore one of context, to identify an area that should be considered in a coastal study. They help focus coastal managers' attention upon the connected nature of marine and terrestrial landforms (Stul et al., 2015). Given the 2020-2035 timeframe for this Coastal Management Plan it is important that any management decisions regarding assets or key areas consider the behaviour of the entire tertiary sediment cell to which it belongs.

The City's coastline is covered by the following sediment cells (Stul et al., 2015) which are summarised for the City's coastline in Figures 5.14:

- Primary sediment cells R06G and R06H
- Secondary sediment cells 29, 30 and 31
- Tertiary sediment cells 29a, 29b, 29c, 29d, 30a, 30b and 31a

Primary sediment cell R06G extends from Pinnaroo Point in the south, offshore at a broad area of sediment transport convergence in the nearshore waters (the ridge of Lal Bank and offshore reefs), and on land at a discontinuity in the Holocene land system. It extends north to Yanchep, which is another broad area of sediment transport convergence offshore (high point of Hugill Reef) and has a depression or contour re-entrant (depression in two offshore ridges), and on land at another discontinuity in the Holocene land system.

Primary Sediment cell R06H extends from Yanchep in the south to the Mallee Reef salient in the north, the next main area of sediment transport convergence on the coast.

Coastal planning and management in the City will continue to utilise the sediment cell hierarchy to guide appropriate monitoring and impact assessment of land development, coastal works, coastal access, etc..

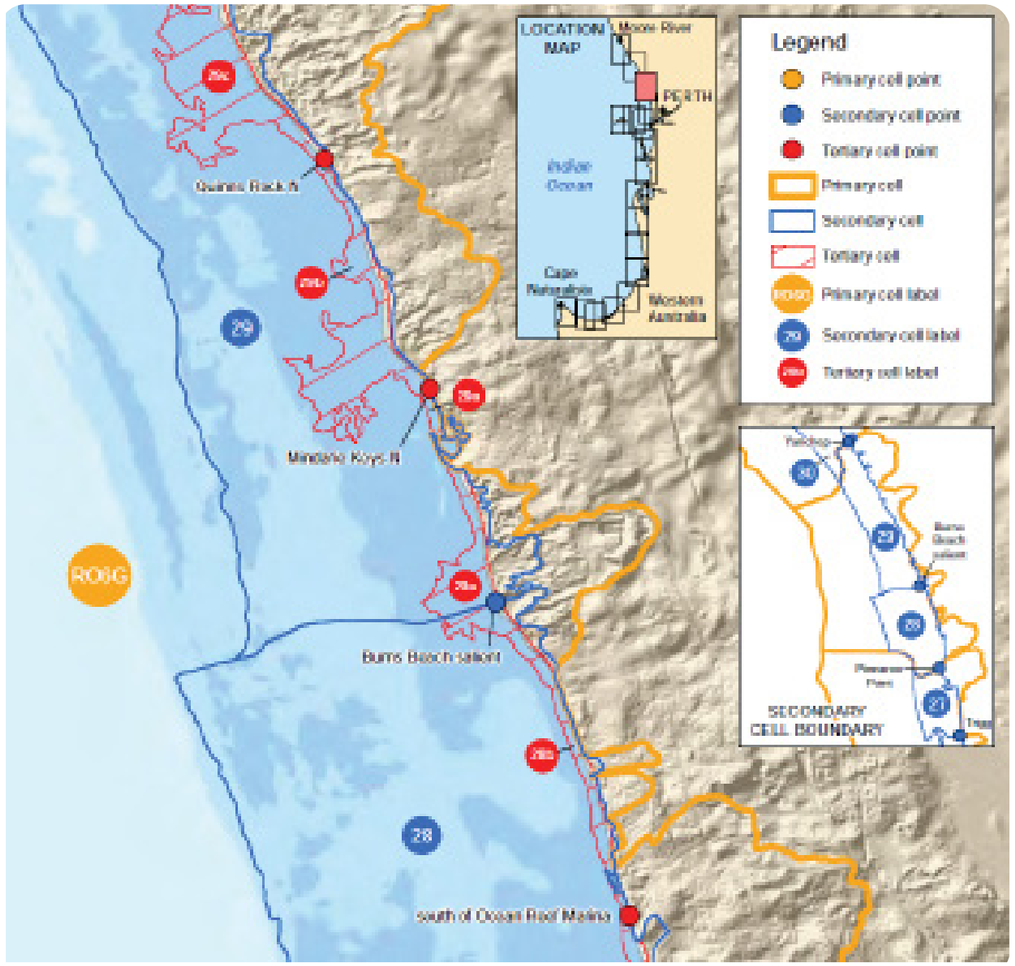
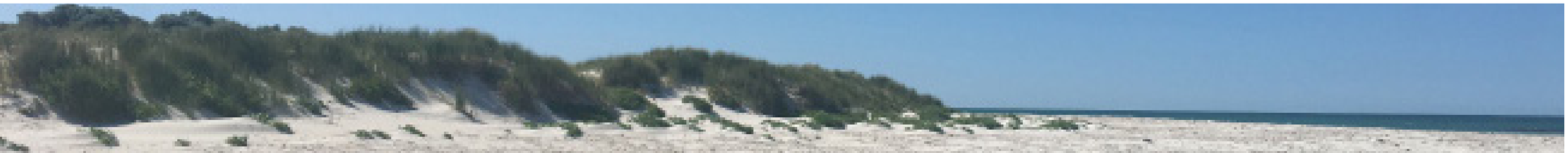


Figure 5.13 – typical representation of sediment cell hierarchy (Stul et al., 2015).



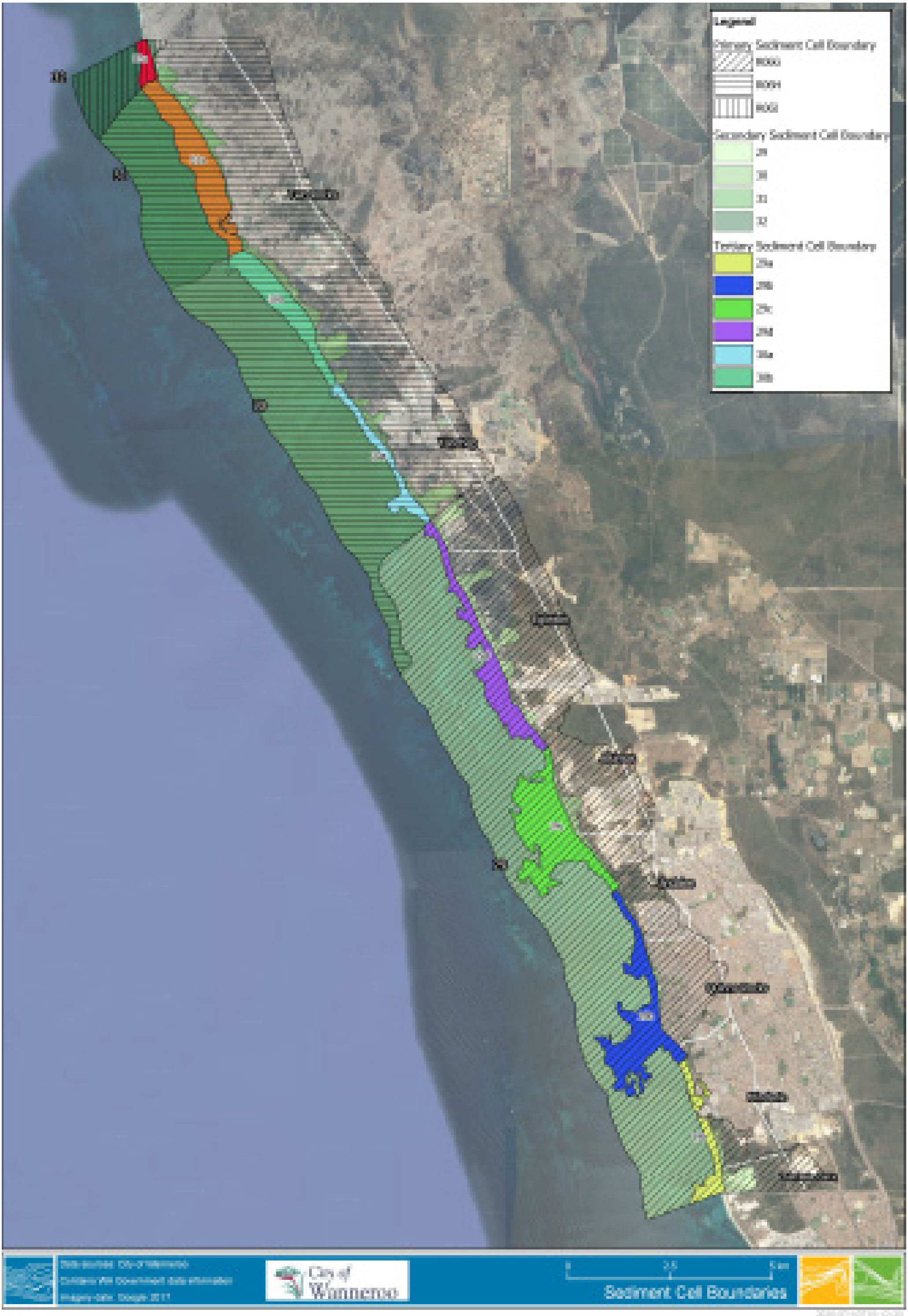


Figure 5.14 – Primary, secondary and tertiary sediment cell boundaries

Sediment transport

Overview

The wind generated waves previously discussed have a significant effect in the nearshore environment because waves arriving at an angle to the shore generate a longshore current in the surf zone. Sediment is suspended and transported in this zone, giving rise to the "littoral drift" of sediment along the coast. Generally, in this region sediment moves northward during summer and southward during winter in response to prevailing seasonal winds. Because the summer wind, swell, and wave regime is dominant, there is an annual northerly bias to net sediment transport (CoW, 2007).

The banks of offshore reefs and seagrass meadows adjacent to the coast significantly attenuate the offshore wave climate and reduce wave heights, resulting in a considerably reduced net sediment transport volumes along much of this coast compared to on an open coast (CoW 2007).

Table 5.7 - Summary of relevant geomorphological information from the review of literature by coastal Section.

Primary Section	Notes
Yanchep / Two Rocks	Yanchep lagoon - An analysis of aerial photographs between 1941 and 1996 indicates that the vegetation line to the south of the Yanchep Lagoon has been fairly constant. In the Lagoon area itself, the vegetation line has moved offshore in the northern sector and remained stable in the southern sector (CoW, 2007). To the north of the Lagoon, the construction of the Club Capricorn groyne appears to have influenced sediment movement and shoreline stability, interrupting the longshore movement of sand causing erosion on the northern side and accretion on the southern side of the groyne (CoW, 2007). Two Rocks - There has been significant coastal erosion immediately north of Two Rocks Marina since its construction. In recent years coastal management options for addressing the erosion have been investigated. MP Rogers (2015) recommended a 25 year plan of managed retreat, with a groyne field as a second option. GBGMAPs (2016) found that although underlying rock is below mean sea level for the majority of the beach area, it is above mean sea level for the majority of the dunes further east adjacent to Sovereign Drive. This information supports a managed retreat option for this Section of coast. Possible future development of the Two Rocks Marina (currently managed by DoT) may also affect this Section of coast.
Jindalee / Eglinton	Jindalee – Investigations suggest the presence of suitably continuous elevated limestone rock under the foreshore to provide long-term protection to the shoreline after the erosion of sand in future. Nine out of 12 boreholes encountered hard limestone rock at heights of approximately 3.5mAHD located approximately 120 to 150m landward of vegetation line (EPCAD, 2013).
Mindarie / Quinns Rocks	Quinns Rocks - Sediment transport at Quinns Beach has a complex response to the spatially variable nearshore wave climate. Waves arriving from offshore are modified considerably through processes including shoaling, breaking, refraction and diffraction across the system of three reefs. Wave shoaling and breaking results in wave set-up over the shallower reef areas, which forces complex nearshore circulation and drives sediment transport pathways within the reef system. At the beach face, the variation in nearshore wave angle caused by the reefs results in complex littoral drift to both the north and south (Cardno, 2015). Erosion concerns have resulted in the construction of beach groynes and seawalls to stabilise the Quinns Beach coastline and protect assets.

Seasonal trends

Seasonal weather patterns drive annual changes to beach width, which tend to be wider in summer and narrowing in winter. Erosion events can vary in timing and severity and are driven by high energy wave conditions combining with elevated storm surge water levels from the passage of storms across the coast. The typical summer season (from October through April) is characterised by frequent and strong south-westerly sea breezes that drive a persistent northward littoral drift. The typical winter season (from May through September) is characterised intermittent strong storm fronts that approach from the northwest and drive a significant pulse of sediment transport southward and offshore (Cardno, 2015).

Sub-tropical low-pressure systems and associated cold fronts tracking across the Indian Ocean produce offshore swell and localised sea waves (from strong onshore winds), as well as storm surge. These high energy wave conditions, combined with high water levels and often atypical wave directions, mean that wave energy can propagate further inshore to the beach face, often to the toe of the foredune. This process results in the removal of beach face sands and transportation of that sand into nearshore sandbars, and along shore to other locations, resulting in some beaches becoming very narrow. In summer however, daily sea breezes dominate the wind and wave climate resulting in lower water levels and reduced wave energy. These conditions promote onshore sediment transport which results in widening beaches over the summer.

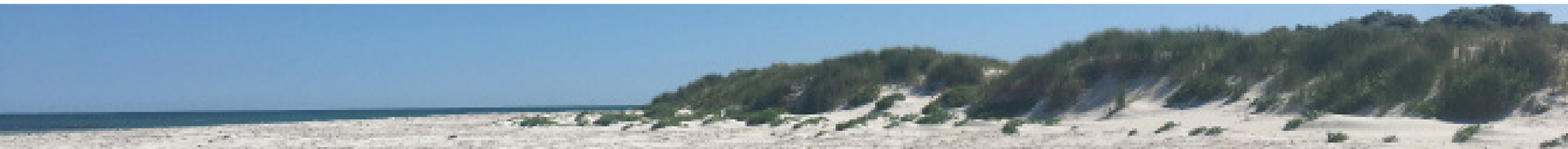


Figure 5.15 – A groyne at Quinns Beach, shown at the end of summer (top) and during winter (bottom) (Cardno, 2018).

Although rare, tropical cyclones can also impact the City's coastline. They will typically move from north to south (away from the tropics) but predicting their impact on the coast is not always straightforward. They generate strong winds (with associated storm surge and sea waves) and barotropic anomalies but resulting wave directions can change significantly depending on the path of the cyclone's track.

The onshore-offshore (cross-shore) movement of sand occurs under the influence of seasonal wave characteristics and ocean levels (Ecoscape, 2004). During winter storms, steep wind-generated waves erode sand from beaches and dunes and deposit it in offshore bars. The beaches at Quinns Rocks, for example, are partially protected from this winter erosion by offshore reefs that dissipate some of the wave energy prior to it reaching the beach. Erosion can occur rapidly however, and sand that has taken months to accumulate can be moved offshore in a matter of hours. During summer, sediment from nearshore sources is returned to the beach by the prevailing south-west swell and wind waves (CoW, 2007).

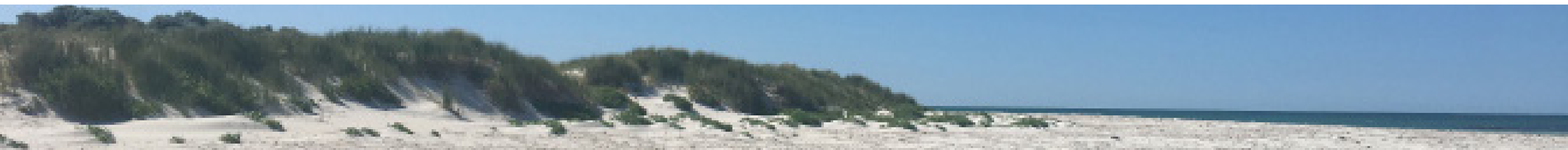
Figure 5.15 depicts the typical result of these processes at Quinns Beach with beaches wider at the end of summer and sand collecting at the northern end of beach compartments.

Interannual trends

The sediment budget and transport pathways at longer time scales largely derive from inter-annual variations in the relative strengths of seasonal cycles (Cardno, 2015). Numerical modelling has demonstrated that gross longshore transport along Quinns Beach, for example, is approximately 60,000 m3 annually, but the direction is highly variable (Cardno, 2015). The resulting balance is an intermittent net northward drift that averages approximately 5,000 m3 per year, but comes with significant inter-annual variability and periods of net southward drift.

The presence of the cliffs and reefs along the City's coastline means the littoral drift and longshore transport near the shoreline is often limited, as it is at Quinns Beach. Through numerical modelling, sediment exchange between Quinns Beach and adjacent coastal cells has been identified to generally occur further offshore at deeper depths (between approximately -5 and -10m AHD), and therefore at much slower rates than is typical at the shoreline (Cardno, 2015).

This type of complex sediment transport regime is likely to be typical of the whole City coast due to the persistence of large areas of variable bathymetry and reef chains.



5.3 COASTAL HAZARD RISK

5.3.1 Context

The State Coastal Planning Policy, State Planning Policy 2.6 (SPP2.6 - WAPC, 2013), provides guidance for decision-making within the coastal zone, including for managing development and land use change, the establishment of foreshore reserves, and to protect, conserve and enhance coastal values.

The policy is to inform and guide decision-making by the WAPC and its Committees and to integrate and coordinate the activities of state agencies that influence the use and development of land in the coastal zone. The Policy also guides local governments, state government agencies, the State Administrative Tribunal and the State Government on aspects of state planning policy concerning the coastal zone that should be considered in decision-making. The policy provides a framework for coordinating those agencies activities with those of the private sector to ensure a cohesive approach to coastal planning.

This policy requires that a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is appropriately developed. This plan should include, as a minimum, the following steps (WAPC, 2013):

- Establish the context
- Vulnerability assessment
- Risk identification, analysis, and evaluation
- Adaptation planning, with funding arrangements, and a maintenance, monitoring and review plan, and
- A communication and consultation plan.

Cardno (2018) undertook the final stages of the City's CHRMAP process as depicted in Figure 5.16.

Coastal erosion and inundation hazards were calculated in accordance with SPP2.6 and have been interpreted to identify at risk assets and values. Risk is defined as a hazardous event or circumstance and the consequences that may arise from it. Risk is measured in terms of a combination of the likelihood of a hazard occurring and the consequence of that hazard occurring (Cardno, 2018).

Separately, Cardno (2018) undertook an assessment to identify what values and assets on the City's coast that may be subject to coastal hazard risk. Each "at risk" value and asset was assigned an adaptive capacity rating that represents the ability of a given asset to be modified to better cope with negative hazard impacts.

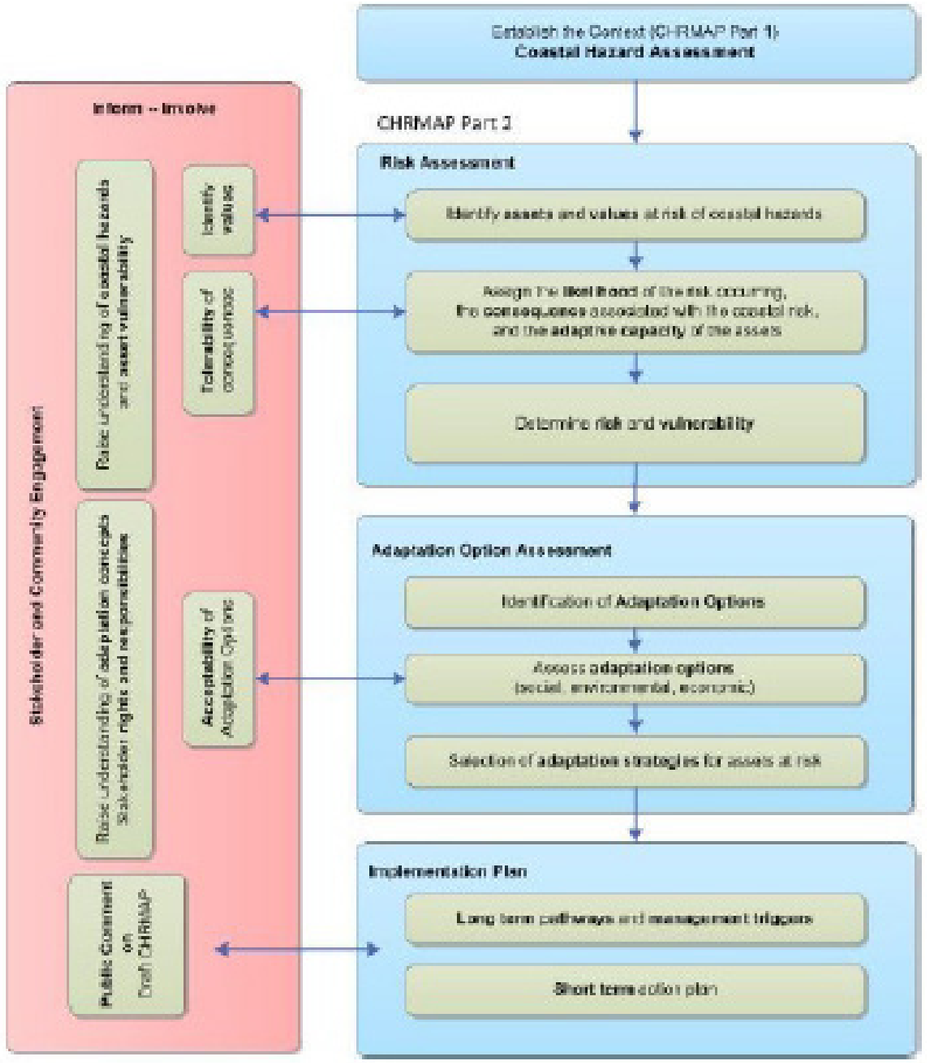
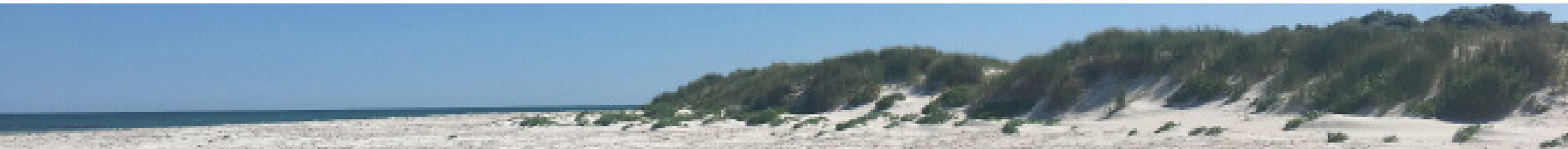


Figure 5.16 – CHRMAP methodology flow chart (Cardno, 2018, after WAPC, 2013b).



