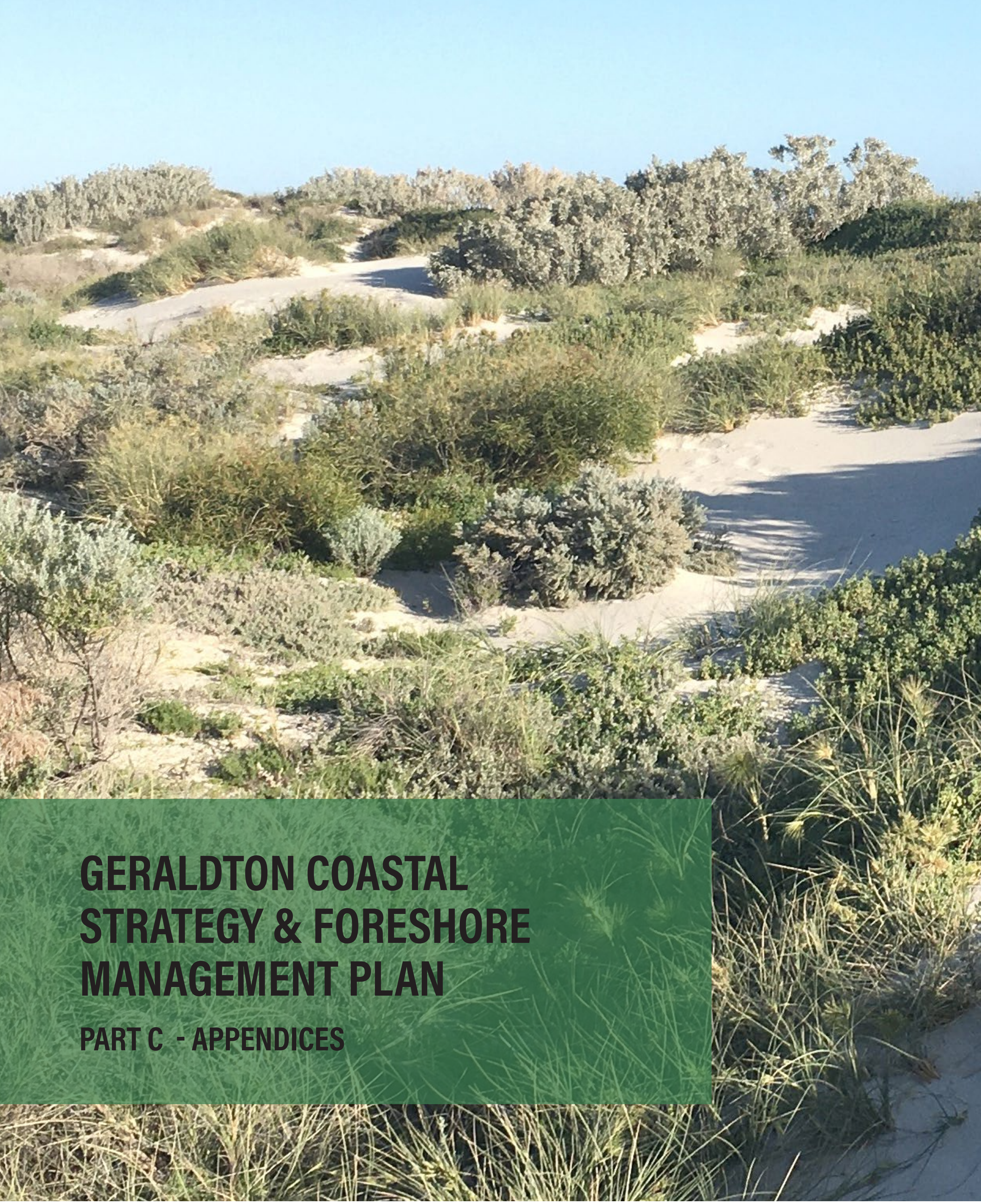

GERALDTON COASTAL STRATEGY & FORESHORE MANAGEMENT PLAN

PART C - APPENDICES

UDLA

City of Greater Geraldton a vibrant future

TABLE 1 EDITION DETAILS

GERALDTON COASTAL STRATEGY & FORESHORE MANAGEMENT PLAN - APPENDICES	
Title	Geraldton Coastal Strategy - Part A
Production Date	31st May 2023
Prepared By	UDLA
Author	Scott Lang/Katherine Hailstone
Status	ISSUED
UDLA Project Code	GERCPMP