The hazard risk rating is then combined with the adaptive capacity rating for each of the identified values and assets to produce a final vulnerability rating. Assets and values which have an unacceptable vulnerability rating are addressed via the implementation of adaptation planning options from WAPC's coastal management hierarchy (in order of preference):

- Avoid
- Planned / managed retreat
- Accommodate
- Protect

5.3.2 Coastal Hazards

The hazard identification stage was conducted by M P Rogers (2015b) and incorporates the S1, S2 and S3 erosion allowances, and the S4 inundation allowance, described in the following Sections (WAPC, 2013a). Sea level rise (SLR) is predicted to lead to an increase in erosion and coastal inundation hazards along the City coastline. The result of the work by M P Rogers was a series of maps depicting relevant coastal hazards at various timeframes over the next 100 years.

Erosion and recession

To determine the calculations of coastal processes SPP2.6 requires different methodologies for different classifications of coast. In accordance with SPP2.6 MP Rogers erosion hazard areas using the method below.

The natural coastline is constantly susceptible to erosion through short term processes, such as storm surge, and long-term processes, such as rising sea levels and changes to alongshore sediment transport. The various forms of erosion are defined in the SPP2.6 as (WAPC, 2013):

- S1 Erosion - Allowance for the current risk of erosion (requires consideration of the 100-year average recurrence interval (ARI) storm event;
- S2 Erosion - Allowance for historic shoreline movement trends; and
- S3 Erosion - Allowance for erosion caused by future sea level rise.

The overall hazard extents associated with these processes is calculated by the summation of the above allowances, plus an additional allowance for uncertainty.

MP Rogers (2015b) and Cardno (2018) considered erosion hazards for 2030, 2050, 2070, 2090 and 2120. As this Coastal Management Plan has a timeframe of 2020-2035 only the 2030 erosion hazard line is directly relevant. To inform this plan the 2035 erosion hazard has been calculated for the City coastline.

The 2035 erosion components (S1, S2 and S3) have been determined by using the MP Rogers 2030 line and an additional assessment of erosion risk from 2030 to 2035. The storm erosion rate S1 is already included in the 2030 erosion line from MP Rogers (2015b). The S2 value (historical shoreline recession) for 2035 was determined by using the same annual rate of change as MP Rogers used for the 2015 to 2030 time frame, and was applied for the additional five years from 2030 to 2035. If different Sections of the coast had varying behaviour, an average for each tertiary sediment cell of S2 annual erosion rate was taken and multiplied by 5 (the number of years from 2030 to 2035). The difference in the S3 erosion allowance due to projected sea level rise is the same across the whole study area. The 2.3 m allowance is calculated from an annual allowance of 0.46 m per year. This assumes an approximate sea level rise rate of 4.6 mm per year for the next 15 years, in line with DoT (2010).

The total increase in the allowance for erosion over the previous 2030 erosion line to 2035 is presented in Table 5.8. The 2030 erosion line has been translated landward by these amounts and subsequently mapped. The erosion line is mapped from the horizontal setback datum (HSD) as identified in MP Rogers (2015b), which is typically around the vegetation line on a beach face. The total distance from the HSD to the 2035 erosion allowance line varies between ~20m and ~65m for the City's coastline depending on local characteristics.

Tertiary cell 29b was excluded from the assessment for 2035 erosion by MP Rogers (2015b) as the Quinns Beach coastal management study was underway at that time and the coastal management approach was yet to be determined. However, on the basis of the subsequently adopted approach, Quinns vulnerability lines were then produced by Cardno (2018) and have been included in the CHRMAP hazard mapping below.

Table 5.8 – Summary of erosion allowance from 2030 to 2035

Tertiary Sediment Cell	S2 Erosion difference 2030 to 2035 (m)	S3 Erosion difference 2030 to 2035 (m)	Uncertainty allowance difference 2030 to 2035 (m)	Total additional erosion from 2030 to 2035 (rounded to nearest m)
32a	1.6	2.3	1	5
31a	2	2.3	1	5
30b	-2.0 (accretion)	2.3	1	1
30a	2	2.3	1	5
29d	0.6	2.3	1	4
29c	1.3	2.3	1	5
29b	0	2.3	1	3
29a	0.8	2.3	1	4

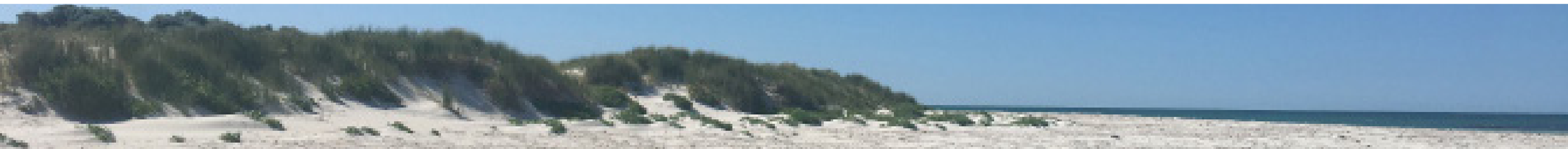


Figure 5.17 - 2035 Erosion Mapping at Mindarie

Figure 5.18 - 2035 Erosion Mapping at Mindarie

Figure 5.19 - 2035 Erosion Mapping at Quinns Rock

Figure 5.20 - 2035 Erosion Mapping at Jindalee

Figure 5.21 - 2035 Erosion Mapping at Alkimos

Figure 5.22 - 2035 Erosion Mapping at Eglinton

Figure 5.23- 2035 Erosion Mapping at Yanchep

Figure 5.24- 2035 Erosion Mapping at Two Rocks

Inundation

Coastal inundation is flooding of land by sea water, typically associated with the combined effects of storm surge and wave run-up during severe weather events. All coastlines are exposed to this hazard and low-lying areas can be particularly vulnerable. SPP2.6 requires consideration of the 500-year ARI water level (storm tide level) to assess the potential impacts of coastal inundation. MP Rogers (2015b) calculated the 500-year ARI storm tide at Fremantle Fishing Boat Harbour as 1.44 m AHD (Figure 5.25) The inundation total water level (including additional allowances for nearshore wind and wave setup and sea level rise) for the City's coast was calculated as 2.9 m AHD for 2030. Factoring of the sea level rise component (an additional 5 years at 4.6 mm per year) gives an additional inundation allowance of 23 mm from 2030 to 2035, which still rounds to 2.9 m AHD. The CHRMAP hazard mapping risk report identified that the only assets likely to be impacted by extreme water levels on the open coastline are beach access paths and determined it was not beneficial to map the results.

Within Mindarie and Two Rocks Marinas the inundation levels are likely to be significantly reduced due to the protection provided by the rock breakwaters and the resultant reduction of wave setup processes. The estimated 2035 500-year water level at these locations was 1.8 m AHD. No potentially vulnerable assets (i.e.: those that would be impacted by sea water) were identified at this level (MP Rogers 2015b).

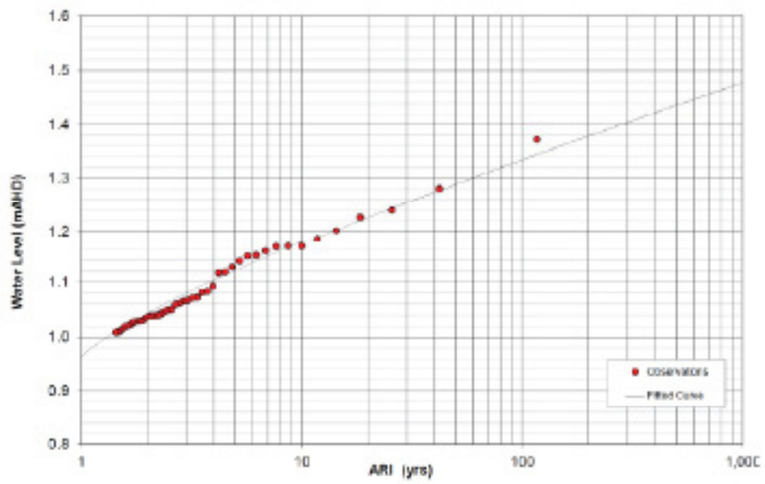


Figure 5.25 – Extreme water level analysis for Fremantle (MP Rogers 2015b)

Climate Change

Sea level rise, although in many instances a dominant factor, is only one of several key environmental variables that may be affected by climate change. Other key environmental variables that may be affected by climate change include (DoT 2010):

- Ocean currents and temperature
- Wind climate
- Wave climate
- Rainfall / runoff, and
- Air temperature
- The frequency and severity of coastal storm events
- Increased poleward migration of tropical cyclones (due to warmer ocean waters)

The combined impact of these variables will vary around the WA coast and require consideration on a local scale. Sea level rise is the focus of SPP2.6, which does not consider the potential changes to the frequency of extreme water level events which may occur through changes to weather patterns.

DoT (2010) recommends that a vertical sea level rise of 0.9 m be adopted when considering the impact of coastal processes over a 100-year planning timeframe (2010 to 2110). It is recommended for planning timeframes beyond 100 years that a vertical sea level rise of 0.01 m per year be added for every year beyond 2110 (Figure 5.26). The City's CHRMAP mapping has used these values to determine the relative hazards from erosion and inundation due to climate change over the next century.

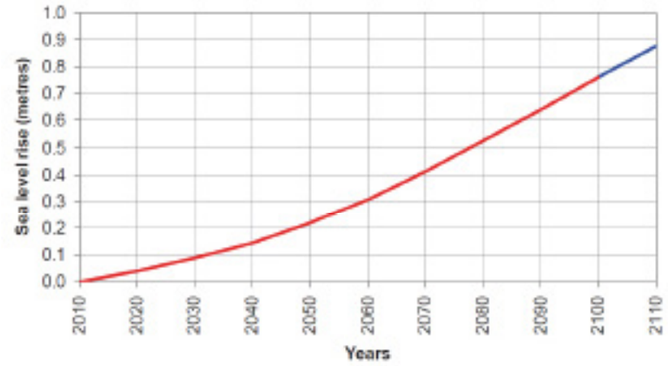
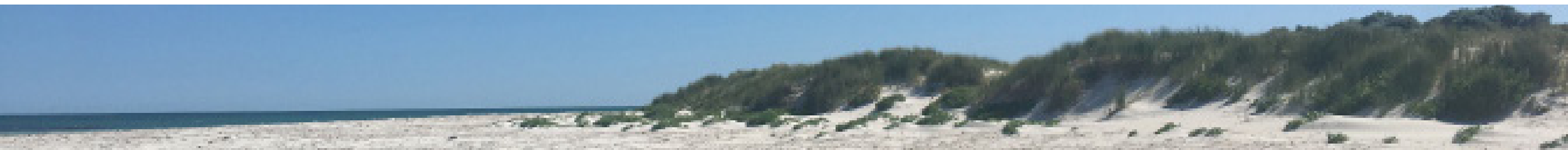


Figure 5.26 – Recommended allowance for sea level rise in coastal planning for WA (DoT, 2010)



The primary projected impacts of mean sea level rise are its contribution to increased shoreline erosion and inundation. SPP2.6 requires these to be considered for sandy coasts as S3 erosion and S4 inundation, respectively. The S3 erosion allowance has been calculated by MP Rogers in accordance with SPP2.6, assuming that for each 1 cm of sea level rise there will correspondingly be 1 m of horizontal shoreline erosion (Figure 5.27). For S4 inundation, the contribution of sea level rise is added to the other components of water level, so it has also been included in MP Rogers assessment of inundation levels.

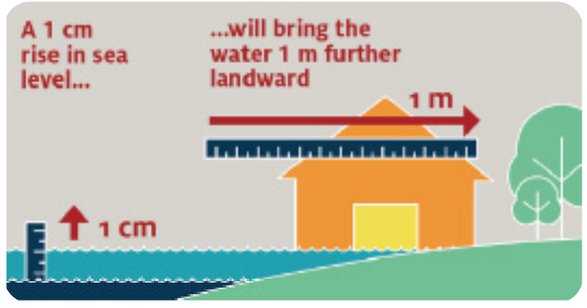


Figure 5.27 – Schematic representing the horizontal erosion allowance from projected vertical sea level rise – a factor of 100 (Coast Adapt 2017)

Other coastal hazards

Besides erosion and inundation, additional potential hazards which have been observed along the City's coast are:

- The accumulation of large quantities of seagrass wrack on some beaches and at some structures; and
- The overtopping of coastal structures by waves during severe storm events

Large wrack accumulations on the beaches south of Two Rocks marina have posed an issue to public safety since the marina was built in the early 1970s (DoT, 2013). DoT is considering future management options to alleviate wrack build-up issues and the City will continue to work with DoT to consider management options. DoT has undertaken monitoring of the wrack on the beach along with nearshore water levels, waves and ocean currents to better understand how wrack accumulates, and is cleared off the beach (DoT, 2020). In general, volumes south of the marina were higher than volumes north of the marina. Southern volumes were dynamic, varying by up to two orders of magnitude on a weekly timescale. Northern wrack volumes were more stable, constituting relatively consistent, and low, wrack volumes each week (DoT, 2013). More wrack accumulates over summer months (approximated as November to March) and persists on the beach for longer periods. Wrack was found to naturally "clear" off the beach with the combination of certain metocean weather conditions, such as rising tide and offshore winds, but similar conditions did not always guarantee wrack was cleared (DoT, 2020).

The original Quinns Beach rock groynes as well as Mindarie Marina have a history of being impacted by wave overtopping during storm events. The potential risk of damage to roadways, the structures themselves, and motorists and pedestrians has seen the City undertake improvement works at the both the Quinns Beach groynes and Sections of the Mindarie southern breakwater in recent years. All coastal protections structures have their condition monitored regularly and future works are currently being considered.

Vulnerability analysis

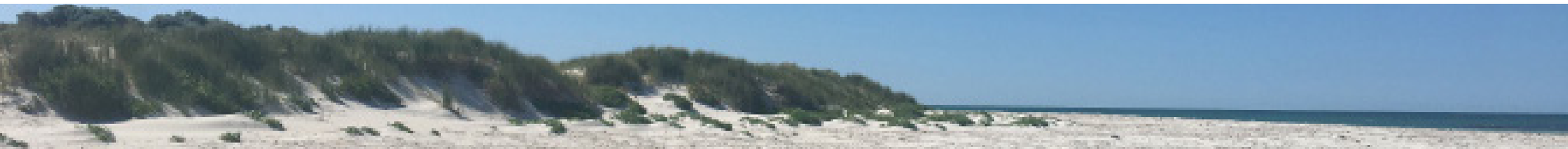
Following the erosion and inundation hazard assessment by M P Rogers (2015b), an assessment of key coastal assets and values was undertaken by Cardno (2018) to determine what is important to the community that may be threatened by identified coastal hazards over the next century. These assets and values were incorporated into a vulnerability risk assessment in order to identify areas of unacceptable vulnerability over management timeframes.

A brief description of this process is provided in the following Sections. The hazard risk assessment combines a likelihood rating with a consequence rating. The likelihood rating is the chance of erosion or storm surge inundation impacting an asset or value, as per hazard lines. The consequence rating is result of a hazard impacting an asset or value, and is assessed via consideration of social, economic, and environmental impacts. The resulting risk rating is combined with an adaptive capacity assessment of the assets and values to produce a vulnerability evaluation. The adaptive capacity is based upon the potential for an asset to be modified or acclimatise to cope with the impacts of identified hazards. An asset or group of assets with a high adaptive capacity is one that can easily (i.e.: at low cost) be adapted, or one that has some capacity to self-adapt with changing conditions (e.g. beaches and dune systems can migrate across shore as the sea level changes). Assets with a high-risk level and low adaptive capacity are deemed highly vulnerable and management options should be investigated.

Values and assets

In the City's CHRMAP an asset is defined as a useful or valuable entity (Cardno, 2018). The CHRMAP investigation identified coastal assets to include:

- Natural features such as beaches and natural vegetation;



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

As defined in the Australian standard climate change adaptation for settlements and infrastructure – A risk based approach (AS 5334-2013) an asset's value can be tangible or intangible, financial or non-financial. Examples of non-tangible assets include ecological function and coastal views. The value of an asset includes consideration of risks and liabilities and can be positive or negative at different stages of the asset's life. Economic assets can be further categorised as public or private. Values in the context of the CHRMAP further encompass the economic, social (including heritage) and environmental values of the coastal area (Cardno, 2018). Aboriginal Heritage Sites are considered a part of social values and could also be considered as individual assets depending on their nature. These sites are discussed further in Chapter 8.

The CHRMAP also considered a suite of adaptation options from the approved options hierarchy to reduce the vulnerability of assets. The options were assessed against several criteria to develop a shortlist of potentially suitable options. Preliminary recommendations were made for vulnerable assets and values. SPP2.6 requires that flexibility of management pathways be maintained and requires appropriate monitoring for identified triggers to determine the most appropriate time to implement management options.

Key issues

The City's CHRMAP identified the following assets as currently vulnerable or likely to become vulnerable by 2030. Subsequent analysis for the preparation of this plan has found that there are no additional assets, or values, under threat by within the extended timeframe to 2035:

- Priority Ecological Community at Two Rocks – threatened by erosion of beach dunes and coupled vegetation. The integrity of the dune and vegetation currently contribute to basic protection of the ecological community.
- Brazier Road carpark at Yanchep – currently potentially vulnerable from erosion. The Sections of beach and rocky shoreline and foreshore reserve are at risk before the car park.
- Residential lots, Brazier Road at Yanchep -— currently potentially vulnerable from erosion. The Sections of beach and rocky shoreline and foreshore reserve will be diminished before the lots.
- Priority Ecological Community at Mindarie - threatened by erosion of beach and dunes and their vegetation. The integrity of the dune and vegetation currently contribute to basic protection of the ecological community.

The areas of concern did not include coastally dependant structures such as beach access paths and stairs as although they can be quite expensive, they will always be required to facilitate coastal access. There are over 30 of these accessways, some adjoining structures, and they are considered on a case by case basis by the Assets Directorate of the City.

Other potential coastal issues, beyond those presented in the CHRMAP, that could require targeted action by the City are discussed below.

Recreational/Amenity issues

The City's CMP Part 1 (2012) outlines a snapshot of local coastal issues regarding recreational amenity. Discussion focuses on dog and horse beach recreation areas with recommendations on changes to existing dog beaches and consideration of new dog and horse beach area. Other key community considerations identified were are the use of Mindarie and Two Rocks Marina for both commercial and recreational activities, the consideration of construction of an artificial surfing reef and a tidal pool, and appropriate locations for improved foreshore and beach amenities (beach volley-ball/soccer areas, amphitheatre, bars/cafes and markets, etc.).

Artificial Surfing Reef

The City commissioned an investigation of several locations on the City's coastline that could potentially accommodate an artificial surf reef, including Posties, Unwin Shoals, Locals and Club Capricorn (MP Rogers, 2014). The key findings of the investigation were:

- The estimated cost of construction at these locations were between $10m-$70m.
- The majority of artificial surf reefs constructed in Australia and worldwide have failed to meet the objective of providing enhanced surfing conditions. Those that have been successful have shown only marginal improvements to surfing conditions.

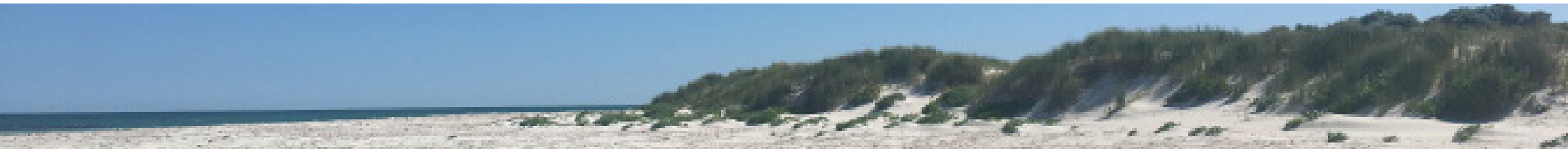
Damage to geotextile bags and infrastructure readily occurs at artificial reefs and require costly improvements over the lifespan of the reef.

The City subsequently determined that although an artificial surf reef is feasible at several locations, the cost of constructing a reef is significant and there is limited evidence to suggest that the project would be successful. Considering these findings, further investigation into the construction of an artificial surf reef has not been pursued.

Tidal Pool

Consideration of the feasibility of construction of an ocean pool was undertaken (M P Rogers, 2014) and it was determined that due to the small tidal range and sand/sea weed movements along the City's coastline, a tidal pool was unlikely to be feasible as there would be ongoing issues associated with water quality due to inadequate flushing, and high maintenance costs to remove sand and sea weed from the pool.

Subsequently, and following engagement with the local community, the City commissioned a location assessment investigation for an ocean pool structure at Quinns Beach (Cardno, 2016b). The purpose of the study was to enable the City to assess the technical feasibility of an ocean pool at Quinns Beach, and



the potential role of an ocean pool structure to also form a constructive coastal management feature. The investigation considered and presented potential pool locations. The technical feasibility of issues such as flushing, sedimentation, seagrass accumulation, and interaction with sediment transport were forecast to require attention at future design stages if the project proceeded.

The outcomes of the study suggested that the extreme southern end of Quinns Beach adjacent the rock cliffs which lead to Mindarie Marina was the best potential location for the ocean pool. This location was the only suitable place within the study area for a pool that has a similar aesthetic to those found on the NSW coast (built along cliffs). Following this determination the City decided not to proceed with the remaining technical feasibility scope of the study, noting that the recommended pool location is not connected to existing or proposed coastal structures and does not contribute to management of the coastal erosion issues at Quinns Beach. (CoW, 2016b).

Quinns Beach

The coastal assets, values and hazard risks at Quinns Beach were not examined in detail by the CHRMAP project. The Long-Term Coastal Management project at Quinns Beach has selected protection as the preferred management option for the coming decades. The existing coastal protection structures, monitoring and coastal management works programs currently undertaken by the City will ensure the key assets and values of the area are maintained. This includes the beach car park immediately north of the groyne at Fred Stubbs Park. The car park would be significantly at risk if an appropriate ongoing sand nourishment program is not undertaken to maintain a beach buffer in front of it.

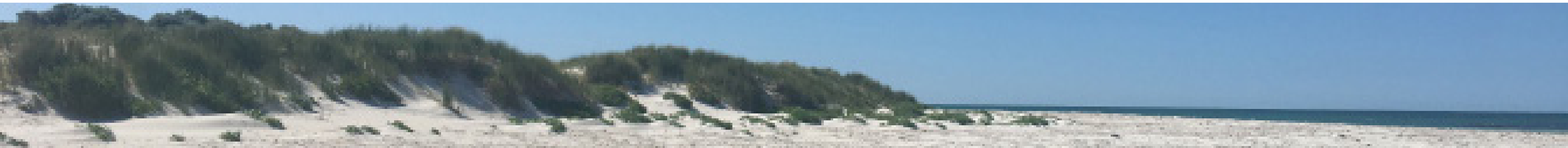
Jindalee Boulevard carpark at Jindalee could be an asset that requires more detailed monitoring for potential vulnerability from coastal erosion. Given its proximity to the ocean and distance of more than 700m north of the northern Quinns Beach groyne it may be at risk in coming decades. There is some anecdotal evidence that suggests this location may have underlying rock formations beneath the dune system that could naturally protect the car park, but the potential level of protection requires further assessment.

Future impacts to local shorelines

In combination with the vulnerable built and natural assets and additional community concerns around foreshore amenity, the preparation of this plan has also considered other future impacts to the City's shorelines. The review of key documents has identified several Sections of the coast which may require special attention in coming years, presented in Table 5.9.

Table 5.9 – Summary of potential future impacts to local shoreline Sections up to 2035.

SubSection	Potential future shoreline impacts
Two Rocks	Significant ongoing recession of shoreline immediately north of Two Rocks Marina due to interruption of longshore sediment transport following construction of the Marina. Management options include Managed Retreat (preferred) and a staged beach groyne field (M P Rogers , 2015). An investigation by GBGMAPS (2016) identified limestone rock above mean sea level which is likely to assist in reducing/halting the rate of recession in the future. This erosion problem has also been acknowledged by the WA State Government (Seashore Engineering, 2019). Correspondingly on the south side of the Marina there has been accretion of the beach creating new dune and foreshore areas for future use. Any future development at the Marina by the DoT, especially any changes to the breakwaters, would require consideration of the relevant coastal processes, including sediment transport and could involve subsequent coastal management activities.
Yanchep	The ongoing care, control and maintenance of the Capricorn beach groyne requires continuing attention. The unusual shore-attached fringing reef platform and associated lagoon at Yanchep is a unique feature of the City's coastline. Although there are no known shoreline impact issues anticipated before 2035 it may become important to consider the effects of mean sea level rise changing the water levels and wave climate over the reef into the lagoon at future time horizons.
Eglinton	The potential future development of a Marina at Eglinton has been discussed in many planning documents in recent decades and like any changes to Two Rocks Marina, if pursued it would require consideration of the relevant coastal processes.
Alkimos	The South Alkimos Local Structure Plan (Landcorp, 2019) notes there is the potential for the future development of a Marina at Alkimos and similar to any changes to Two Rocks Marina, if pursued it would require consideration of the relevant coastal processes.
Jindalee	No known shoreline impacts besides the potential vulnerability of the Jindalee Boulevard carpark to erosion.



SubSection	Potential future shoreline impacts
Quinns Rocks	The car park on the beach immediately north of Fred Stubbs Park is currently protected by an informal rock seawall. It is still at risk from storm damage and erosion. But was determined, through community engagement to be a significant asset for the community. The ongoing care, control, and maintenance of coastal protection structures (beach groynes and seawalls), as well as sand nourishment works at Quinns Beach requires continuing attention. This extent and severity of the ongoing erosion at Quinns Beach has also been acknowledged by the WA State Government (Seashore Engineering, 2019).
Mindarie	No known shoreline impacts.
Mindarie	No known shoreline impacts.

5.4 Adaptation Planning

The City's CHRMAP summarised 13 key recommendations, based on the findings of the project, for implementation before 2030 when a CHRMAP revision is proposed. The recommendations include community engagement, further economic assessment and cost-benefit analysis, planning controls, ongoing beach renourishment, establishment of a coastal asset inventory and investigation of future sediment sources. The City is currently working through these recommendations and prioritising coastal works and investigations.

5.4.1 Current management and monitoring

The City's coastal management staff are responsible for various management and monitoring practices which are currently undertaken. Numerous physical controls have been implemented along the City's coast, particularly along Quinns Beach, including groynes, seawalls, an artificial headland as well as long-term management requirements such as sand nourishment, dune maintenance, including:

- Annual Beach Renourishment Programme for Quinns Beach and Yanchep Lagoon
- Coastal Monitoring Programme – 6 monthly photographic monitoring, 6 monthly aerial coastal surveys and annual condition assessment of our coastal protective structures
- Additional photographic monitoring following extreme storm events
- Beach Access Way maintenance including removing sand and rubbish, pruning vegetation, weed control, and reporting any damage to paths and fencing
- Beach Access Way condition assessments (conducted every 5 years)
- Beach Access Way Upgrade/Renewal Programme which targets a beach access way each year for design and another for construction
- Inspection of beach foreshores to monitor revegetation works, condition of wind breaks, general beach condition (erosion etc.)
- Two Rocks Coastal Management Study to address erosion to the north of the Marina
- Plans to manage sea wrack pushing offshore south of the Two Rocks Marina
- Liaising with DoT regarding future plans for Two Rocks Marina
- DoT Coastal Adaptation and Protection Grant funding applications
- Beach cleaning
- Beach signage inspections and maintenance (SLSWA signs and BEN signs)
- Marine animal management (e.g. management of whale carcasses)
- Shark sightings and shark related incidents
- Marine debris issues (such as boats washing up on beaches)

A summary of the City's coastal protection structures, and those that have a significant effect on coastal processes is summarised in Table 5.10 and presented in Figure 5.28.

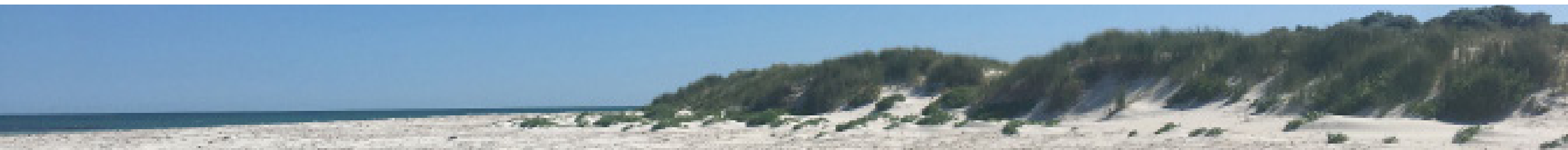
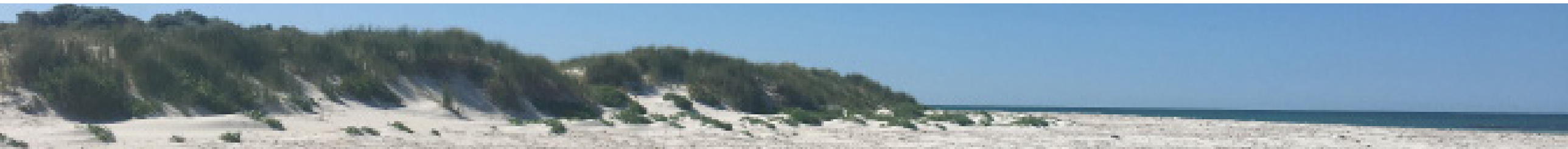


Table 5.10 – Summary of significant coastal protection structures along the City's coastline.

SubSection	Coastal management structures
Two Rocks	Two Rocks Marina – not built as a coastal protection structure, but the Marina breakwaters have a significant effect on local coastal process
Yanchep	Capricorn beach groyne – deteriorated rubble mound beach-perpendicular rock groynes
Eglinton	None
Alkimos	None
Quinns Rocks	Quinns Beach groynes - four limestone rubble mound beach-perpendicular rock groynes Informal rock seawall in front car park immediately north of Fred Stubbs Park Seawalls – GSC sandbag revetment backed by limestone retaining wall; rock revetment tie-in between GSC wall and southern beach groyne Headland – deteriorated structure south of Fred Stubbs park.
Mindarie	Mindarie Marina – not built as a coastal protection structure, but the Marina breakwaters have a significant effect on local coastal process
Mindarie	None



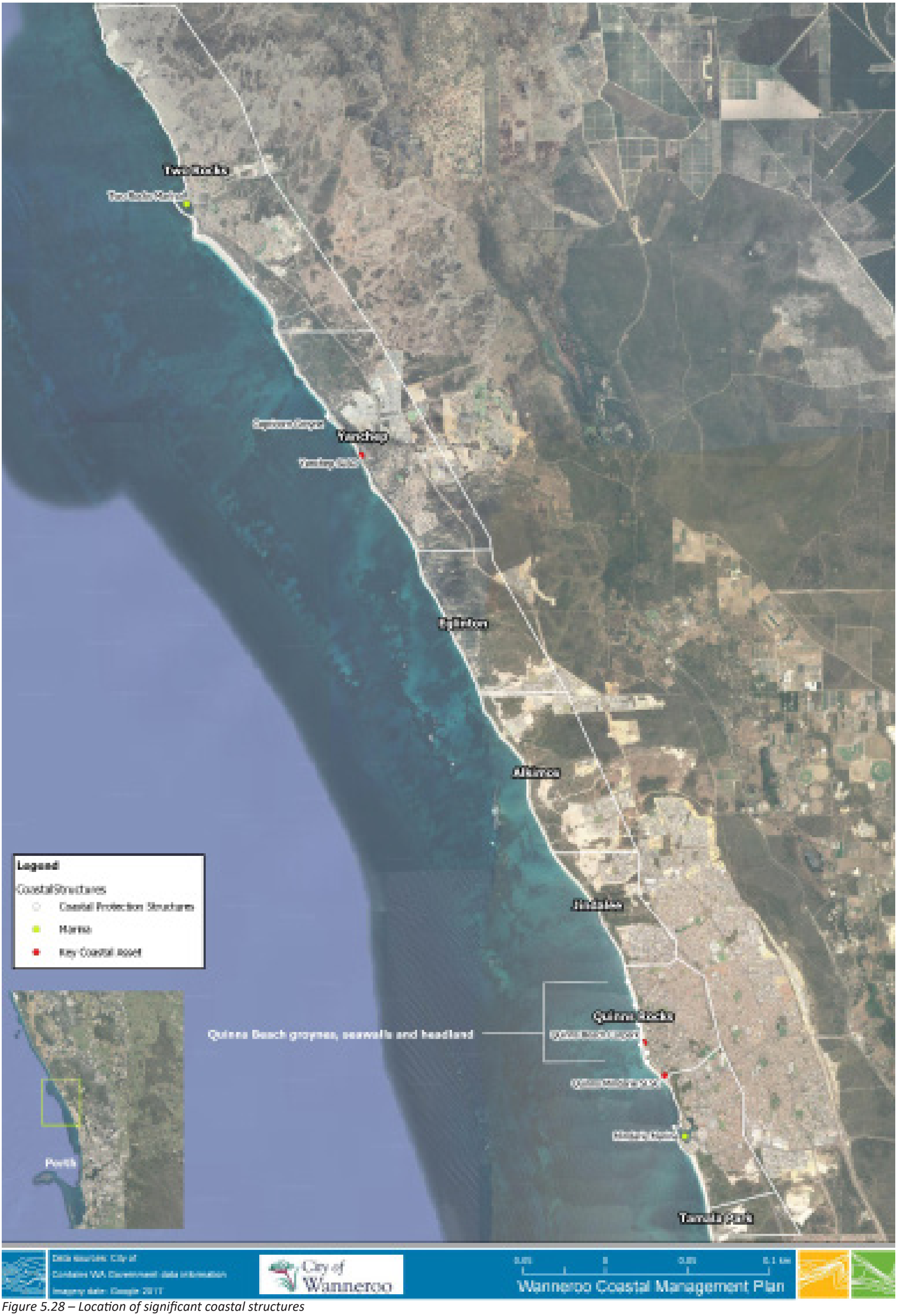


Figure 5.28 – Location of significant coastal structures

City staff have also undertaken specific coastal works activities since the CMP Part 1 was finalised in 2012, including:

- A new Geotextile Sandbag Container (GSC) seawall and limestone block wall in front of Fred Stubbs Park
- A connecting rock revetment seawall between GSC seawall and southern groyne
- Beach re-nourishment works, often in front of the Quinns Beach car park, and based on the results of monitoring surveys
- Quinns Beach Long Term Coastal Management Works were completed in December 2019. The works followed the detailed coastal engineering studies completed between 2014 and 2017 and comprised:
  - Extension and upgrade of the three existing rock groynes, and
  - Construction of a new rock groyne.
- CHRMAP report with subsequent recommendations and actions.
- Installation and ongoing management and maintenance of the Quinns Beach Swimming Enclosure.
- Mindarie breakwater maintenance – in 2017/18 works were undertaken to increase and widen the crest level of the structure successfully resulting in less wave overtopping and associated safety issues for a Section of the structure. The City is also undertaking the Mindarie Breakwater Options Assessment and Detailed Design Study to determine a preferred maintenance option for the other structure Sections.
- Preparation work to determine an appropriate upgrade and significant maintenance program for the southern beach groyne at Quinns Beach with works forecast for 2020/21.
- Design works for the renewal, upgrade, and relocation (eastward) of the Quinns Beach car park. As part of these works the coastal protection requirements of the car park are being reviewed.

5.4.2 Future activities

All assets identified as possibly vulnerable before 2035, as well as any other potential coastal issues have been summarised. Broad adaptation pathways or management approaches, in line with the recommended hierarchy from SPP2.6 (WAPC, 2019) to address these type of challenges are presented in Figure 5.29. Table 5.11 lists a summary of the pathways recommended from the City's CHRMAP (Cardno, 2018) and other investigations.

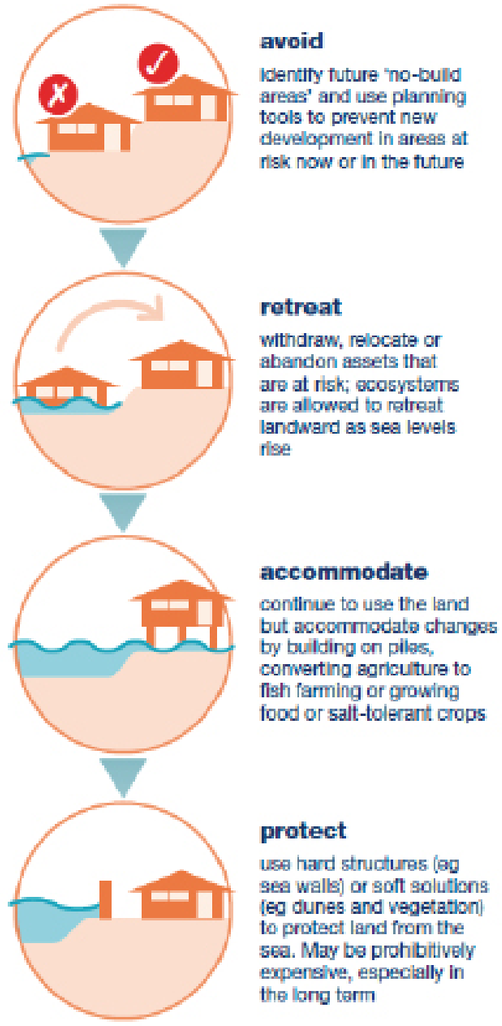


Figure 5.29 – Risk management and adaption options hierarchy (WAPC, 2019).

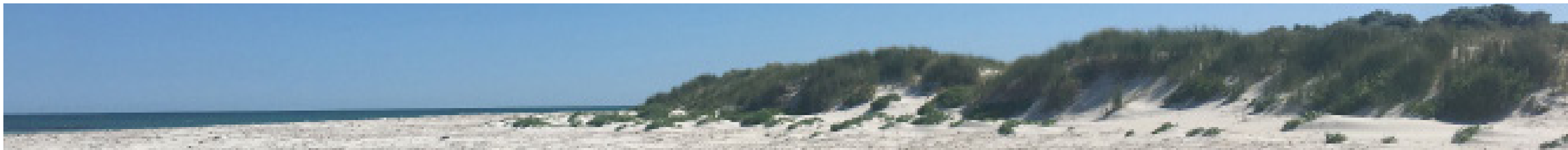
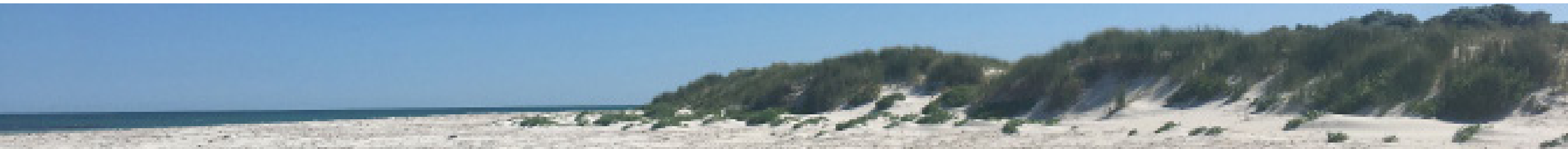


Table 5.11 – Summary of possibly vulnerable assets and other potential coastal issues to 2035, and the identified potential adaptation pathways to address the risks.

SubSection	Asset or Potential Issue	Adaptation Pathway and Actions
Two Rocks	Priority Ecological Community vulnerable to erosion	Avoid development and undertake dune care and sand management works
Two Rocks	Erosion north of Two Rocks Marina	Continued monitoring and further work will be undertaken to determine the cost and likely effectiveness of Managed Retreat or Protection options
Yanchep	Capricorn beach groyne	SPP2.6 requires the City to be responsible for the ongoing care, control and maintenance of the structure. Continued monitoring will inform the City of future requirements
Yanchep	Yanchep lagoon and reef platform	Ongoing monitoring into future, reconsideration of available data in next revision of the CHRMAP.
Yanchep	Brazier Road carpark	Continued monitoring and further work will be undertaken to determine the cost and likely effectiveness of Managed Retreat or Protection options.
Yanchep	Residential lots, Brazier Road	Continued monitoring and further work will be undertaken to determine the cost and likely effectiveness of Managed Retreat or Protection options.
Eglinton	The potential future development of a Marina	Continued monitoring and further work will be undertaken to determine any other requirements as part of the approvals process.
Alkimos	The potential future development of a Marina	Continued monitoring and further work will be undertaken to determine any other requirements as part of the approvals process.
Jindalee	Potential vulnerability of the Jindalee Boulevard carpark to erosion.	Continued monitoring and further work will be undertaken to determine the suitability of different options, as this asset was not included in the CHRMAP project.
Quinns Rocks	The Quinns Beach car park vulnerable to erosion	The city will undertake design works for the renewal, upgrade and relocation (eastward) of the Quinns Beach car park. As part of these works the coastal protection requirements of the car park are being reviewed.
Quinns Rocks	Quinns Beach coastal protection structures (groynes, seawalls and headland)	SPP2.6 requires the City to be responsible for the ongoing care, control and maintenance of the structures. Continued monitoring will inform the City of future requirements.
Mindarie	Priority Ecological Community vulnerable to erosion	Avoid development and undertake dune care and sand management works.
Mindarie	No known vulnerable assets or potential issues	N/A



6. Flora and Vegetation

The City's coastline extends 32 kilometres from Mindarie to Two Rocks and provides an excellent environment for residents to enjoy recreational activities and natural areas. It is characterised by coastal limestone cliffs and coastal heathland vegetation and includes relic sand dune formations (the Quindalup dune system) occurring as beach ridges. (City of Wanneroo 2012)

The vegetation communities within the City are typical of coastal areas, which are fairly homogeneous at a broad scale but vary considerably on closer inspection depending on the age of the dune, underlying limestone or deep sand, dune stability and external influences from disturbance such as weeds, fire, and other anthropogenic influences.

The vegetation communities, significant flora and environmental hazards and threats along the coastline of the City of Wanneroo are described below.

In line with the City's CMP 2020, the study area has been split into the following three CMAs for reporting:

- CMA 1 - Mindarie to Quinns Rocks
- CMA 2 - Jindalee to Eglinton
- CMA 3 - Yanchep to Two Rocks

6.1 Bioregion

The City of Wanneroo is located in the Swan Coastal Plain IBRA bioregion. This bioregion is a 30 km wide coastal plain on the Indian Ocean coast directly west of the Darling Scarp uplands running from Cape Naturaliste in the south to north of the city of Perth.

The area generally consists of fairly infertile sandy soil along with coastal sand dunes, river estuaries, and a number of wetlands kept back from the sea by the dunes. A number of rivers cross the plain from east to west from the Darling Scarp towards the sea, including the Swan and its main tributary, the Canning.

The sediments of the Perth Basin are Tertiary and Quaternary in age immediately below Perth and include coquina, travertine, and sandy limestones with abundant shelly material. Perth is sited on a set of sand dunes formed during the Pliocene-Pleistocene during the last ice age. Offshore, the sand dune system and surficial deposits transition into a system of partly eroded limestones and sandy limestones. These form a series of drowned cuestas which today form submerged reefs.

The dune topology also results in extensive north-to-south-oriented chains of wetlands, again located in the swales. For example, the chain of lakes north of Perth includes lakes of the Wanneroo wetlands including – Lake Pinjar, Jandabup Lake and Gnangara Lake. The large bodies of water in the estuary of the Swan River, Perth Water and Melville Water are also located in dune swales.