TABLE 2 DOCUMENT REGISTER

DOCUMENT REGISTER			
Version	**Date**	**Amendments**	**Prepared By**
A	19/10/22	Draft for Review	KH
B	24/03/23	Draft for Public Comment	KH
C	31/05/23	Issued following edits	LH
0	28/06/23	Endorsed by Council 27 June 2023	

Prepared for: City of Greater Geraldton

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We would like to respectfully acknowledge the Yamatji Peoples who are the Traditional Owners and First People of the land on which we stand. The Nhanhagardi, Wilunyu, Naaguja. We pay our respects to the Elders past, present and future for they hold the memories, the traditions, the culture and hopes of the Yamatji Peoples.

We recognise the importance of coastal zones as they are sites of significance for Aboriginal people.

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APPENDICES

DIRECT UPDATE TO FMP2005
LANDSCAPE CHARACTERISTICS AND BACKGROUND INFORMATION

DIRECT UPDATE TO FMP 2005

1.0 LANDSCAPE CHARACTERISTICS AND BACKGROUND INFORMATION

As the 2005 FMP is still largely relevant, the following sections will only refer to sections that need updating or have changed since 2005.

1.1 CULTURAL HERITAGE

Sites of significance to the Aboriginal community are often concentrated near river or wetlands and coastal dunes. These areas are therefore of significance in general regardless of the identification of artefacts or archaeological material because they traditionally attracted a high level of usage or served a specific function.

It is acknowledged that not all Aboriginal sites may be registered and could be yet uncovered. Due to the mobile nature of the coastal dunes and changes that occur over time it is highly possible that historical artefacts or burials occur within the foreshore area. It is likely that these will remain undiscovered unless the dunes become unstable, earthworks or development occurs within the dunes, or the coastline erodes. Refer to the Aboriginal Heritage Inquiry System, Department of Planning, Land and Heritage for known locations.

The CGG Reconciliation Action Plan 2017 – 2020, namely the objective of ‘Recognising and preserving Aboriginal heritage, history, traditions, languages and culture’ supports the understanding and recognition that there are sites that hold significance within the indigenous community, and therefore require special consideration and consultation as the landscape changes.

1.2 CLIMATE

Geraldton is in an extra dry Mediterranean climate zone characterised by hot, dry summers and mild winters. Bureau of Meteorology (BoM) data collected at Geraldton Airport between 1941 and 2014 summarises the climate statistics (BoM, 2019). More detailed information on wind and oceanographic data are presented in later sections. The mean maximum temperature typically exceeds 27 °C from November to April (inclusive) peaking in February, and an average year sees around 81 days exceeding 30 °C and 9 days exceeding 40 °C.

During the cooler months from June to September the mean maximum temperature stays around 20-22 °C. Mean minimum temperatures vary similarly throughout the year, with a maximum of around 19 °C in February, falling to 9 °C in August. Maximum temperatures of over 47 °C have been recorded in summer, and minimums around 0 °C are possible in winter.

Rainfall is distinctly seasonal with around 75% of the yearly rainfall occurring between May and August in a typical year. Mean rainfall for the year is 440 mm and is relatively consistent, with 8 out of 10 years seeing 300 – 590 mm. Mean monthly rainfall in the winter exceeds 60 mm while in summer it is usually less than 10 mm.