6.2 Vegetation Complexes

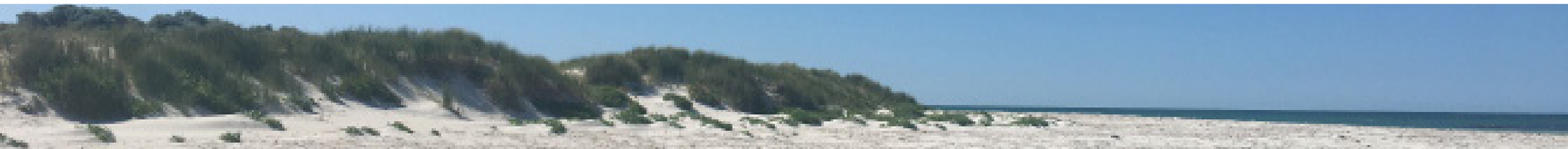
Heddle et al. (1980) classified the vegetation of the Perth metropolitan area into vegetation complexes. The City of Wanneroo coastline supports two vegetation complexes:

- The Quindalup Complex
  - A coastal dune complex consisting mainly of two alliances – the strand and fore-dune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *Melaleuca lanceolata – Melaleuca preissii* and the closed scrub of *Acacia rostellifera* (Heddle 1980)
- The Cottesloe Complex – North
  - Predominantly low open forest and low woodland of *Banksia attenuata* (Slender Banksia) - *Banksia menziesii* (Firewood Banksia) - *Eucalyptus todtiana* (Pricklybark); closed heath on the Limestone outcrops (360 Environmental nd)
- The Cottesloe Complex – Central and South
  - A mosaic of woodland of *Eucalyptus gomphocephala* and open forest of *E. gomphocephala – E. marginata – E. calophylla* closed heath on the Limestone outcrops (Ecological 2015)

The area of each complex that occurs within the three CMAs of the study area is listed in Table 6-1 below.

Vegetation complex	Extent in CMA 1	Extent in CMA 2	Extent in CMA 3
Quindalup Complex	60%	84%	98%
Cottesloe Complex – North	0	0	2%
Cottesloe Complex – Central and South	40%	16%	0

Table 6-1: Extent of vegetation complexes in study area and each CMA.



6.3Bush Forever Sites

Introduced by the State Government in December 2000, Bush Forever is the whole of government strategic plan to protect 51,200 hectares of regionally significant bushland on the Swan Coastal Plain portion of the Perth Metropolitan Region. It seeks to represent at least 10% of each of the original Heddle vegetation complexes where more than 10% currently remains. There are 287 Bush Forever sites.

Bush Forever seeks to establish a 'CAR' (Comprehensive, Adequate and Representative) conservation reserve system of protected areas under the Government's commitment to the 1996 National Strategy for the Conservation of Australia's Biological Diversity for the Swan Coastal Plain portion of the Perth Metropolitan Region (Urban Bushland Council of WA 2020).

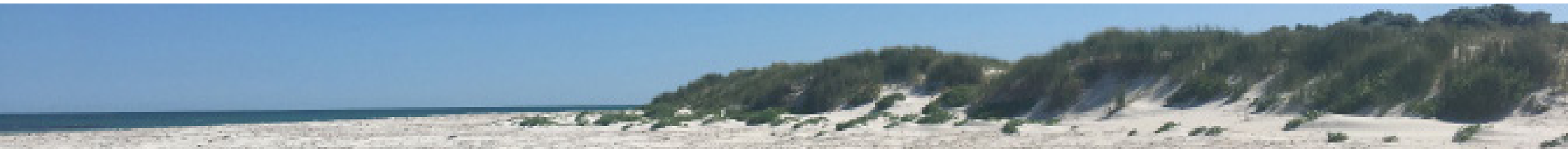
Four Bush Forever sites are present in the City of Wanneroo:

- Bush Forever Site 289
  - Is referred to as Ningana Bushland Yanchep / Eglinton. It is 551.5ha and encompasses both Spearwood Dunes with associated Cottesloe North vegetation complex and Quindalup Dunes and associated Quindalup vegetation complex. More than 60% of the Site is in Excellent to Very Good condition. Vegetation types within the site include:
    - *Eucalyptus gomphocephala* open woodland to woodland
    - *Banksia attenuata* woodlands
    - Open to low closed heaths of *Melaleuca systena* and *Acacia* species over herblands
    - Closed low heaths to shrubland of *Olearia axillaris – Scaevola crassifolia* shrublands
- Bush Forever Site 322
  - Is referred to as Burns Beach Bushland and is 407.9 ha. It encompasses both Spearwood Dunes with associated Central/South Cottesloe vegetation complex and Quindalup Dunes with Safety Bay sands and associated Quindalup vegetation complex. More than 70% of the Site is in Excellent to Pristine condition. Vegetation types within the site include:
    - *Banksia attenuata* – Eucalyptus woodlands
    - *Acacia rostellifera* – Melaleuca systena shrublands
    - *Olearia axillaris* – Scaevola crassifolia shrublands
    - *Spinifex longifolius* grasslands and low shrubland.
- Bush Forever Site 323
  - Is a link from Burns Beach Bushland to Neerabup National Park and is 106.1 ha. It encompasses Spearwood Dunes with Tamala Limestone sands and Quindalup Dunes with Safety Bay sands. Vegetation complexes are Cottesloe Central and South vegetation complex and Quindalup vegetation complex. Less than 30% of the Site is in Good to Very Good Condition. Vegetation types within the site include:
    - Northern Spearwood shrublands and woodlands
    - Spearwood *Banksia attenuate* or *Banksia attenuata – Eucalyptus* woodlands
    - *Acacia* shrublands on taller dunes
- Bush Forever Site 397
  - Is the Coastal Strip from Wilbinga to Mindarie, and is 404.7ha in area. Floristically it is similar to Burns Beach Bushland, consisting of Spearwood Dunes with Tamala Limestone sands under Cottesloe Central and South vegetation complex, and Quindalup Dunes with Safety Bay sand under the Quindalup vegetation complex. There is a sumpland within the site that is the only one in the Quindalup Dunes north of Perth in the Perth Metropolitan Region. Vegetation types within the Site include:
    - *Acacia rostellifera – Melaleuca systena* shrublands
    - *Olearia axillaris – Scaevola crassifolia* shrublands
    - *Spinifex longifolius* grasslands
    - Low shrubland.
    - *Frankenia pauciflora* low shrubland on Tamala Limestone Cliffs (seasonal wetland)

The area of each Bush Forever site that occurs in each of the CMAs of the study area is listed in Table 6-2 below.

Bush Forever Site	% of site in CMA 1	% of site in CMA 2	% of site in CMA 3
289	0	10	4
322	22	0	0
323	2.4	0	0
397	4	14	10

Table 6.2: Extent of Bush forever sites in each CMA.



6.4 Vegetation communities and condition

6.4.1 CMA 1

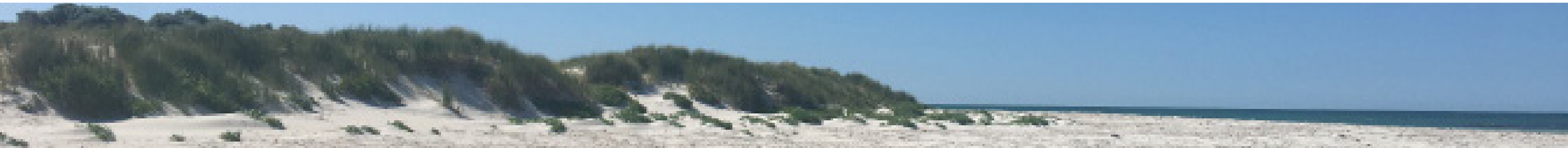
CMA 1 supports 609 ha of the Quindalup Vegetation Complex and 417 Ha of the Cottesloe Central and South Vegetation Complex. The coastal vegetation communities within these in CMA 1 range from low closed heath to open heath, low shrubland, low closed forest, herbland, grassland and sedgeland. Key overstorey species are *Acacias* and *Melaleucas* with a range of other woody species, herbs and grasses. Further information on the mapped vegetation communities is presented in Appendix 2.

Vegetation condition in the CMA is variable. Most of the communities mapped in the foreshore reserve are in 'Good' or 'Very Good' condition, with degraded areas occurring near tracks and in areas adjacent to housing or other infrastructure, with a number of garden escapes colonising bare and disturbed areas.

Vegetation communities of conservation significance which have previously been recorded in CMA 1 are presented in Table 6.3. These are mapped in Appendix 5.4.

Table 6.3 Vegetation communities of conservation significance in CMA 1

Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Section (extent / location)
Melaleuca huegelii - Melaleuca acerosa (currently M. systena) shrublands on limestone ridges (Gibson et al. 1994) FCT 26a	Threatened ecological community -Endangered	-	Occurs on skeletal soil on ridge slopes and ridge tops and is known from massive limestone ridges.	The north eastern corner of the CMA is within close proximity to the buffer for an occurrence of this community (MP Rogers & Assoc. 2015; CoW GIS data 2020)
Acacia shrublands on taller dunes FCT 29b	Priority Ecological Community -Priority 3	-	Community is dominated by Acacia shrublands or mixed heaths on the larger dunes. No consistent dominant but species such as *Acacia rostellifera, Acacia lasiocarpa*, and *Melaleuca acerosa* were important.	Occurs in the south western corner of the CMA (MP Rogers & Assoc. 2015; CoW GIS data 2020)
Coastal shrublands on shallow sands, southern Swan Coastal Plain ('floristic community type 29a')	Priority Ecological Community -Priority 3	-	Mostly heaths on shallow sands over limestone close to the coast. No single dominant but important species include Spyridium globulosum, Rhagodia baccata, and Olearia axillaris (Parks and Wildlife 2014).	Occurs in the south western corner of the CMA (CoW GIS data 2020)
Northern Spearwood shrublands and woodlands (FCT 24) (can be a component of the Endangered *Banksia* Woodlands of the Swan Coastal Plain EPBC listed)	Priority Ecological Community -Priority 3	Endangered (part)	Heaths with scattered *Eucalyptus gomphocephala* occurring on deeper soils north from Woodman Point. Most sites occur on the Cottesloe unit of the Spearwood system. The heathlands in this group typically include *Dryandra sessilis, Calothamnus quadrifidus*, and *Schoenus grandiflorus*	Occurs in the southern corner of the CMA (offshore) (CoW GIS data 2020)



Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Section (extent / location)
Banksia Woodlands of the Swan Coastal Plain ecological community	Priority Ecological Community -Priority 3	Endangered	A woodland associated with the Swan Coastal Plain of southwest Western Australia. It typically has a prominent tree layer of Banksia sometimes with scattered eucalypts and other tree species present within or above the *Banksia* canopy. The understorey is species rich and has many wildflowers, including sclerophyllous shrubs, sedges and herbs (DAWE 2020)	Not shown on CoW GIS data but community may occur within area (EPBC Act Protected Matters Search Tool 2020)
Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community	Priority Ecological Community -Priority 3	Critically endangered		Not shown on CoW GIS mapping but community likely to occur within area (EPBC Act Protected Matters Search Tool 2020)

6.4.2 CMA 2

CMA 2 supports 1416 ha of the Quindalup Vegetation Complex and 248 ha of the Cottesloe – Central and South Vegetation Complex. The foreshore vegetation within these complexes in CMA 2 consists generally of heaths and woodlands. Further information on the mapped vegetation communities is presented in Appendix 2.

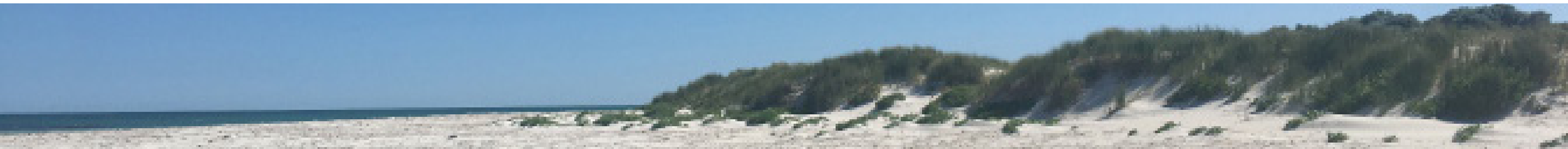
Vegetation condition in the CMA is also variable. The communities mapped in foreshore management plans in Excellent condition generally support relatively undisturbed, remnant vegetation and a low density of weeds. Areas in Very Good or Good condition include intact remnant vegetation, as well as scattered patches of weeds.

Examples of areas in lesser condition include sand (dune) blow outs e.g. alongside the Alkimos wreck (Completely Degraded) or cleared patched behind foredunes, along the edges of pedestrian tracks or along tracks made withing the foreshore reserve by unrestricted 4WD access. These tracks are evident in the aerial photography for the CMA.

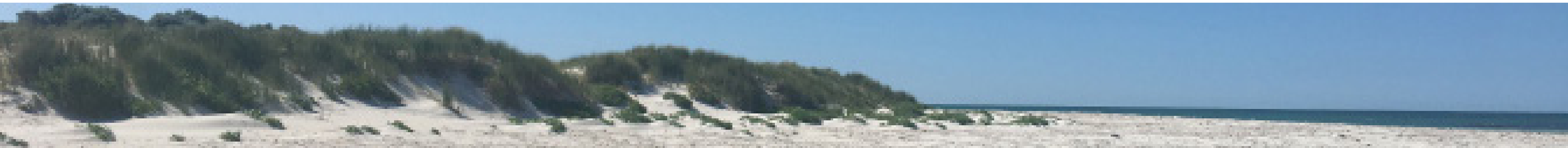
Vegetation communities of conservation significance which have previously been recorded in CMA 2 are presented in Table 1-4. The legislative context and definitions of conservation significance are presented in Appendix 4. Communities are mapped in Appendix 5.3.

Table 6.4 Vegetation communities of conservation significance in CMA 2

Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Section (extent / location)
Aquatic Root Mat Community Number 1 of Caves of the Swan Coastal Plain	Threatened Ecological Community – Critically Endangered	Endangered	At Yanchep and on the Leeuwin Naturaliste Ridge, permanent streams and pools occur in caves and some support dense growths of root mats (English et al 2000). The root mats provide a constant and abundant primary food source for some of the richest aquatic cave communities known (English et al 2000).	Only occur within the City of Wanneroo in caves at Yanchep National Park. Buffer (5000m) of TEC occurs within the northern end of the CMA (MP Rogers & Assoc. 2015; CoW GIS data 2020)



Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Section (extent / location)
Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Threatened Ecological Community – Critically Endangered	Endangered	Sedgelands in Holocene dune swales community occurs in linear damplands and occasionally sumplands, between Holocene dunes (DEC 2011). Typical and common native species are the shrubs *Acacia rostellifera, Acacia saligna, Xanthorrhoea preissii,* the sedges *Baumea juncea, Ficinia nodosa, Lepidosperma gladiatum*, and the grass *Poa porphyroclados* (DEC 2011).	The present known extent is approximately 193 ha mostly occurring between parallel sand ridges of the Rockingham-Becher Plain; there are also some small occurrences at Yanchep and Dalyellup. Occurrence in City of Wanneroo is approximately 4 km inland from coast. Buffer of TEC occurs within the study area (DEC 2011; MP Rogers & Assoc. 2015).
Melaleuca huegelii - *Melaleuca acerosa* (currently M. systena) shrublands on limestone ridges (Gibson et al. 1994) FCT 26a	Threatened Ecological Community – Endangered	-	Occurs on skeletal soil on ridge slopes and ridge tops and is known from massive limestone ridges around Yanchep north of Perth and South of Perth near Lake Clifton (Luu and English 2005).	Buffer (5000m) of community is in the central part of the CMA (MP Rogers & Assoc. 2015; CoW GIS mapping 2020)
Acacia shrublands on taller dunes FCT 29b	Priority Ecological Community -Priority 3	-	Community is dominated by Acacia shrublands or mixed heaths on the larger dunes. No consistent dominant but species such as *Acacia rostellifera, Acacia lasiocarpa*, and *Melaleuca acerosa* were important	Not mapped is the City's GIS data but potentially occurs in the North Alkimos foreshore reserve (Cardno 2012; MP Rogers & Assoc. 2015; CoW GIS data 2020)
Banksia Woodlands of the Swan Coastal Plain ecological community	Priority Ecological Community -Priority 3	Endangered	A woodland associated with the Swan Coastal Plain of southwest Western Australia. It typically has a prominent tree layer of Banksia sometimes with scattered eucalypts and other tree species present within or above the Banksia canopy. The understorey is species rich and has many wildflowers, including sclerophyllous shrubs, sedges and herbs (DAWE 2020)	Not shown on CoW GIS data but community may occur within area (EPBC Act Protected Matters Search Tool 2020)



Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Section (extent / location)
Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community	Priority Ecological Community -Priority 3	Critically endangered		Not shown on CoW GIS mapping but community likely to occur within area (EPBC Act Protected Matters Search Tool 2020)

6.4.3 CMA 3

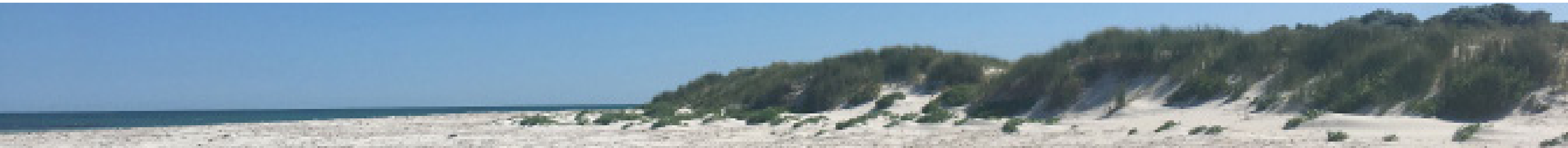
CMA 3 supports 2582 ha of the Quindalup Vegetation Complex and 0.12 ha of the Cottesloe – North Vegetation Complex. The coastal vegetation communities within these complexes in CMA 3 range from open and closed heaths, shrublands, scrubs, low closed forest, grassland and sedgeland. Further information on the mapped vegetation communities is presented in Appendix 2.

Vegetation condition in the CMA is variable. It is generally in 'Good' to 'Very Good Condition'. However, in some areas it is Degraded or Completely Degraded due to anthropogenic disturbance (e.g. by weed incursion, trampling dune vegetation and vehicle tracks for access to the beach) (using the Keighery 1994 scale).

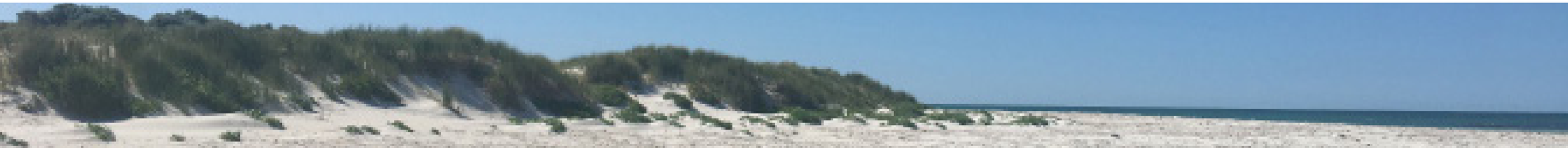
Vegetation communities of conservation significance which have previously been recorded in CMA 3 are presented in Table 6.5. These are mapped in Appendix 5.4.

Table 6.5 Vegetation communities of conservation significance in CMA 3

Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Seection (extent / location)
Aquatic Root Mat Community Number 1 of Caves of the Swan Coastal Plain	Threatened Ecological Community – Critically Endangered	Endangered	At Yanchep and on the Leeuwin Naturaliste Ridge, permanent streams and pools occur in caves and some support dense growths of root mats (English et al 2000). The root mats provide a constant and abundant primary food source for some of the richest aquatic cave communities known (English et al 2000).	Only occur within the City of Wanneroo in caves at Yanchep National Park. Buffer (5000m) of TEC occurs within the northern end of the CMA (MP Rogers & Assoc. 2015; CoW GIS data 2020)
Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Threatened Ecological Community – Critically Endangered	Endangered	Sedgelands in Holocene dune swales community occurs in linear damplands and occasionally sumplands, between Holocene dunes (DEC 2011). Typical and common native species are the shrubs *Acacia rostellifera, Acacia saligna, Xanthorrhoea preissii,* the sedges *Baumea juncea, Ficinia nodosa, Lepidosperma gladiatum*, and the grass *Poa porphyroclados* (DEC 2011).	The present known extent is approximately 193 ha mostly occurring between parallel sand ridges of the Rockingham-Becher Plain; there are also some small occurrences at Yanchep and Dalyellup. Occurrence in City of Wanneroo is approximately 4 km inland from coast. Buffer of TEC occurs within the study area (DEC 2011; MP Rogers & Assoc. 2015).



Community and floristic community type (FCT)	Status in WA	Status EPBC Act	Description	Seection (extent / location)
Melaleuca huegelii - Melaleuca acerosa (currently M. systena) shrublands on limestone ridges (Gibson et al. 1994) FCT 26a	Threatened Ecological Community – Endangered	-	Occurs on skeletal soil on ridge slopes and ridge tops and is known from massive limestone ridges around Yanchep north of Perth and South of Perth near Lake Clifton (Luu and English 2005).	Buffer (5000m) of community is in the central part of the CMA (MP Rogers & Assoc. 2015; CoW GIS mapping 2020)
Acacia shrublands on taller dunes FCT 29b	Priority Ecological Community -Priority 3	-	Community is dominated by Acacia shrublands or mixed heaths on the larger dunes. No consistent dominant but species such as *Acacia rostellifera, Acacia lasiocarpa*, and *Melaleuca acerosa* were important	Not mapped is the City's GIS data but potentially occurs in the North Alkimos foreshore reserve (Cardno 2012; MP Rogers & Assoc. 2015; CoW GIS data 2020)
Banksia Woodlands of the Swan Coastal Plain ecological community	Priority Ecological Community -Priority 3	Endangered	A woodland associated with the Swan Coastal Plain of southwest Western Australia. It typically has a prominent tree layer of Banksia sometimes with scattered eucalypts and other tree species present within or above the Banksia canopy. The understorey is species rich and has many wildflowers, including sclerophyllous shrubs, sedges and herbs (DAWE 2020)	Not shown on CoW GIS data but community may occur within area (EPBC Act Protected Matters Search Tool 2020)
Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community	Priority Ecological Community -Priority 3	Critically endangered		Not shown on Cow GIS mapping but community likely to occur within area (EPBC Act Protected Matters Search Tool 2020)



6.5Flora species of conservation significance

6.5.1 CMA 1

Several flora species of conservation significance have been recorded in CMA 1. The records held by the Western Australian Herbarium and shown on NatureMap (GOW 2020c) are listed in listed in Table 6-6. Some species are not shown on NatureMap but have been identified in foreshore management plans, these are also indicated in Table 6-6.

Table 6.6 Flora species of conservation significance in CMA 1.

Scientific name	Status in WA	EPBC Act	Habitat
Conostylis bracteata	Priority 3	-	Sand, limestone. Consolidated sand dunes.
Eucalyptus argutifolia (Wabling Hill Mallee, Yanchep Mallee)	Threatened species - Vulnerable	Vulnerable	Grows in shallow soils over limestone and on slopes or gullies of limestone ridges and outcrops.
Jacksonia gracillima	Priority 3	-	Variable
Lasiopetalum membranaceum Not listed in Naturemap. Indicated in Ecoscape (2003) survey referred to in Mindarie - Quinns Rocks FMP (2004)	Priority 3	-	Sand over limestone
Marianthus paralius	Threatened species - Endangered	Endangered	Grows in dry white sand over limestone.
Stylidium maritimum	Priority 3	-	Grows in coastal heath and shrubland and open Banksia woodland
Tetraria sp. Chandala (G.J. Keighery 17055)	Priority 2	-	Variable

The Protected Matters Search Tool for the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 lists several other threatened species which may occur in the CMA, or for which habitat may occur. These are included in Appendix 2.

6.5.2 CMA 2

Several flora species of conservation significance have been recorded in CMA 2. The records held by the Western Australian Herbarium and shown on NatureMap (GOW 2020c) are listed in listed in Table 6-7.

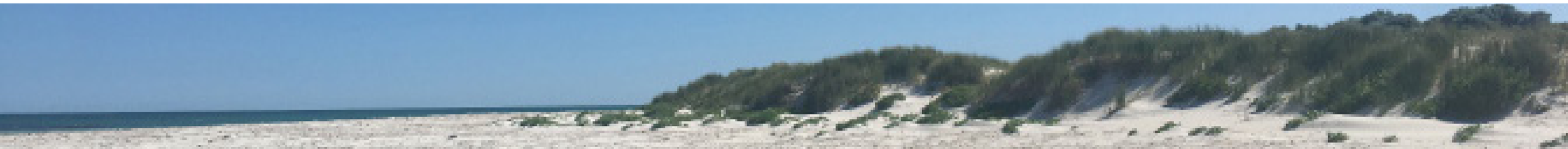


Table 6.7 Flora species of conservation significance in CMA 2.

Scientific name	Status in WA	EPBC Act	Habitat
Leucopogon maritimus	Priority 1	-	Near-coastal Quindalup dunes. Deep, calcareous sands, on the mid to upper slopes of dunes or in shallow sand over limestone, but avoiding the thicker vegetation of the swales. Low heathland communities dominated by *Melaleuca systena, Acanthocarpus preissii, Acacia lasiocarpa* and *Olearia axillaris*, sometimes in close proximity to the common coastal epacrids *Leucopogon parviflorus* and *L. insularis.* (Hislop 2011)
Hibbertia leptotheca (syn. Hibbertia spicata subsp. *leptotheca)*	Priority 3	-	Occurs in coastal and near-coastal sites, growing in sand over limestone in coastal heaths and thickets usually dominated by species of *Melaleuca* and *Acacia* (Thiele 2019).
Stylidium maritimum	Priority 3	-	Grows in coastal heath and shrubland and open Banksia woodland
Conostylis pauciflora subsp. *euryrhipis*	Priority 4	-	White, grey or yellow sand. Consolidated dunes (Western Australian Herbarium 2020)

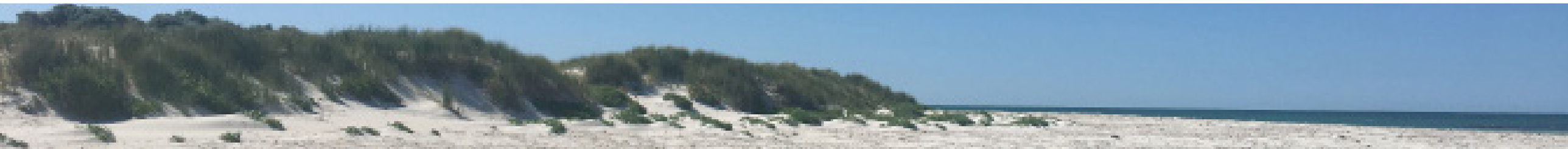
The Protected Matters Search Tool for the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 lists several other threatened species which may occur in the CMA, or for which habitat may occur. These are included in Appendix 2.

6.5.3 CMA 3

Several flora species of conservation significance have been recorded in CMA 3. The records held by the Western Australian Herbarium and shown on NatureMap (GOW 2020c) are listed in listed in Table 6-8.

Table 6.8 Flora species of conservation significance in CMA 3.

Scientific name	Status in WA	EPBC Act	Habitat
Leucopogon maritimus	Priority 1	-	Near-coastal Quindalup dunes. Deep, calcareous sands, on the mid to upper slopes of dunes or in shallow sand over limestone, but avoiding the thicker vegetation of the swales. Low heathland communities dominated by *Melaleuca systena, Acanthocarpus preissii, Acacia lasiocarpa* and *Olearia axillaris*, sometimes in close proximity to the common coastal epacrids *Leucopogon parviflorus* and *L. insularis.* (Hislop 2011)
Hibbertia leptotheca (syn. Hibbertia spicata subsp. *leptotheca)*	Priority 3	-	Occurs in coastal and near-coastal sites, growing in sand over limestone in coastal heaths and thickets usually dominated by species of *Melaleuca* and *Acacia* (Thiele 2019).



Scientific name	Status in WA	EPBC Act	Habitat
Stylidium maritimum	Priority 3	-	Grows in coastal heath and shrubland and open Banksia woodland
Leucopogon sp. Yanchep (M. Hislop 1986)	Priority 3	-	Light grey-yellow sand, brown loam, limestone, laterite, granite. Coastal plain, breakaways, valley slopes, low hills (Western Australian Herbarium 2020)
Lepidium pseudotasmanicum	Priority 4	-	Loam, sand (Western Australian Herbarium 2020).

The Protected Matters Search Tool for the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 lists several other threatened species which may occur in the CMA, or for which habitat may occur. These are included in Appendix 2.

6.6 Environmental hazards and threats

The City of Wanneroo is experiencing rapid urbanisation and land-use change, which generally results in loss of vegetation and threatens biodiversity. There are several environmental hazards and threats which apply to the whole coastline of the City of Wanneroo. These include urban development and associated land clearing, habitat fragmentation, weeds, plant pathogens, bushfire, uncontrolled access, lack of awareness and climate change.

6.6.1 Urban development and land clearing

Land clearing for development is the biggest threat to biodiversity in the City of Wanneroo. Between 2001 and 2005, 1,192 ha of native vegetation was cleared and between 2011 and 2016, 1,450 ha was cleared. Land clearing causes habitat fragmentation, leading to an increasing number of isolated areas, which are then more vulnerable to the effects of climate change, disease and weed invasion. Land clearing has specific implications on the natural environment in the study area, which include:

- Altered hydrology
  - Constructed roads and impervious surfaces with traditional piped drainage networks and altered topography significantly alter the natural hydrological regime. Stormwater flows through urban areas into natural waterways, bringing with it litter, chemicals, nutrient and sediments that impact on water quality in wetlands and waterways. With an increase in urban development there is an increase in stormwater flows, with greater potential for impact to water quality (360 Environmental nd).
- Soil erosion
  - Particularly in vulnerable areas where vegetation helps to bind unconsolidated sediments such as in dunal or highly erosive systems

Increased greenhouse gas emissions

  - Through the loss of vegetation and carbon sequestration opportunities

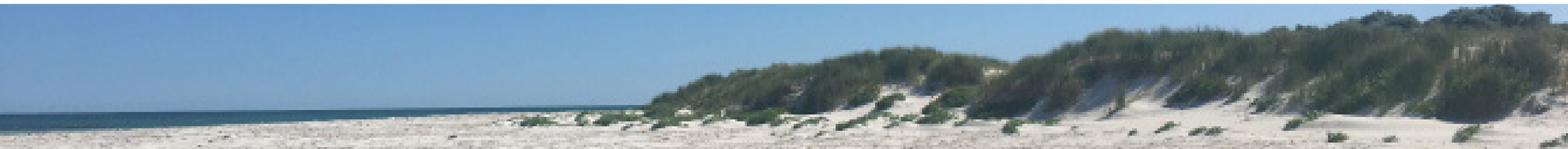
Land clearing within the City of Wanneroo is expected to increase with ongoing urban expansion as a result of population growth, which will require considered planning for long term sustainability and biodiversity protection.

Urban development, without adequate planning controls and monitoring, also has the potential to impact on flora and vegetation through the following:

- Accidental clearing of vegetation outside of the agreed clearing footprint
- Degradation of vegetation as a result of edge effects in areas adjacent to the clearing footprint
- The spread of weeds and pathogens as a result of clearing
- Disturbance to vegetation as a result of unauthorised third-party access
- Fragmentation, and reduction in area of intact remnant vegetation communities of conservation significance.

6.6.2 Habitat fragmentation

Habitat fragmentation is a key threatening process which can lead to a loss of biodiversity. When habitats become fragmented through land clearing, development and land use change, the ability of native animals and plants to disperse across landscapes is affected, as is the ability of populations to re-colonise areas after a disturbance. This results in the continued loss of species across the broader landscape long after the initial clearing has occurred (360 Environmental nd).



6.6.3 Weeds

A number of introduced (weed) species have been identified in the study area. Weeds often invade native vegetation and subsequently have negative impacts on the biodiversity of flora and fauna, fire management regimes, dune stability and erosion. Weeds often respond positively and rapidly to land or habitat disturbance, such as clearing, rubbish dumping, trampling and fire. Weeds create a number of issues for biodiversity within the City of Wanneroo including:

- Competition with native vegetation by inhibiting growth, seedling recruitment and displacing native species
- Replacement of diverse native plant communities with more uniform weed communities
- Changing the structure of vegetation communities, often by the removal of the shrub layer or native ground covers.
- Changing nutrient cycling of native communities
- Altering soil acidity
- Altering geomorphic processes, such as increased or decreased erosion
- Weeds may increase bushfire risk
- Reducing resources available for fauna by altering the habitat
- Loss of species and genetic diversity
- Some weeds are poisonous to native fauna.

The introduction and spread of weed species or diseases has the potential to occur through a number of means, particularly associated with spread from vehicles and machinery. The key activities which may result in the introduction and spread of weed and diseases include:

- Movement of vehicles, machinery and people along tracks, roads or in intact bushland; or to and from development areas
- Importation of material containing weeds or diseases may cause introduction of new diseases or weed infestations to the City of Wanneroo

6.6.4 Pathogens

Plant pathogens such as Phytophthora (*Phytophthora cinnamomi*), Honey Fungus (*Armillaria luteobalbina*) and Cankers also have the potential to threaten the integrity of the native vegetation in the City of Wanneroo.

While there is no evidence of these pathogens in the study area, and the coastal soils are not particularly favourable for Phytophthora, steps should be taken to ensure that infection does not occur, particularly during development or rehabilitation activities. It is important to practice soil hygiene; for example, ensuring that any soil brought in during construction or landscaping is not from an infected area. Infected soil can be moved around on vehicles or bikes, footwear, animal movements, road construction and earth moving equipment.

6.6.5 Bushfire

The majority of the study area is in a Bushfire Prone Area (Appendix 5.1). The frequency of bushfires in Western Australia has increased in the past decade and these changed fire regimes are a major threat to native species population reduction and extinction. Increasingly, fire regimes are characterised by very large recurrent fires with shorter intervals between fires. Intense fires impact on the populations of sensitive species and fires that are too frequent may result in limited population recovery. The impacts of bushfires on biodiversity within the City of Wanneroo potentially include:

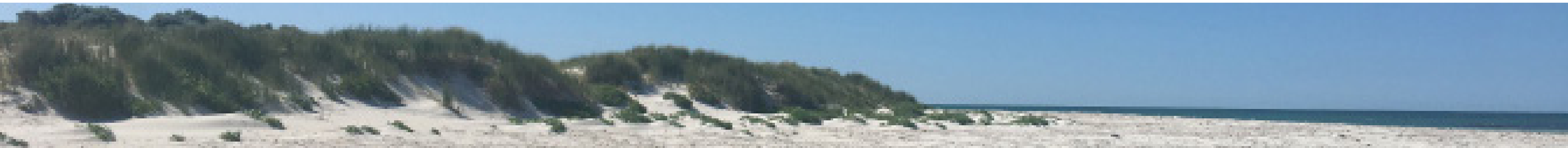
- Reduction in native species and increased weed infestation
- Reduction in success of re-sprouting of native plants after each fire
- Significant reduction in above-ground material including leaf litter and logs, which are important habitats for native fauna species
- High mortality of native fauna species (360 Environmental nd)

6.6.6 Lack of Awareness

Knowledge and awareness of local biodiversity within the community is critical to improving behaviours and attitudes towards the natural environment and reducing damage due to anthropogenic factors. The City of Wanneroo has an important role in promoting environmental awareness, engaging the community in biodiversity conservation and educating the public, schools, universities and businesses (360 Environmental nd).

6.6.7 Uncontrolled Access

Uncontrolled access to natural areas for recreational activities such as trail bike riding and four-wheel driving are a threat to the native flora, fauna and habitats in the study area. People use vehicles in bushland and along the coast for transport and recreational purposes which can cause significant damage to landscapes through physical removal of vegetation, soil compaction, introduction of pathogens, soil disturbance and disturbance to fauna. Uncontrolled pedestrian access within natural areas can lead to trampling of vegetation, disturbance of soil surfaces leading to erosion and reduction in aesthetic values of the natural landscape (360 Environmental nd)



6.6.8 Climate Change

Climate change is a threat to biodiversity within the study area. The southwest of Western Australia is becoming a hotter and drier climate with more frequent and severe bushfires and extreme weather events. Temperature changes in Wanneroo are in line with the Perth average of a 0.5°C increase, and projections indicate an increase of between 0.5°C and 2.1°C by 2030. Drought months are predicted to increase by 40% by 2030 and seasonal rainfall decline will continue to intensify. The impacts of climate change on biodiversity include:

- Reduced water availability in wetlands and other groundwater dependant ecosystems, and deterioration of water quality causing negative ecological impacts
- Changes to wildlife migration patterns
- Changes to critical seasonal timing of reproduction
- Movement of species to areas of adequate rainfall causing a reduction in local biodiversity
- Damage to natural areas causing hazards for wildlife
- Erosion and inundation of sensitive dune ecosystems threatening coastal biodiversity (360 Environmental nd).

6.6.9 CMA 1

Weeds

Some weed species which have been recorded in CMA 1 are aggressive colonisers of disturbed areas. They may require management and monitoring. Examples include:

- Sea spinach (*Tetragonia decumbens*)
- Rose Pelargonium (*Pelargonium capitatum*)
- Geraldton Carnation Weed (*Euphorbia terracina*)
- Gazania (*Gazania linearis*)
- Mediterranean Turnip (*Brassica tournefortii*)
- Great Brome (*Bromus diandrus*)
- Hare's Tail Grass (*Lagurus ovatus*)
- Coast Teatree (*Leptospermum laevigatum*)

Vulnerable areas

The City of Wanneroo CHRMAP Part 1 Coastal Vulnerability Study & Hazard Mapping identified several values within the study area as having high or moderate vulnerability.

Ecological values with high vulnerability were generally known only from potential coastal erosion zones in CoW, had few known records or were unlikely to have adaptive capacity. These values were:

- The conservation listed flora species *Marianthus paralius*
- The Priority Ecological Community (PEC) *Acacia* shrublands on taller dunes (29b)
- The Priority Ecological Community (PEC) Coastal shrublands on shallow sands (29a)

Ecological values with moderate vulnerability include those that could potentially be impacted, as records were limited to the coastline, but they had scope for adaptive capacity. Values with moderate vulnerability were:

- The Environmentally Sensitive Area (ESA) Bush Forever Site 322

6.6.10 CMA 2

Weeds

A number of weed species are present in CMA Two. In particular, species which are aggressive colonisers of disturbed areas and require management and monitoring include:

- Sea spinach (*Tetragonia decumbens*) (North Alkimos, Amberton)
- Rose Pelargonium (*Pelargonium capitatum*) (North Alkimos, Amberton))
- Geraldton Carnation Weed (*Euphorbia terracina*) (Amberton)
- Hare's Tail Grass (*Lagurus ovatus*) (Amberton)
- Dune Onion Weed (*Trachyandra divaricate*) (Amberton)
- Perennial Veldt Grass (*Ehrharta calycina*) (Amberton)

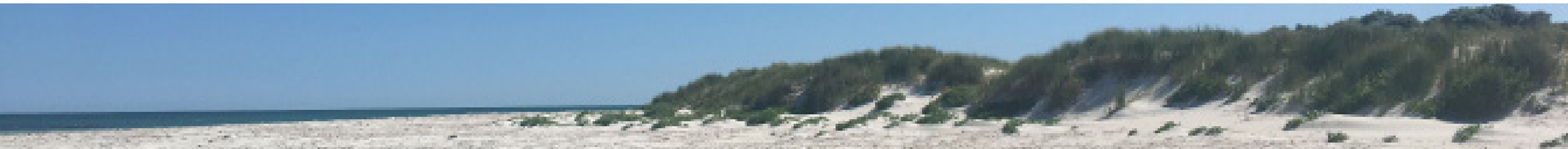
Erosion

Erosion caused by the use of four-wheel drives and subsequent loss of vegetation is present in this CMA. An example is the dunal blowout near the Alkimos Wreck which was caused by human pressure and further activated by the strong winds (sea breezes and easterlies). The dynamic nature of the blowout means it is likely to remain unstable unless significant works are undertaken to stabilise the sand (Cardno 2012).

Erosion caused by the removal of vegetation is also present in this CMA. This creates unstable dune systems which can lead to further erosion and the creation of blow outs (Emerge Associates 2016).

Vulnerable areas

The City of Wanneroo CHRMAP Part 1 Coastal Vulnerability Study & Hazard Mapping identified several values within the study area as having high or moderate vulnerability.



Ecological values with high vulnerability were generally known only from potential coastal erosion zones in CoW, had few known records or were unlikely to have adaptive capacity. These values were:

- The Priority Ecological Community (PEC) *Acacia* shrublands on taller dunes (29b)
- The Environmentally Sensitive Area (ESA) Bush Forever Site 397.

Ecological values with moderate vulnerability include those that could potentially be impacted, as records were limited to the coastline, but they had scope for adaptive capacity. Values with moderate vulnerability were:

- The conservation listed flora species *Leucopogon maritimus*
- The Environmentally Sensitive Area (ESA) Bush Forever Site 289

Drainage and stormwater runoff

As development increases in the CoW, the quantity of stormwater runoff will also increase due to the increase of impermeable surfaces. Drainage and runoff within the foreshore reserves could threaten the ecological integrity of these reserves and requires appropriate management to ensure any runoff is treated, contained and used appropriately.

6.6.11 CMA 3

Weeds

Some weed species recorded in CMA 3 are aggressive colonisers of disturbed areas. They may require management and monitoring. Examples include:

- Geraldton Carnation Weed (*Euphorbia terracina*)
- Mediterranean Turnip (*Brassica tournefortii*)
- Great Brome (*Bromus diandrus*)
- Hare's Tail Grass (*Lagurus ovatus*)
- Coast Teatree (*Leptospermum laevigatum*)
- Sea spinach (*Tetragonia decumbens*)
- Pyp Grass (*Ehrharta villosa*)
- Rose Pelargonium (*Pelargonium capitatum*)
- Dune Onion Weed (*Trachyandra divaricate*)
- Gazania (*Gazania linearis*)
- White Arctotis (*Arctotis stoechadifolia*)
- Perennial Veldt Grass (*Ehrharta calycina*)

Vulnerable areas

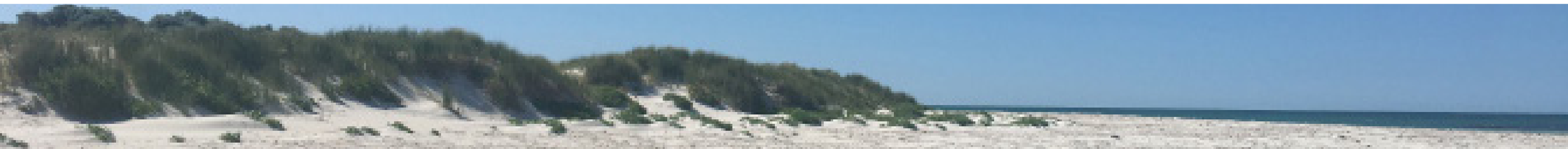
The City of Wanneroo CHRMAP Part 1 Coastal Vulnerability Study & Hazard Mapping identified several values within the study area as having high or moderate vulnerability.

Ecological values with high vulnerability were generally known only from potential coastal erosion zones in CoW, had few known records or were unlikely to have adaptive capacity. These values were:

- The Priority Ecological Community (PEC) Coastal shrublands on shallow sands (29a)
- The Priority Ecological Community (PEC) *Acacia* shrublands on taller dunes (29b)
- The Environmentally Sensitive Area (ESA) Bush Forever Site 397.