Dissipating tropical cyclones typically generated on the NW shelf can have a dramatic effect on local climatic conditions from November to April. While infrequent in the area, these tropical lows can produce gale force winds and intense rainfall. This results in highly skewed summer rainfall, with monthly totals exceeding 100 mm possible. However, months with virtually no rainfall at all are more common during this period.

According to the Bureau’s climate records (BoM, 2019a) mean temperature for the Geraldton area increased by 0.15 - 0.2 °C per decade since 1940 and by 0.2 - 0.3 °C per decade since 1980. These same periods also saw a decrease in annual rainfall by 10 - 20 mm and 20 - 40 mm per decade, respectively. These climatic trends are expected to continue in future decades, although long term predictions of changes to rainfall patterns have significant uncertainty.

1.3 LANDFORMS & SOILS

Geraldton is in the northern section of the Perth Basin, a geographic area that stretches from the southwest coast of WA to the north of Geraldton. The area is characterised by Permian siltstone and Jurassic sandstone overlain by coastal limestone and Holocene sand dune deposits (DPaW, 2002). The primary sand dune systems in the area are the Quindalup and Spearwood Systems (GSW, 2000). These dune systems are characterised by highly permeable soils that are susceptible to erosion when stabilising vegetation is removed.

Significant areas of unvegetated and highly mobile dunes exist at both the southern (Southgate Dunes) and northern extents of the study area. Smaller blowout areas are present in less developed areas along the coastline as well, for example between Sunset Beach and Drummond Point.
The region outlined in the Coastal Planning and Management Manual inclusive of Geraldton is Shark Bay to Dongara and has summarised this area as:

Geology

- Includes the Northampton Block and, mainly, the Phanerozoic sediments of the Perth Basin

Processes

- Micro-tidal range
- Low discharge from rivers during the wet season
- Strong sea breezes
- Low-to-moderate wave environment

Major Landforms

- Cliffed rocky coast
- River estuaries
- Coastal lagoons
- Sheltered sandy beaches
- Cuspate forelands and tombolos
- Coral reefs

The strong sea breezes significantly affect the region. Major natural elements such as Lucys and Flat Rocks are well documented as important features along the Geraldton Coastline.
Unless there has been a major climate event, or human development the landforms have not changed significantly. The landforms may change as the Sea Level Rises. These aspects need to be taken into consideration when considering the FMP and how the Sea Level Rise (SLR) is managed over the next 10 – 90 years especially to the adopted adaptation strategies.

1.4 COASTAL PROCESSES & STABILITY

Over the past few decades numerous studies have been undertaken to assess the dominant metocean conditions and coastal geomorphology of the Geraldton coastline. These studies have provided a good understanding of the main coastal processes that influence the study area and their probable effect on both short- and long-term shoreline stability.

The key existing coastal studies utilised for this report are:

- Point Moore Inundation & Coastal Processes Study (MRA, 2015)
- Town Beach to Drummond Cove Inundation & Coastal Processes Study (MRA, 2016)
- Cape Burney to Greys Beach & Coastal Processes Study (MRA, 2017)
- Geraldton Coastal Hazard Risk Management and Adaption Planning Project (CHRMAP) (Baird, 2019)
- Carbonate sediment dynamics and compartmentalisation of a highly modified coast: Geraldton, Western Australia (Tecchiato, 2016).
- Additional meteorological data has been sourced from the BoM and oceanographic data from the Department of Transport (DoT).

1.4.1 METEOROLOGICAL & OCEANOGRAPHIC CONDITIONS

Wind Regime

At the synoptic scale, the local wind regime is largely determined by the seasonal position of the Subtropical High-Pressure Belt. During summer, the Belt is centred between 35 - 40 S (south of Geraldton) and the study area experiences winds largely from the south. In addition to regional effects, a diurnal sea-breeze system causes wind variations which are pronounced during the hotter months. This typically results in light offshore winds in the morning and moderate winds from the south to southwest in the afternoon.