Ecological values with moderate vulnerability include those that could potentially be impacted, as records were limited to the coastline, but they had scope for adaptive capacity. Values with moderate vulnerability were:

- The conservation listed flora species *Leucopogon maritimus*
- The Environmentally Sensitive Area (ESA) Bush Forever Site 289



7. FAUNA

7.1 Fauna species and habitat

7.1.1 CMA 1

The vegetation and fauna habitats in CMA 1 are a complex mosaic of communities and habitat types. The distribution of communities and habitats is influenced by exposure, topography, geomorphology, soil depth and extent of disturbance. As a result, fauna habitats are diverse and an array of fauna types are present.

Historical surveys of the fauna of the Swan Coastal Plain have recorded a variety of reptiles, amphibians, mammals and birds. Particularly well represented in the dunal zones are reptiles, such as the legless lizards (*Pygopodidae*), skinks, and elapid snakes (Ecoscape 2004). The dunal zone, due to the presence of limestone, is twice as rich as other areas of the Swan Coastal Plain in geckos (Ecoscape 2004).

Over thirty species of reptiles have been recorded in the two Bush Forever Sites (322 and 323), which are partly within CMA 1 (Ecoscape 2004). Reptiles were recorded in the Quindalup coastal heath in a survey in 1998, including Burton's Legless Lizard (*Lialis burtonis*); Western Bearded Dragon (*Pogona minor*); West Coast Ctenotus (*Ctenotus fallens*); Gould's Snake (*Rhinoplocephalus gouldii*); and the Western Pale Flecked Morethia (*Morethia lineoocellata*).

Amphibians are also present in the dunal zone of the metropolitan area but to a lesser extent due to the lack of unpolluted, consistent areas of fresh surface water in the dunes. Species previously observed include the frogs Turtle Frog (*Myobatrachus gouldii*) in the Burns Beach Bush Forever site and Moaning Frog (*Heleloporus eyrie*) and Pobblebonk (*Lymnodynastes dorsalis*) in the Quindalup coastal heath (Ecoscape 2004).

Over ten native mammal species have been recorded from the northern section of the Swan Coastal Plain, which includes CMA 1. In the two Bush Forever sites, four native mammal species were recorded, with two significant species, known to be poorly represented, observed in the Burns Beach Bushland. These are the Western Brush Wallaby (*Macropus irma*) and the Honey Possum (*Tarsipes rostratus*) (Ecoscape 2004).

Birds are also prevalent in the CMA due to the diversity of habitats available. The coastal strip from Wilbinga to Mindarie consists of several major habitats. The heathland nearest the coast is the habitat of over 20 bird species. Fifty four bird species have been observed at Bush Forever Site 322.

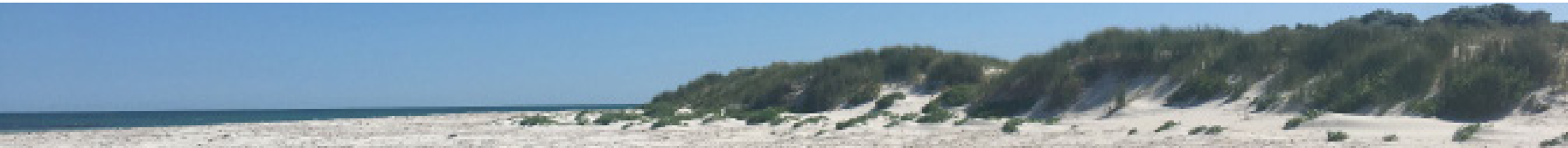
Other significant species recorded in the coastal area of Wanneroo include the White-Winged Fairy Wren, White-Browed Scrubwren, White-Breasted Robin, New Holland Honeyeater and Carnaby's Black Cockatoo. The results of a comprehensive survey undertaken by Jones and Gole (2003) in the parks and reserves in the City of Wanneroo are presented in Appendix 3, along with other results identified in FMPs. It should be noted that many of these surveys are over thirty years old and these species may or may not continue to be present within the CMA.

NatureMap indicates that 64 fauna species have been recorded in this CMA in surveys registered with the Western Australian Museum (NatureMap 2020). The ten species of conservation significance in this CMA, or in the marine area off the coast, are listed below in Table 7.1.

The Protected Matters Search Tool for the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 lists several other threatened species which may occur in the CMA, or for which habitat may occur. These are included in Appendix 3.

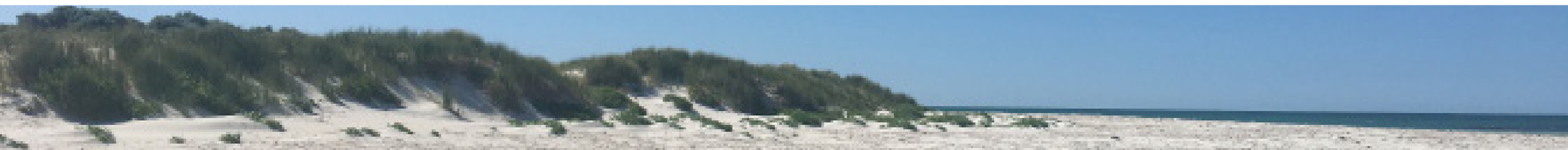
Table 7.1 Species of conservation significance in CMA 1

Scientific name	Common name	Status in WA	EPBC Act	Habitat
Actitis hypoleucos	Common Sandpiper	International agreement (IA)	Marine Migratory	Coastal or inland wetlands, both saline or fresh. It is found mainly on muddy edges or rocky shores. Breeds in Europe and Asia. It visits Australia, mainly in the north and west (Birdlife 2020)
Thalasseus bergii	Crested Tern	International agreement (IA)	Marine Migratory	Coastal and riverine environments
Synemon gratiosa	Graceful Sunmoth	Priority 4	-	Coastal heathland on Quindalup dunes where it is restricted to secondary sand dunes due to the abundance of the preferred host plant *Lomandra maritima*. Also, Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant *L. hermaphrodita* is widespread (DAWE 2020).
Megaptera novaeangliae	Humpback Whale	Priority 5 (Conservation Dependent)	Vulnerable Cetacean Migratory	Marine species. Migration pathway for the western Australian population is generally within 200 km from shore (DAWE 2020)



Scientific name	Common name	Status in WA	EPBC Act	Habitat
Caretta caretta	Loggerhead Turtle	Endangered	Endangered	Use a wide variety of tidal and sub-tidal habitat as feeding areas. They occur in waters with both hard and soft substrates including rocky and coral reefs, muddy bays, sandflats, estuaries and seagrass meadows. Require sandy beaches to nest. Sand temperatures between 25–33 °C are needed for successful incubation. Beaches free from light pollution are required to prevent disorientation, disturbance and to allow nesting females to come ashore (DAWE 2020).
Calyptorhynchus latirostris	Carnaby's Cockatoo; White-tailed Short-billed Black Cockatoo	Endangered	Endangered	Native woodlands dominated by eucalypts such as Wandoo and Salmon Gum, as well as nearby heathlands. From late winter till summer, they usually occur in these habitats in inland parts of their range, and in late summer they move to coastal and near-coastal areas, when they sometimes occur in built-up areas (Birdlife 2020).
Isoodon fusciventer	Quenda ; Southwestern brown bandicoot	Priority 4	-	Forest, woodlands, heath and coastal scrub, usually on sandy combination soils (ALA 2020)
Neelaps calonotos	Black-striped burrowing snake	Priority 3	-	Banksia woodlands and sandy areas (ALA 2020).

Scientific name	Common name	Status in WA	EPBC Act	Habitat
Pandion cristatus	Eastern Osprey	International agreement (IA)	-	Littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They require extensive areas of open fresh, brackish or saline water for foraging. They frequent a variety of wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes. Preference for coastal cliffs and elevated islands in some parts of their range, but may also occur on low sandy, muddy or rocky shores and over coral cays. They may occur over atypical habitats such as heath, woodland or forest when travelling to and from foraging sites (DAWE 2020).
Chelonia mydas	Green Turtle	Vulnerable	Vulnerable Marine Migratory	Spend first five to ten years drifting on ocean currents. Then settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds. The shallow foraging habitat of adults contains seagrass beds or algae mats on which Green Turtles mainly feed (DAWE 2020)



7.1.2 CMA 2

The range and quality of habitats in CMA 2 are likely to support a high diversity of fauna species. This is particularly due to the connectivity of the CMA with other vegetated areas and the foreshore reserve forming a linkage along the coast (Cardno 2012). The foreshore reserve provides habitat for small birds, mammals, reptiles, frogs and invertebrates who seek shelter within areas of native vegetation.

Maintaining connectivity and improving fauna habitat values (through revegetation in degraded areas) is an important consideration for the City of Waneroo.

Bush Forever Sites 289 and 397 are included in this CMA. A limited survey of site 397 in 1990 observed 30 bird species, with 16 of these considered significant species.

Fifty-six species, ranging from birds, mammals, reptiles, frogs and invertebrates, have been recorded in this CMA in surveys registered with the Western Australian Museum (NatureMap 2020) (Appendix 3). FMPs also include information on species recorded during associated surveys. Where available, species lists are included in Appendix 3.

The three species of conservation significance previously recorded in this CMA are listed below in Table 7.2.

Table 7.2 Species of conservation significance in CMA 2

Scientific name	Common name	Status in WA	EPBC Act	Habitat and distribution
Calyptorhynchus latirostris	Carnaby's Cockatoo; White-tailed Short-billed Black Cockatoo	Endangered	Endangered	Native woodlands dominated by eucalypts such as Wandoo and Salmon Gum, as well as nearby heathlands. From late winter till summer, they usually occur in these habitats in inland parts of their range, and in late summer they move to coastal and near-coastal areas, when they sometimes occur in built-up areas (Birdlife 2020).
Thalasseus bergii	Crested Tern	International agreement (IA)	Marine Migratory	Coastal and riverine environments
Synemon gratiosa	Graceful Sunmoth	Priority 4	-	Coastal heathland on Quindalup dunes where it is restricted to secondary sand dunes due to the abundance of the preferred host plant *Lomandra maritima*. Also, Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant *L. hermaphrodita* is widespread (DAWE 2020).

The Protected Matters Search Tool for the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 lists several other threatened species which may occur in the CMA, or for which habitat may occur. These are included in Appendix 3.

7.1.3 CMA 3

The fauna species and habitats in CMA 3 are typical of heathland on coastal dunes, located throughout the Swan Coastal Plain Bioregion. The area is likely to contain a moderate level of species richness which would be expected in relatively undisturbed intact heathland vegetation.

Fauna species which inhabit this CMA include birds, reptiles, mammals, frogs, fish and invertebrates. Ninety nine species have been recorded in this CMA in surveys registered with the Western Australian Museum (NatureMap 2020). However, many of them are fish recorded offshore. FMPs also include information on species recorded during associated surveys. Where available, species lists are included in Appendix 2.

The 20 species of conservation significance previously recorded in this CMA, or in the marine area off the coast, are listed below in Table 7.3.

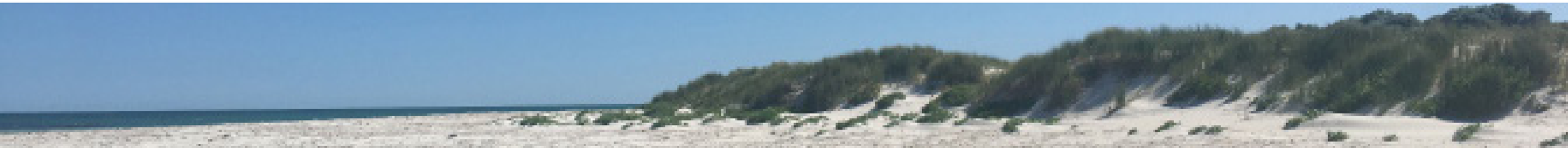
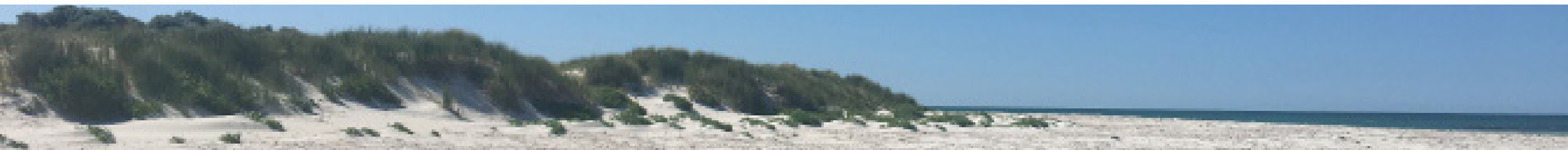
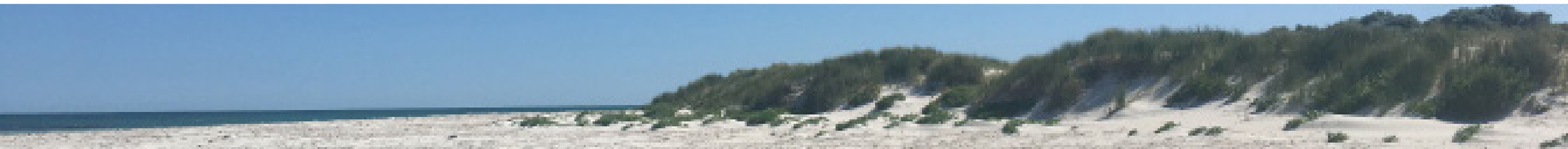


Table 7.3 Species of conservation significance in CMA 3

Scientific name	Common name	Status in WA	EPBC Act	Habitat
Isoodon fusciventer	Quenda ; Southwestern brown bandicoot	Priority 4	-	Forest, woodlands, heath and coastal scrub, usually on sandy combination soils (ALA 2020)
Actitis hypoleucos	Common Sandpiper	International agreement (IA)	Marine Migratory	Coastal or inland wetlands, both saline or fresh. It is found mainly on muddy edges or rocky shores. Breeds in Europe and Asia. It visits Australia, mainly in the north and west (Birdlife 2020)
Arenaria interpres	Ruddy Turnstone	International agreement (IA)	Marine Migratory	Along the coastline and only occasionally inland. They are mainly found on exposed rocks or reefs, often with shallow pools, and on beaches. In the north, they are found in a wider range of habitats, including mudflats (Birdlife 2020).
Calidris alba	Sanderling	International agreement (IA)	Marine Migratory	Open sandy beaches at the edge of the waves, on sandbars and spits. They roost on bare sand in the dunes or behind piles of kelp (Birdlife 2020).
Calidris ruficollis	Red-necked Stint	International agreement (IA)	Marine Migratory	On the coast, in sheltered inlets, bays, lagoons, estuaries, intertidal mudflats and protected sandy or coralline shores. They may also be seen in saltworks, sewage farms, saltmarsh, shallow wetlands including lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in saltflats, flooded paddocks or damp grasslands. They are often in dense flocks, feeding or roosting (Birdlife 2020).
Hydroprogne caspia	Caspian Tern	International agreement (IA)	Marine Migratory	Sheltered coastal embayments (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins. They also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks. They also use artificial wetlands, including reservoirs, sewage ponds and saltworks. In offshore areas the species prefers sheltered situations, particularly near islands, and is rarely seen beyond reefs. Large numbers may shelter along the coast, behind coastal sand-dunes or coastal lakes during rough weather, and have been recorded inland after storms (DAWE 2020).

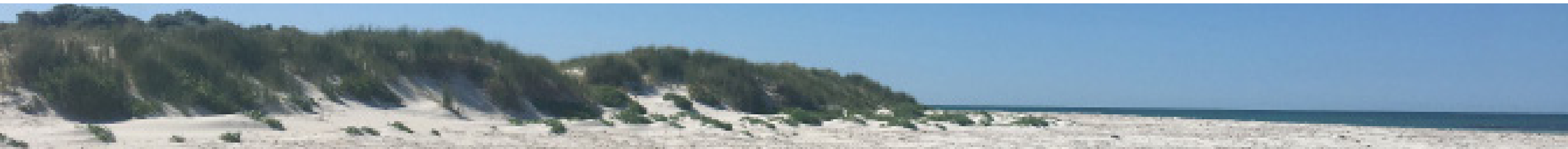


Scientific name	Common name	Status in WA	EPBC Act	Habitat
Macronectes giganteus	Southern Giant Petrel	Priority 4	Endangered Marine Migratory	A marine bird that occurs in Antarctic to subtropical waters. In summer, it mainly occurs over Antarctic waters. At sea, it feeds mainly on the surface, but might occasionally dive to shallow depths. On the pack-ice, it will roost on icebergs and snow slopes at the sea edge. It may occur in both pelagic and inshore waters. It may be attracted to land at sewage outfalls. It can scavenge ashore and distribution may shift towards land in summer, when birds frequent penguin and seal colonies (DAWE 2020).
Onychoprion anaethetus	Bridled Tern	International agreement (IA)	Marine Migratory	Tropical and subtropical seas, breeding on islands, including vegetated coral cays, rocky continental islands and rock stacks. Only rarely found in inshore continental waters and along mainland coastlines, though the species breeds on the mainland of far southern Western Australia. During the breeding season, birds forage over offshore, mid- and outer continental shelf waters, usually within approximately 70 km of breeding colonies but mostly within 20–40 km of a colony 9DAWE 2020).
Sterna dougallii subsp. *gracilis*	Roseate Tern	International agreement (IA)	Marine Migratory	Coastal and marine areas in subtropical and tropical seas. The species inhabits rocky and sandy beaches, coral reefs, sand cays and offshore islands. Birds rarely occur in inshore waters or near the mainland, usually venturing into these areas only accidentally, when nesting islands are nearby (DAWE 2020).
Thalasseus bergii	Crested Tern	International agreement (IA)	Marine Migratory	Coastal and riverine environments
Synemon gratiosa	Graceful Sunmoth	Priority 4	-	Coastal heathland on Quindalup dunes where it is restricted to secondary sand dunes due to the abundance of the preferred host plant *Lomandra maritima*. Also, Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant *L. hermaphrodita* is widespread (DAWE 2020).
Tringa brevipes	Grey-tailed Tattler	-	Marine Migratory	Sheltered coasts with reefs and rock platforms or with intertidal mudflats. It can also be found at intertidal rocky, coral or stony reefs as well as platforms and islets that are exposed at low tide (DAWE 2020).
Megaptera novaeangliae	Humpback Whale	Priority 5 (Conservation Dependent)	Vulnerable Cetacean Migratory	Marine species. Migration pathway for the western Australian population is generally within 200 km from shore (DAWE 2020)



Scientific name	Common name	Status in WA	EPBC Act	Habitat
Caretta caretta	Loggerhead Turtle	Endangered	Endangered	Use a wide variety of tidal and sub-tidal habitat as feeding areas. They occur in waters with both hard and soft substrates including rocky and coral reefs, muddy bays, sandflats, estuaries and seagrass meadows. Require sandy beaches to nest. Sand temperatures between 25–33 °C are needed for successful incubation. Beaches free from light pollution are required to prevent disorientation, disturbance and to allow nesting females to come ashore (DAWE 2020).
Chelonia mydas	Green Turtle	Vulnerable	Vulnerable Marine Migratory	Spend first five to ten years drifting on ocean currents. Then settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds. The shallow foraging habitat of adults contains seagrass beds or algae mats on which Green Turtles mainly feed (DAWE 2020)
Dermochelys coriacea	Leatherback Turtle	Vulnerable	Endangered Marine Migratory	A highly pelagic species, can be found foraging year round over Australian continental shelf waters, venturing close to shore during the nesting season. Requires sandy beaches to nest, some evidence that coarser sand is more conducive to successful hatching than finer sand. Sand temperatures between 24–34 °C are needed for successful incubation. Beaches free from light pollution are required to prevent disorientation, disturbance and to allow nesting females to come ashore (DAWE 2020).
Neophoca cinerea	Australian Sea-lion	Vulnerable	Vulnerable Marine	A wide variety of habitats for breeding sites and during the non-breeding season for haul-out sites (rest stops, which are also useful for predator avoidance, thermal regulation and social activity). Onshore habitats include exposed islands and reefs, rocky terrain, sandy beaches and vegetated fore dunes and swales. They also use caves and deep cliff overhangs as haul-out sites or breeding habitat (DAWE 2020)
Calyptorhynchus latirostris	Carnaby's Cockatoo; White-tailed Short-billed Black Cockatoo	Endangered	Endangered	Native woodlands dominated by eucalypts such as Wandoo and Salmon Gum, as well as nearby heathlands. From late winter till summer, they usually occur in these habitats in inland parts of their range, and in late summer they move to coastal and near-coastal areas, when they sometimes occur in built-up areas (Birdlife 2020).
Arctocephalus forsteri	New Zealand Fur Seal	Other protected fauna	Marine	Rocky coastlines and offshore islands characterised by large, jumbled angular rocks, boulder-strewn beaches, smooth rock platforms and some vegetated areas (ALA 2020).

The Protected Matters Search Tool for the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 lists several other threatened species which may occur in the CMA, or for which habitat may occur. These are included in Appendix 3.



7.2 Environmental hazards and threats

Many of the environmental hazards and threats that impact upon flora species and fevegation communities also apply to fauna species and their habitats (Refer chapter 6.6). Specific threats to fauna and habitats in each of the CMAs are listed below.

7.2.1 CMA 1

Pest/feral animals

Pests animals are a key threat to biodiversity in Western Australia causing a decline in native species populations due to changes to competition, predation, mortality or habitat degradation.

Several species of feral animals are present in CMA 1. These include Cat (*Felis catus*), European Red Fox (*Vulpes vulpes*), Rabbit (*Oryctolagus cuniculus*), Domestic Dog (*Canis familiaris*), House Mouse (*Mus musculus*), Black Rat (*Rattus rattus*), Laughing Turtle Dove (*Streptopelia senegalensis*), Galah (*Cacatua rosecapilla*) and Rainbow Lorikeet (*Trichoglossus haematodus*).

The feral rodents, House Mouse and Black Rat, are ubiquitous species commonly associated with human settlement. Feral cats and foxes are predators of a wide range of small native animals, including birds, mammals, frogs and reptiles. The European Rabbit poses a significant threat to the germination of seedlings, particularly after bushfires (Ecoscape 2004).

Vulnerable areas or species

The City of Wanneroo CHRMAP Part 1 Coastal Vulnerability Study & Hazard Mapping identified several fauna species or habitats within the study area as having high or moderate vulnerability.

Ecological values with high vulnerability were those that generally only occurred in potential coastal erosion zones in the CoW, had few known records, or were unlikely to have adaptive capacity. These values were:

- The Priority Ecological Community (PEC) *Acacia* shrublands on taller dunes (29b)
- The Priority Ecological Community (PEC) Coastal shrublands on shallow sands (29a)

Ecological values with moderate vulnerability included those that could potentially be impacted due to records being limited to the coastline, but they did have some scope for adaptive capacity. Values with moderate vulnerability were:

- The Environmentally Sensitive Area (ESA) Bush Forever Site 322
- Carnaby's Cockatoo (*Calyptorhynchus latirostris*)
- Land snail (*Bothriembryon perobesus*) (although limited knowledge of presence in the study area and habitat)

7.2.2 CMA 2

Vulnerable areas or species

The City of Wanneroo CHRMAP Part 1 Coastal Vulnerability Study & Hazard Mapping identified several fauna species or habitats within the study area as having high or moderate vulnerability.

Ecological values with high vulnerability were generally only known from potential coastal erosion zones in CoW, had few known records, or were unlikely to have adaptive capacity. These values were:

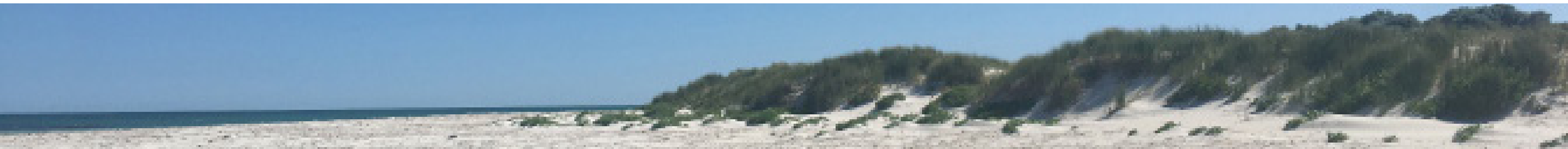
- The Priority Ecological Community (PEC) *Acacia* shrublands on taller dunes (29b)
- The Environmentally Sensitive Area (ESA) Bush Forever Site 397.

Ecological values with moderate vulnerability as included those that could potentially be impacted as records were limited to the coastline, but they had scope for adaptive capacity. Values with moderate vulnerability were:

- The Environmentally Sensitive Area (ESA) Bush Forever Site 322
- Carnaby's Cockatoo (*Calyptorhynchus latirostris*)
- Land snail (*Bothriembryon perobesus*) (although limited knowledge of presence in the study area and habitat)

Erosion

Erosion caused by the removal of vegetation and the use of four wheel drives in the dunes is present in this CMA. This creates unstable dune systems which can lead to further erosion and the creation of blow outs (Emerge Associates 2016). These processes compromise the structural integrity of the vegetation communities, and diversity of faunal habitats in these areas (Cardno 2012).



7.2.3 CMA 3

Pest/Feral Animals

Several species of feral animals have been recorded in CMA 3. These include Cat (*Felis catus*), Rabbit (*Oryctolagus cuniculus*), European Red Fox (*Vulpes vulpes*) and Domestic Dog (*Canis familiaris*). Feral cats and foxes are predators of a wide range of small native animals, including birds, mammals, frogs and reptiles. The European Rabbit poses a significant threat to the germination of seedlings, particularly after bushfires (Ecoscape 2004). Unrestrained dogs can have an impact on the natural environment as well as posing danger or distress to other recreational users. Dog faeces pose a hazard to health (Two Rocks FMP 2007).

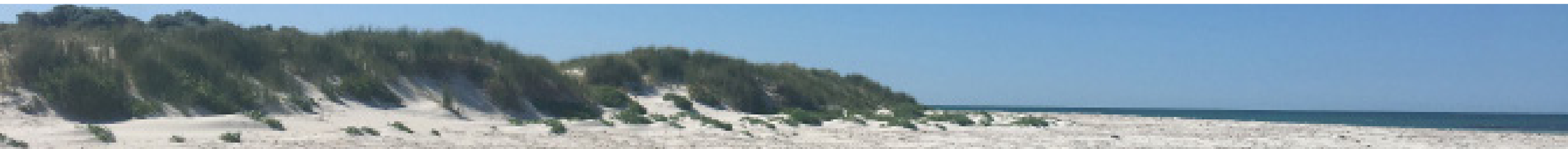
Vulnerable areas or species

The City of Wanneroo CHRMAP Part 1 Coastal Vulnerability Study & Hazard Mapping identified several fauna species or habitats within the study area as having high or moderate vulnerability. Ecological values with high vulnerability were those that generally only occurred in potential coastal erosion zones in the CoW, had few known records, or were unlikely to have adaptive capacity. These values were:

- The Priority Ecological Community (PEC) Coastal shrublands on shallow sands (29a)
- The Priority Ecological Community (PEC) *Acacia* shrublands on taller dunes (29b)
- The Environmentally Sensitive Area (ESA) Bush Forever Site 397.

Ecological values with moderate vulnerability included those that could potentially be impacted due to records being limited to the coastline, but they did have some scope for adaptive capacity. Values with moderate vulnerability were:

- The Environmentally Sensitive Area (ESA) Bush Forever Site 322
- Carnaby's Cockatoo (*Calyptorhynchus latirostris*)
- Land snail (*Bothriembryon perobesus*) (although limited knowledge of presence in the study area and habitat).



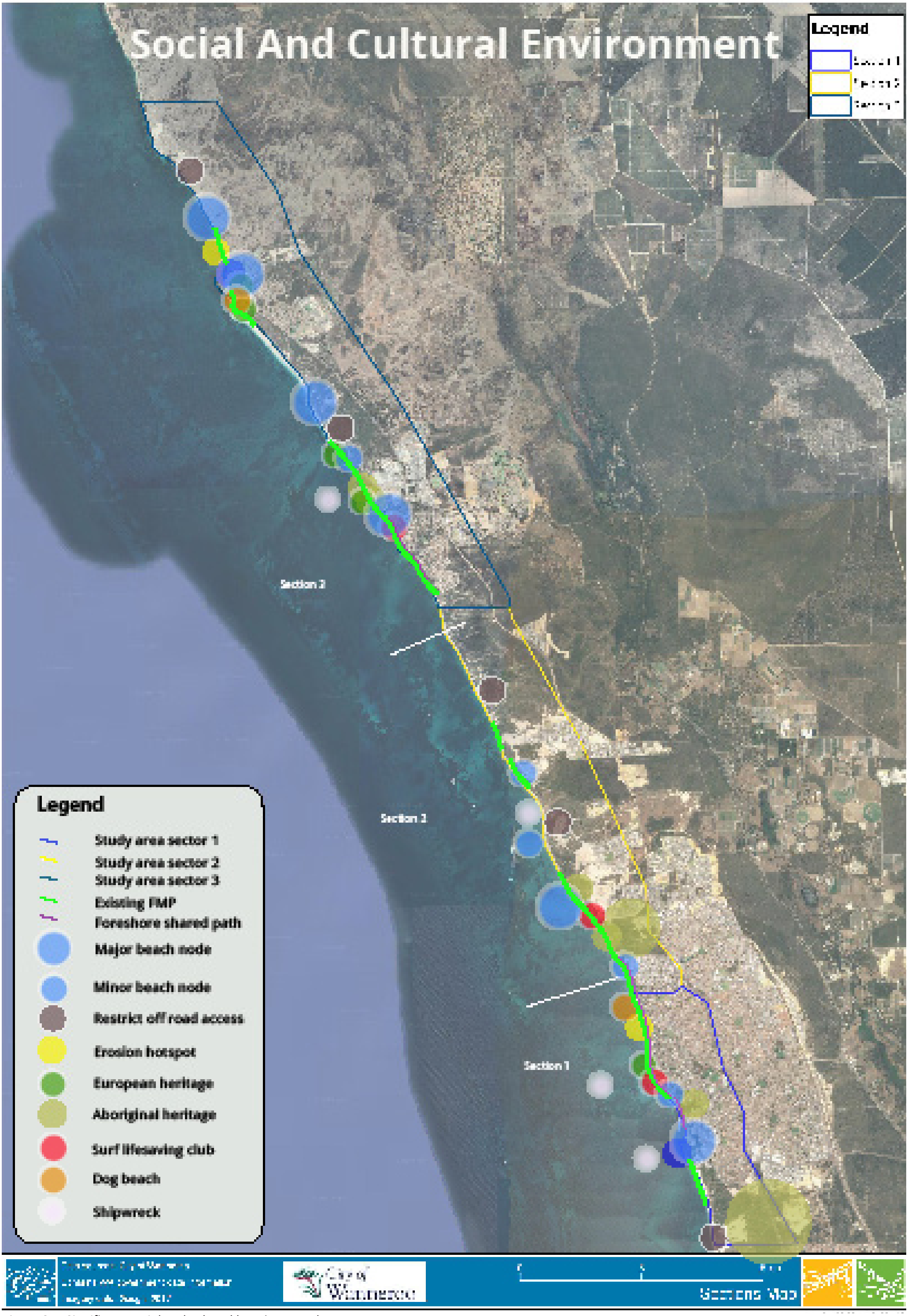


Figure 8.1 Significant social and cultural locations -study area

8 . SOCIAL AND CULTURAL CONTEXT

8.1 Introduction

The foreshore reserve that is included in this Coastal Management Plan is made up of that part of the coastal environment that is experienced by residents and visitors when they visit the beach or get involved in activities adjacent to the beach. It includes the beach, the dunes, and the adjacent road reserve as well as the natural and improved parks and facilities within this area.

The way people experience this reserve is the essence of the social and cultural environment. This chapter of the Coastal Management Plan (CMP) looks at the important elements of that interaction and the challenges and conflicts created through legislation, policy and uses with a view to improve the environment to protect and enhance.

This Section provides the research and investigation behind the Actions suggested in CMP 2020. Ongoing studies will be required to deliver site specific outcomes in areas where detailed Foreshore Management Plans do not exist.

Where further development is not proposed, this Coastal Management Plan (CMP) provides direction.

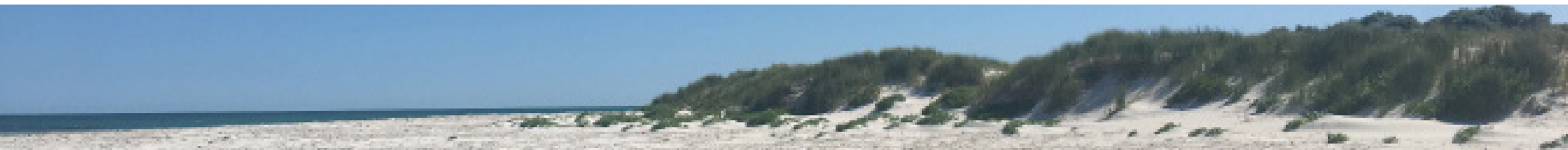
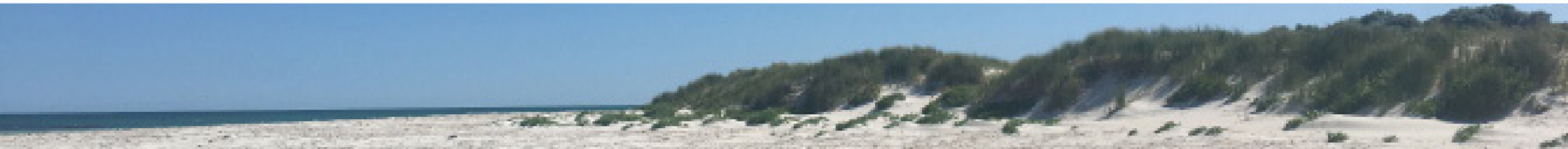


Figure 8.2 Significant social and cultural locations -CMA 1



8.2 CMA 1 - Mindarie and Quinns Rocks

This CMA of coast stretches from the southern border of the City of Wanneroo through to Jindalee Beach. It is the most developed of the three CMAs of coast (see Figure 8.2). It includes:

- Tamala Park Conservation Park;
- Catalina Beach foreshore;
- Mindarie Beach;
- Mindarie Keys with its associated Marina and Harbour including Clayton's Beach;
- Quinns Rocks Beach;
- Quinns Beach;
- Quinns Dog Beach; and
- Queenscliffe.

8.2.1 Social and cultural environment

FMPs are required for all new structure plan areas along the coast in the City of Wanneroo. For this Section of the study area there are existing Foreshore Management Plans for Catalina, Mindarie and Quinns Rocks (see Appendix 6). A structure plan has also been approved for Mindarie Keys and Harbour.
The plans, their implications and recommendations are incorporated into this CMP.

8.2.2 Land management and tenure

The land within the foreshore reserve is reserved under the Metropolitan Region Scheme as Regional Reserve, Parks and Recreation or Waterways. The land within the reserve is managed by the City of Wanneroo.

8.2.3 Existing land use and zoning

Zoning

The land within CMA 1 of the CMP is primarily reserved as Regional Reserve Parks and Recreation which reflects the Metropolitan Region Scheme reserves. The area of Mindarie Keys and Harbour is zoned as Urban and waterways under the MRS and is covered by an Approved Structure Plan providing zoning of Marina with varying densities between R20 and R60.

With the works being undertaken to construct groynes and nourish the sand at Quinns Beach there is a heightened awareness of coastal process and interest in management and adaptation. The adequacy of the reserve to provide protection in some locations has been highlighted in the CHRMAP report. The recognition of trigger points for risk to assets could enhance the understanding of where the greatest risks are and allow for acceptance of the extension of the reserve.

Land use

There are existing developments within the reserve with associated uses related to recreation and beach use including:

- Change rooms
- Toilets,
- Car parks,
- Walk and bike trails, and
- Playgrounds.

In several locations these are threatened by erosion and should be considered for relocation as part of a retreat and management process. This is referenced in more detail in 8.2.10 Land use Conflicts below.

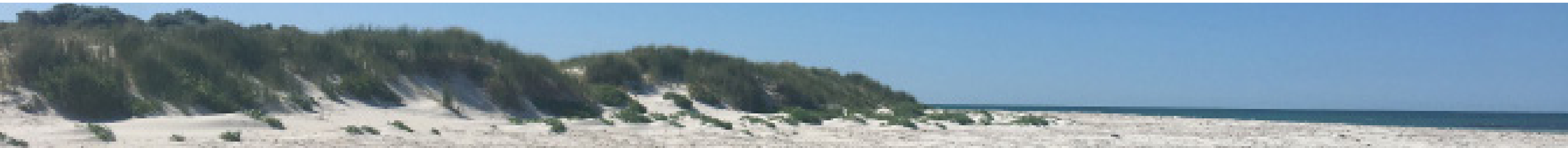
8.2.4 Recreation uses

A shared path stretches north from Rosslare park to Jindalee Beach. Extension of the path should be a priority as beach side development takes place and other access points are formalised. The ultimate aim is to create an uninterrupted path for the length of the coast From Two Rocks to Burns Beach. In the interim pedestrian and cycle access should be enhanced along existing roads.

Other recreation activities associated with the beaches include walking along formal and informal trails, running, formal and informal exercise and gathering spaces. The formalised grass areas located at Rosslare Park, Quinns Beach, Frederick Stubbs Park, Queenscliffe Park and Jindalee also provide gathering spaces

A formalised Dog exercise beach is located near Camira Way (see Figure 8.1).

Yanchep, Two Rocks and Quinns Beaches were identified in the first phase of the CHRMAP engagement as the



most popular by beach users.

Protection of natural environmental values was ranked highly by respondents to the CHRMAP engagement. The preservation of natural assets such as sand dunes and foreshore vegetation was strongly supported by the majority of respondents

To build on this support a program of rehabilitation and revegetation could be enhanced by descriptive signage to provide education and tell the story of the natural flora and fauna for the various locations.

8.2.5 Water sports

A selection of water sports are presently located within the study area including swimming, Stand up Paddle boarding, surfing, sailing, water skiing, kayaking, diving and fishing.

A Water Ski Area stretches from Quinns Beach to north of Jindalee. There is opportunity to promote beach activities along this stretch of beach for picnic and pick up locations for skiers.

Para gliding is popular along the beach with the location near the dog beach appearing to be the most accessible. There are concerns expressed about the groynes and rocks as well as conflicts with boats making the locations more limited.

A shark barrier has been installed at North Mindarie Beach creating an enclosed swimming area. This is in an area where beach facilities including change rooms, toilets, showers and Surf Life Saving Club.

Surfing often occurs at Clayton's Beach even though swimming is discouraged.

The Marina is popular for kayaking and stand up paddle boarding with commercial hiring available.

8.2.6 Vehicle access

Carparking is available at along the coast at Claytons Beach, Mindarie Keys, Rosslare Park, North Mindarie Beach, Quinns Beach, Quinns Dog Beach and Queenscliffe with several on street carparking spots near beach access points in between.

Informal beach access used by four wheel drive and other off road vehicles are observed at Tamala Conservation Park. There is a concerted effort to restrict this access as part of the rehabilitation and protection of the Tamala Conservation Park. This should be reinforced through the CMP

8.2.7 Boat launching

Recreational boating is focused on Mindarie Harbour with this being the only location for boat launching in this CMA. There are also boat pens available in the marina.

8.2.8 Pedestrian access

There was majority support in the CHRMAP engagement for ensuring ongoing access to beaches and foreshore areas for all community members.

Pedestrian access to the beach is provided at several formal and informal locations from Clayton Beach through to Jindalee. There is a strong footpath and shared path network through CMA 1 from Clayton Beach through to Jindalee Beach.

Universal Beach access is provided at North Mindarie Beach. The availability of Universal access points should be increased over time.

There is opportunity for formalising nature trails and providing sealed shared paths connecting these through undeveloped areas over the longer term.

8.2.9 Surf club locations

A Surf Lifesaving club with associated patrols is located at Quinns Rocks Beach (see Figure 8.1). The Quinns/ Mindarie SLSC has wheelchair hire and access. As beach visitation rates increase at other beaches, a lifesaving and surveillance outpost could be accommodated and connected to the nearest Surf Lifesaving Club.

8.2.10 Land use conflicts

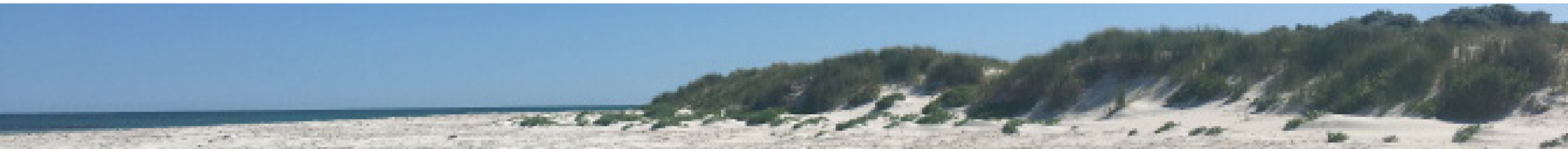
Coastal hotspots

The southern end of the sandy beach at Quinns Beach has experienced erosion since before 1970. The removal of beach shacks, installation of groynes and sand nourishment has maintained the buffer width and moved the erosion risk further north.

As per the recommendations of the Coastal erosion hotspots report, continue the preparation of planning frameworks to implement the management and adoption options focused on continuing the removal of the remaining facilities including park, playground and toilet block to landward side of Ocean drive. Longer term the report suggests a seawall structure to protect Ocean Drive. The State Hotspots Report suggests high value or long term facilities seaward of Ocean Drive and infill development near Camira Way should be avoided (see Coastal Hotspots 22 – Quinns Beach).

Unexploded ordnances

The study area is impacted significantly by the possible presence of unexploded ordnances (UXO). Specifically,



those areas that have not yet been developed need to consider the possible presence. Specific areas are listed in the southern portions of CMA 1 as UXO area ID 1041 (Location number N61 and page number C51).

Bush fire prone areas

The whole of the CMA apart from the Mindarie Keys Harbour is classified as being in a Bushfire prone area. The bush fire regulations are well managed. No action required. Any development within the areas will require additional protections.

Bush forever sites

Bush forever area cover the whole of the CMA along the foreshore reserve apart from the Mindarie Harbour. There are bush forever reserves registered for Tamala Conservation Park, Rosslare park through to behind Quinns Rocks Beach, Quinns Beach. The whole of the reserve north to Alkimos is reserved as Bush Forever.,

Bush forever sites have previously been identified as 'conservation' in the Green Growth Plan which is currently on hold.

8.2.11 Heritage

Aboriginal heritage

Aboriginal connections and cultural values are extensive for the whole CMA of coast with cultural connections identified between all CMAs. A 2005 report prepared by Estille and Associates into the Aboriginal cultural values related to the Gnangara Mound groundwater stated that several of the sites including the sites shown in the Mindarie area have interconnections through Emu Dreaming and Waugyl association (see Estille and Assoc. 2005).

Two sites of significance are the registered Aboriginal Site (3567) (Mindarie Waugyl) and Rosslare Soak (water source and camp) which is listed as an 'other Aboriginal Heritage place (24408). The CMP recognises these registered sites as a starting point.

The sensitivity of these connections, sites and cultural values should be explored through reference to local traditional owners. Consultation with local elders should be prioritised in the process to explore registered sites as well as those cultural values and connections along the coast that are not yet registered such as the Waitj Dreaming. Appropriate methods of recognition, celebration and acknowledgement and implantation should also be explored with local Elders. There may be opportunity for signposting, renaming of associated parks or locations, connecting paths and/or formal or informal trails.

European heritage

Quinns Beach House at 68 Ocean Drive, Quinns Rocks is adjacent to the study area and has historic value for its association with the development of Quinns Rock for the fishing industry and as a holiday destination in the 1950's. It is a category 4 listing and could be recognised within the foreshore with a public artwork possibly showing the view of the house from the foreshore reserve.

Shipwrecks

This CMA of the coast has 3 registered shipwrecks.

- WH Gemini 1993 Mindarie Keys,
- Klaraborg 1982
- Conference 1904 – Quinn's Rock

The wrecks could be incorporated as part of a land based or marine tourist trail which could be linked to the foreshore through landing/launch points (see http://museum.wa.gov.au/maritime-archaeology-db/wrecks/map).