During winter, the Belt is situated roughly on top of the study area. This results in dominant winds from the east and allows for energetic low-pressure systems from the Southern Ocean to reach the area, with resulting storms driving strong winds from the northwest to southwest with associated rainfall. Information on the wind regime has been supplied by BoM (2019) (Figure 1).

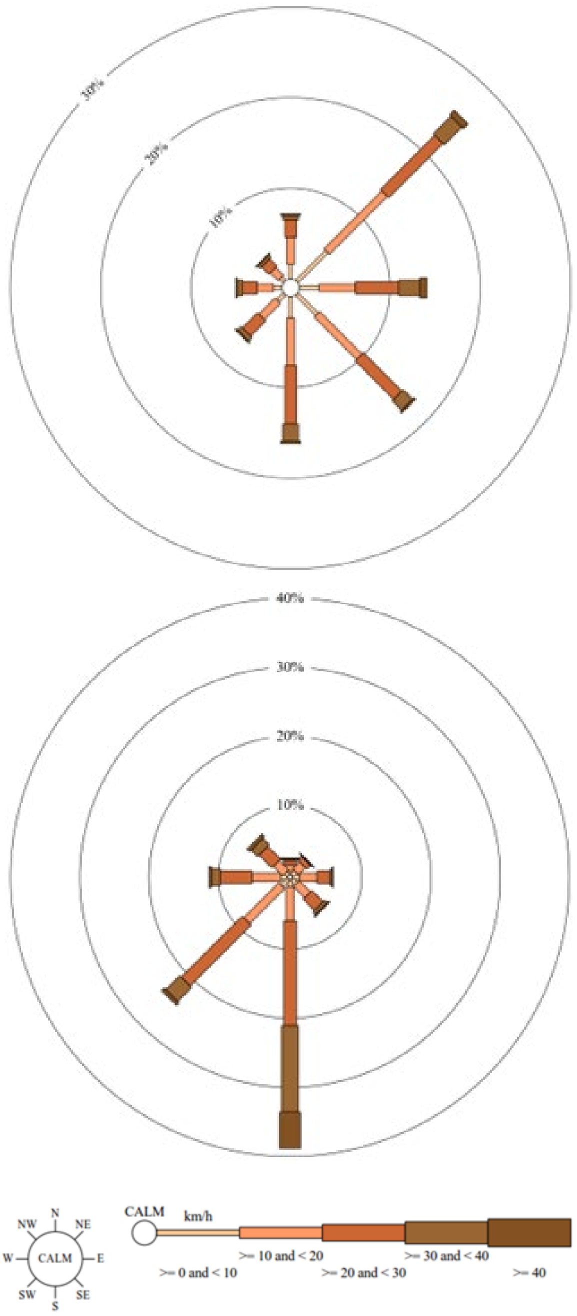

FIGURE 1. ANNUAL WIND RECORDS AT 9 AM (TOP) AND 3 PM (BOTTOM) AS MEASURED AT GERALDTON AIRPORT BETWEEN 1941 AND 2014 (BOM, 2019).

Monthly mean 9 am wind speeds at Geraldton airport were generally light to moderate year-round, with average speeds of around 15 km/h in winter months, increasing to speeds of around 20 km/h during the hotter months. Monthly mean 3 pm wind speeds were moderate (~30 km/h) during hotter months, again decreasing during winter (less than 20 km/h). Winter storms typically bring strong winds over 40 km/h which can occur from the northwest to the south and generally swing southward as the storm passes. Cyclonic related winds are irregular and unpredictable but can bring damaging winds to the area. Gusts of over 100 km/h have been recorded during both cyclonic summer months and stormy winter months.

The strong winds from winter storms create high-energy erosive sea waves and contribute to storm surges which can significantly erode beaches and dunes. Light to moderate winds during summer result in low-energy sea waves that typically help rebuild the beach profile. Onshore summer winds can also feed significant wind-blown sand into the dune system.