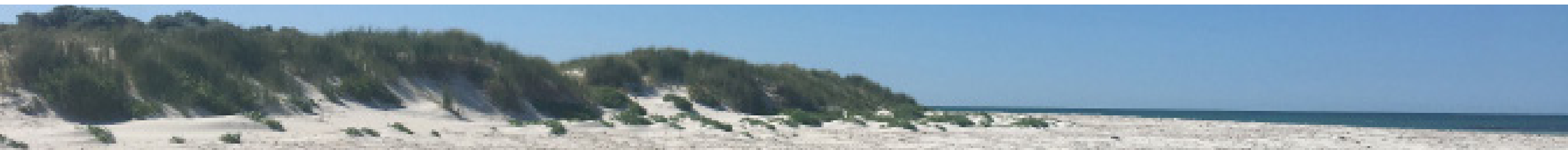
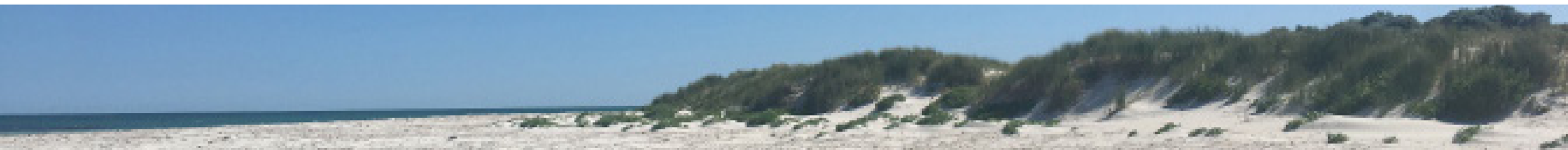


Figure 8.3 Significant social and cultural locations -CMA 2



8.3 CMA 2 – Jindalee, Alkimos and Eglinton

8.3.1 Social and cultural environment

This CMA of coast stretches from the Jindalee through to Eglinton (see Figure 8.3). It includes

- Jindalee Beach;
- Jindee Beach;
- Eden Beach;
- Alkimos Beach;
- Shorehaven Foreshore; and
- Amberton Beach.

8.3.2 Land management and tenure

This is a relatively undeveloped stretch of coast apart from break out points where adjoining residential development has created beach access at Jindalee, Eden Beach, Alkimos, Shorehaven and Amberton. There are existing Foreshore Management Plan for Jindalee, Amberton Estate (Eglinton/Alkimos) and North Alkimos (see Appendix 6). The plans, their implications and recommendations are incorporated into this CMP.

8.3.3 Existing land uses and zoning

Zoning

The land within CMA 2 of the CMP is primarily reserved under the Metropolitan Region Scheme as Regional Reserve Parks and Recreation or Waterways. The Alkimos/Eglinton Approved Structure plan provides development guidelines and future activation of the foreshore for this CMA.

Land use

There are existing developments within the reserve with associated uses related to recreation and beach use including:

- Change rooms
- Toilets,
- Car parks,
- Walk and bike trails, and
- Playgrounds.

8.3.4 Recreation uses

There is no shared path within this CMA of the study area. The path connection should be continued in stages to connect the beach nodes from Jindalee to Amberton. The ultimate aim is to create an uninterrupted path for the length of the coast From Two Rocks to Burns Beach. In the interim pedestrian and cycle access should be enhanced along existing roads.

Recreation activities associated with the beaches include walking along formal and informal trails, running, formal and informal exercise and gathering spaces. The formalised grass areas located at Jindalee, Eden Beach, Shorehaven and Amberton also provide gathering spaces. Café/Restaurant facilities exist at Eden Beach, Shorehaven and Amberton

There is no formalised dog exercise beach in this CMA. An investigation into locations to designate an extra stretch of beach as a dog exercise area is recommended to remedy this.

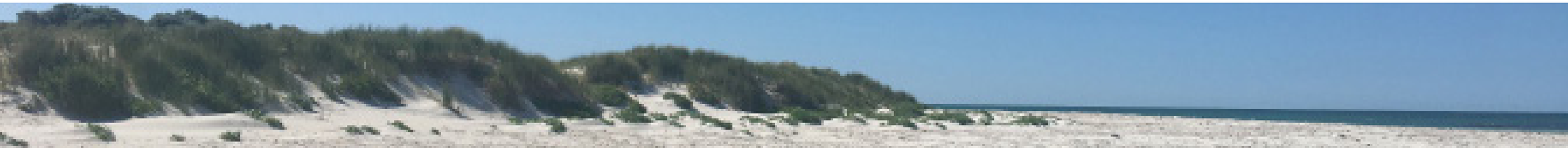
Protection of natural environmental values was ranked highly by respondents to the CHRMAP engagement. The preservation of natural assets such as sand dunes and foreshore vegetation was strongly supported by the majority of respondents

8.3.5 Water sports

A selection of water sports are presently undertaken within the study area including swimming, surfing, diving and fishing.

Surfing occurs at Alkimos although it is not shown as a recognised surf spot within the City of Wanneroo.

8.3.6 Vehicle access



Informal tracks for off road vehicles appear frequently along this CMA of coast. This should be managed through fencing and signage and education.

There are carparks developed at Jindalee Beach, Eden Beach, Alkimos Beach, Shorehaven Beach and Amberton Beach.

8.3.7 Boat launching

There are no boat launching facilities within this CMA. The Perth Boating Facility Study proposed a short-term initiative of a privately funded development of the Eglinton Marina including ramps and pens as well as a medium-term initiative of developing a new public harbour near Alkimos. These two developments would provide boat launching and storage facilities for this CMA.

8.3.8 Pedestrian access

Pedestrian Access is provided to the beach at Eden Beach, Alkimos Beach, Shorehaven Beach and Amberton Beach. There is no Universal access facilities in this CMA.

8.3.9 Surf club locations

Surf lifesaving club, changerooms, playground and Carpark are all available at Alkimos Beach (See Figure 8.2). This is the only location in this CMA. Other beaches are not serviced and may require temporary or extended patrols as popularity increases.

8.3.10 Land use conflicts

Protection of natural environmental values was ranked highly by respondents in the CHRMAP engagement along with safe and accessible use of coastal areas.

The preservation of natural assets such as sand dunes and foreshore vegetation was also strongly supported by the majority of respondents Similarly, there was majority support for ensuring ongoing access to beaches and foreshore areas for all community members.

Coastal hotspots

There were no areas of coast within this CMA addressed in the Coastal Hotspots report. Recognition of the CHRMAP risk assessment through the Physical process setback area will help to plan for any erosion and/or inundation.

Unexploded ordnances

Areas of unexploded ordnances are present through the whole of the CMA 2 with designation of slight occurrence given to the majority of the CMA as part of the UXO ID 836 with a slight occurrence status (Location number N155 and page number C112). The area around Eglinton, however, has more substantial occurrence designation.

The UXO procedures are well managed. No action required. Any development within the UXO identified areas will trigger a referral to DFES.

Bush fire prone areas

The whole of the CMA apart from Shoalhaven Beach is designated as bushfire prone. The bush fire regulations are well managed. No action required. Any development within the areas will require additional protections

Bush forever sites

The whole of the reserve is designated as bush forever. Bush forever sites have previously been identified as 'conservation' in the Green Growth Plan which is currently on hold.

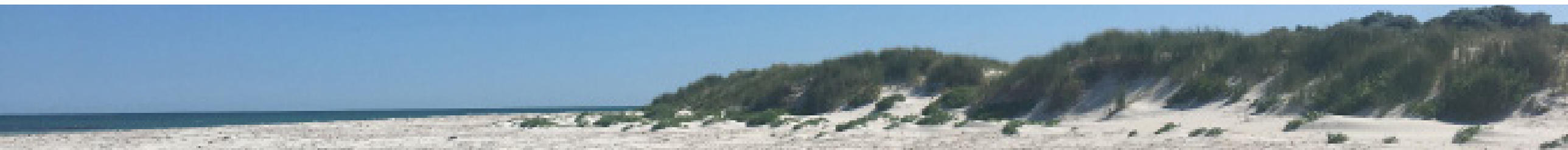
8.3.11 Heritage

Aboriginal heritage

There a registered mythological site 20772 located in the general Jindalee area; it is considered sensitive and in proximity to the coastal fringe. There is also a swamp (24404) located within the foreshore reserve. The Jindalee Foreshore Management Plan 2013 reported an earlier study commenting that the pools and swamps identified in the region are apparently associated with the drainage channels that extend across the areas resulting in an interpretation by the Elders that the spiritual water essence is the manifestation of the Creation Waugyl.

The report also commented on a DIA request to not sign areas of Aboriginal significance also noting that any signage and wording relating to Aboriginal Heritage should be approved by DIA and SWALSC.

The Alkimos Eglinton District Structure Plan included a heritage assessment which found in broad context



that the coastal dune system was expressed as being significant to Aboriginal People. Karli Springs has been protected through inclusion into a Parks and Recreation Reserve.

The sensitivity of these connections and sites should be explored through reference to local traditional owners and appropriate methods of recognition, celebration and acknowledgement should be implemented. This may be through renaming of associated parks or locations, connecting paths and/or formal trails.

A strategy should be prepared in conjunction with the local traditional owners to develop a trail to recognise the importance of aboriginal cultural connection to sites in the area even if not specific to this sensitive CMA. This plan is to include agreed recognition and naming of locations to reflect the Aboriginal Heritage and connection.

European heritage

The two sites recognised in the Heritage survey within this CMA are both shipwrecks.

Shipwrecks

The Alkimos and the Eglinton are both recognised in suburb names in proximity to the sites. The wrecks could be incorporated as part of a land based or marine tourist trail linked to the foreshore through landing/launch points (see http://museum.wa.gov.au/maritime-archaeology-db/wrecks/map).

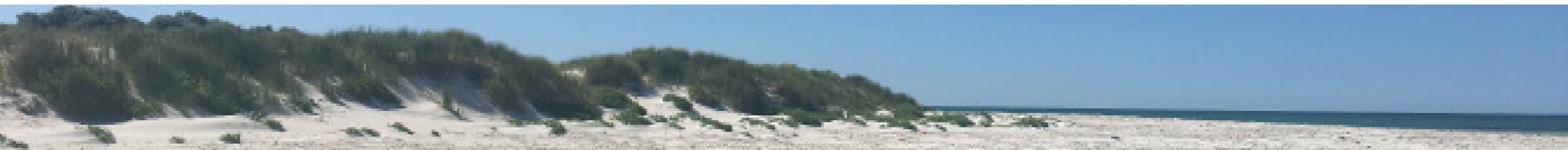
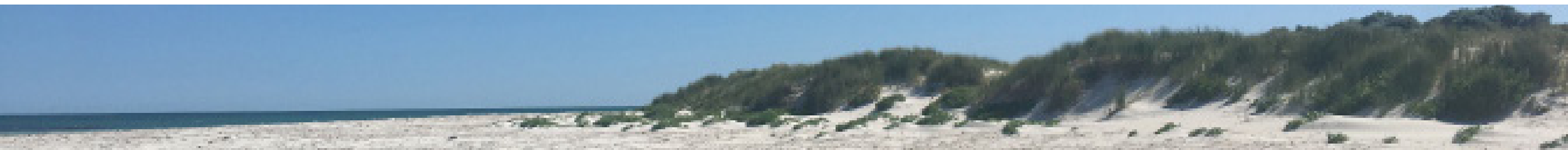


Figure 8.4 Significant Social and Cultural locations - CMA 3



8.4 CMA 3 – Yanchep and Two Rocks

8.4.1 Social and Cultural Environment

This CMA of coast stretches from the Eglinton to Wilbinga Dunes (see Figure 8.4). It includes

- Longfin
- Yanchep Dog Beach,
- Fisherman's Hollow
- Yanchep Lagoon,
- Yanchep Beach
- Capricorn
- The Spot
- Two Rocks Beach
- Two rocks Marina
- Sovereign Park; and
- Dewars Beach

8.4.2 Land management and tenure

There are existing Foreshore Management Plans for Capricorn, Yanchep and Two Rocks (see Figure 8.4).

8.4.3 Existing land uses and zoning

Zoning

The land within CMA 3 of the coastal management plan is primarily reserved as Regional Reserve Parks and Recreation which reflects the Metropolitan Region Scheme reserves. Adjacent to the reserve at Yanchep and Two Rock is residential land zoned urban under the MRS.

Land Use

Within the reserve are uses related to recreation and beach use including

- Change rooms
- Toilets,
- Car parks,
- Walk and bike trails, and
- Playgrounds.

These uses are permitted within the reserve. The Mary Lindsay Homestead which is used as a community arts centre is also located within the reserve. 4 lots zoned rural are situated on Capricorn Esplanade in proximity to the Mary Lindsay Homestead.

8.4.4 Recreation

There is a small Section of shared path within this CMA of the study area from Longfin Park to South Yanchep Lagoon. Completing the path to access the length of the residential area of Yanchep will increase use and access for cycling and walking. Ultimately connecting to Two Rocks in the north and Eglinton and Alkimos in the south will complete a coastal cycling network. The ultimate aim should be to create an uninterrupted path for the length of the coast. In the interim there should be pedestrian and cycle access along existing roads as recommended in the Yanchep Lagoon Master Plan (2019).

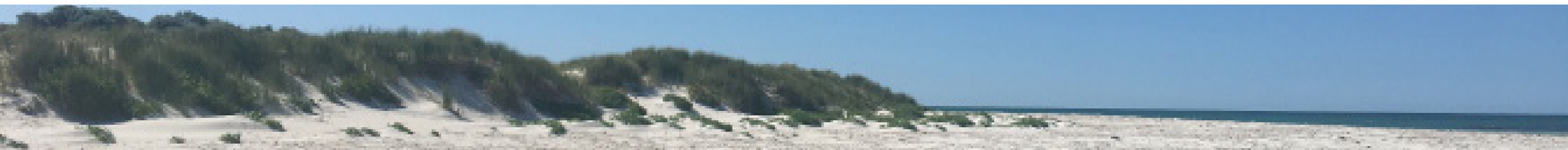
A dog exercise beach is designated in the south of Yanchep, off Compass Circle (see Figure 8.3).

Yanchep, Two Rocks and Quinns Beaches were identified in the first phase of the CHRMAP engagement as the most popular by beach users. Level of detail is not sufficient to refine the preferred beach/s

8.4.5 Water sports

A selection of water sports are presently undertaken within the study area including swimming, surfing, snorkeling, diving, fishing, sailing and recreational boating.

There is a recognised surf spot at the Spot.



8.4.6 Vehicle access

Informal Vehicle access appears to be an issue north of Two Rocks and South of Yanchep. This should be managed through fencing and signage.

There are carparks developed at Longfin Park, Yanchep Dog Beach, Fisherman's Hollow, Yanchep Lagoon, Mary Lindsay Homestead, Leeman's Landing and Two Rocks. There is also an unpaved car park at The Spot.

Other access points have small marked street parking embayments.

8.4.7 Boat launching

Boat launching facilities are available at Two Rocks (see Figure 8.3). The Department of Transport undertook an extensive community engagement exercise through 2018-2019 to develop the Two Rocks Marina Redevelopment Masterplan. The masterplan sets a frameworks for the expansion of the marina to approximately three times its current size allowing for a Hillarys style marina development in the area that also includes additional boat launching and boat pens to support anticipated population growth. The community involved indicated that they maintain a strong connection to the coastal environment and the maritime industry located at the marina.

8.4.8 Pedestrian access

Pedestrian Access is provided to the beach at several locations. The major access is at Yanchep Lagoon, where there is a carpark, and Changerooms with a Surf Lifesaving Club and Club Capricorn, although this access is steep and challenging for some. There are also less formal access points with on street parking outside of these locations.

The Two Rocks beach access feasibility study highlighted 4 designated beach access nodes; Sovereign Park Beach, Two Rocks Marina, Leeman's Landing and The Spot.

During preparation of the Two Rocks Marina Redevelopment Masterplan, the community expressed a need to be able to access the beach safely both north and south of the marina, which is currently a challenge. The redevelopment of the marina would provide increased access in the future.

8.4.9 Surf club locations

A Surf Lifesaving Club is located at Yanchep Lagoon (see Figure 8.3). This is the only location in this CMA. As beach visitation rates increase at other beaches, a lifesaving and surveillance outpost could be accommodated and connected to the nearest Surf Lifesaving Club.

8.4.10 Land use conflicts

Coastal hotspots

Protection of natural environmental values was ranked highly by in the CHRMAP engagement. Safe and accessible use of coastal areas was also ranked highly.

The preservation of natural assets such as sand dunes and foreshore vegetation was strongly supported by the majority of respondents in phase 2 of the CHRMAP engagement. Similarly, there was majority support for ensuring ongoing access to beaches and foreshore areas for all community members.

The Coastal Hotspots Report explains that the foreshore north of the Two Rocks Marina has seen 100 metres of a 200 metre setback progressively eroded since the marina was constructed. Infrastructure including stairs and a navigation lead are at risk in the short term with Sovereign Drive and the assets within the road reserve at risk longer term.

The report recommends planning for retreat in the next phase of planning, relocation of the Navigation Aid and construction of a back-up seawall (see Coastal Hotspots 21 - Two Rocks).

Unexploded ordnances

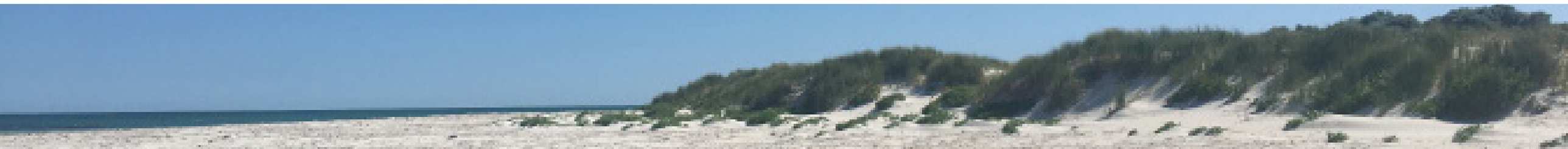
Areas of unexploded ordnances are present through the whole of the CMA 3 with designation of slight occurrence given to the majority of the CMA. The area north of Two Rocks and South to Wreck Point is designated as substantial occurrence.

Bush fire prone Areas

The whole of the CMA apart from a small area just south of Fisherman's Hollow is designated as bushfire prone. The bush fire regulations are well managed. No action required. Any development within the areas will require additional protections

Bush forever sites

The whole of the reserve is designated as bush forever. Bush forever sites have previously been identified as 'conservation' in the Green Growth Plan which is currently on hold.



8.4.11 Heritage

Aboriginal heritage

Aboriginal connections and cultural values are extensive for the whole CMA of coast with cultural connections identified between all CMAs. The Two Rocks/Yanchep FMP quotes an earlier report prepared by Lily Bhavna Kauler for Elder Harry Nannup of Aboriginal Community College, Gnangara (1997-1998) which included the following story:

"The Story has been told about the shark and the whale and the crocodile and the fight that they had and the formation of Rottnest and Garden Island and as the crocodile was walking back he laid down exhausted at what is now known as Yanchep beach and here you can see the outline of his whole skeletal frame work and it was here that he shed his skeletal frame work and then moved on."

(Adopted Two Rocks Yanchep Foreshore Management Plan May 2007).

The sensitivity of these connections and sites should be explored through reference to local traditional owners and appropriate methods of recognition, celebration and acknowledgement should be implemented. This may be through signposting, renaming of associated parks or locations, connecting paths and/or formal trails or even festivals or interpretive events.

European heritage

The heritage survey for the City recognises the place the Yanchep and Capricorn Lodge have in the story of the development of Yanchep. They are both recognised in the naming of streets and locations. The other site in Yanchep is for the Alex T Brown Shipwreck which has a plaque and monument dedicated to it.

Within Two Rocks the main focus of registration on the heritage survey is to celebrate and show the development of the town in the 1970's centered around the development of the Atlantis Resort and Theme park and the Americas Cup challenge. Several statues as well as examples of buildings have been listed.

The Leeman's Boat Landing is marked by a rock and plaque commemorating an early Dutch landing.

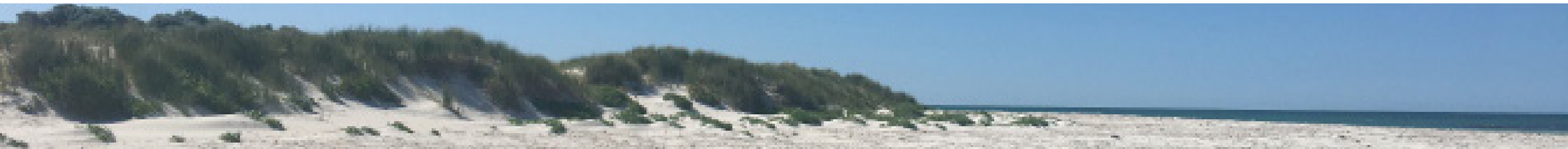
These sites could be considered as part of a heritage trail as well as the wrecks and landing sites being incorporated into a marine heritage trail.

Shipwrecks

This Section of the coast has 3 registered shipwrecks.

- Yanchep Dredge 1
- Yanchep Dredge 2
- Alex T Brown 1917/05/29 – 2 miles North Yanchep

These wrecks could be incorporated as part of a land based or marine tourist trail which could be linked to the foreshore through landing/launch points (see http://museum.wa.gov.au/maritime-archaeology-db/wrecks/map).



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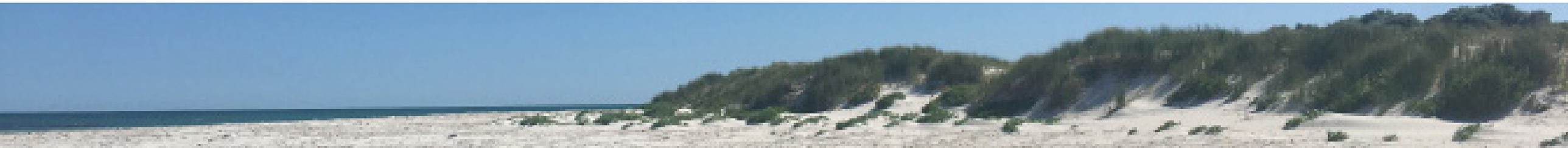

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