Wave Climate

The wave climate is composed of locally or regionally generated seas combined with swell waves generated by distant storms in the Southern Indian Ocean. Geraldton is exposed to significant wave energy from the open ocean, with a 100-yr ARI significant wave height estimate of almost 8 m offshore of the area (MRA, 2017). Waves approaching the coast refract and shoal over the local bathymetry, reducing in height before ultimately breaking at the shoreline. This process has the potential to transport significant amounts of sediment and can drive strong alongshore currents making them a key component of coastal processes.

The presence of nearshore and offshore reefs and the Abrolhos Islands create a complex and spatially variable wave climate at the shoreline. Waves can reflect, diffract, refract, attenuate, and break as they encounter these reefs and these processes vary with water depth and wave direction. This makes detailed wave prediction and resultant sediment transport difficult. Nevertheless, the general coastal geomorphology and shoreline stability is relatively well understood, described in Section 1.3.

Available DoT wave measurements for the area are relatively sporadic, with short term records (less than 2 years) previously collected at Geraldton, Oakagee and Dongara during the 70s and 80s. The Mid West Ports Authority (MWPA) maintains more informative wave records collected at the Outer Channel in around 10 m of water. Data from this record between 2004 and 2009 was summarised by Tecchiato (2016) (Figure 2).

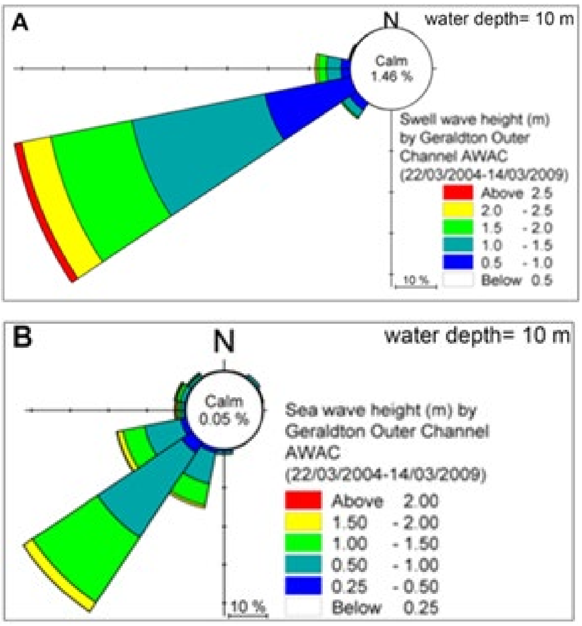

FIGURE 2. SWELL AND SEA WAVE CONDITIONS MEASURED AT THE GERALDTON OUTER CHANNEL USING AN ACOUSTIC WAVE AND CURRENT (AWAC) INSTRUMENT (TECCHIATO, 2016)

Coastal Engineering solutions (2001) generated nearshore wave conditions for Geraldton using an 8-year hindcast (1992-1999), which provided a picture of the overall wave climate. The study indicated the nearshore wave environment is composed of:

- Locally generated seas fetch limited by the extent of the sea breeze system
- Typically 0.1 - 0.4 m high (up to 1.5 m)
- Period of 3 to 6 seconds
- Generally from 220º to 250º
- Seas generated locally by the passage of cold fronts during winter, which vary greatly between storms.
- Typically around 1 - 2 m high (up to 5 m)
- Periods of 5 to 10 seconds
- Range from northwest to southwest
- Swell waves from distant storms in the Southern Indian Ocean
- Typically 0.5 m high (occasionally over 2 m)
- Periods of 10 to 16 seconds
- Crests reasonably parallel to the shoreline

The frequency of occurrence for all types of waves were assessed for the nearshore zone as part of the northern beaches study, presented in Table 1 (MRA, 2001).

Significant Wave Height	Batavia Coast Marina	Bluff Point	Sunset
Greater than 0.1 m	100%	100%	100%
Greater than 0.5 m	32%	81%	72%
Greater than 1 m	3%	24%	18%
Greater than 2 m	0%	4%	2%

TABLE 1: WAVE FREQUENCY AT VARIOUS NEARSHORE LOCATIONS IN THE STUDY AREA

The tidal range at Geraldton is relatively small and as a result non-tidal drivers of water level, such as storms, are very important drivers of coastal processes, as they can contribute a large proportion of actual water levels.

Short term (storm) variations in water level can be caused 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. As the tidal range is small, these storm-induced water level variations can easily reach high up the beach allowing wave action to erode the dune system.

Geraldton is exposed to both winter storm systems from the Southern Ocean and the occasional tropical low system (cyclone or ex-cyclone) from the north. Both can result in significant storm surge and coastal inundation and were assessed as part of the local coastal vulnerability studies undertaken by MRA (2015, 2016, 2017). The estimated extreme water levels are presented in Table 2 for the 20-yr, 100-yr and 500-yr return intervals. The 500-yr return interval is the storm return period that must be considered for coastal development as per the SPP2.6 .

Seasonal and interannual processes can also influence the water level at Geraldton, including ENSO (El Nino). These effects are encompassed in the extreme water level analyses conducted by MRA.

Scenario	20-yr ARI (m AHD)	100-yr ARI (m AHD)	500-yr ARI (m AHD)
Present day – cyclonic	1.8 - 2.0	2.2 - 2.9	3.0 - 3.6
Present day – non-cyclonic	2.0	2.1	Not assessed
2030	1.85-2.05	2.25-2.95	3.05-3.65

TABLE 2 EXTREME WATER LEVELS AT PRESENT AND IN 2030

Currents

Circulation in the nearshore study area is believed to be primarily wind driven, with additional alongshore currents when wave energy is sufficient. The wind driven current is expected to flow north during the summer at speeds of around 0.1 – 0.3 m/s. During winter the expected flow is southward and variable, ranging from 0.1 – 0.5 m/s during storm activity.

In the wave breaking zone, the action of waves arriving at an angle to the beach can generate significant currents along the shore. For exposed coasts, where wave energy is high, these currents in the surf zone can reach 0.5 m/s. The combined action of waves and the current they induce is one of the primary transporters of sediment, as wave action lifts sediment from the bed and allows it to be moved away by the current. The direction of transport typically follows the seasonal winds, i.e. to the north in summer and the south in winter, although strong storm events can temporarily reverse (or enhance) this trend.

Further offshore the Leeuwin Current brings warm water southward from Exmouth to Cape Leeuwin. This current is seasonal and variable. During wet winters, the two rivers in the study area may discharge a significant volume of fresh sediment laden water into the nearshore area. Aside from being a potentially important source of sediment for the area these flows are expected to have little impact on coastal processes away from the river mouth. Some short-term adverse effects on nearby marine organisms may be possible during large outflows.

Cyclones

Cyclones, although rarely experienced at Geraldton, can have a significant effect on the water level, local coastal processes, and sediment transport. Only 14 cyclones (with a central pressure < 1000 hPa) were tracked within 300 km of Geraldton in the 40 years from 1978 to 2018 (BoM, 2019b).

Cyclones cont.

All cyclones that tracked within 300 km of Geraldton since records began in 1960 are shown in Figure 3. Recently, in 2021 Cyclone Sejora battered the coast of WA and severely affected the mid west region. It is predicted more Cyclones of this severe nature will affect the region.

MRA (2015) undertook a coastal hazard study for the study area which looked at extreme wave and water level conditions. Using 2000 years of synthetic cyclone tracks they estimated the 100-yr ARI significant wave height offshore for coastal erosion assessments and the cyclonic water levels shown previously in Table 2. They found that cyclonic-induced water levels exceed non-cyclonic extreme water levels when considering return periods greater than 20 years.

1.4.2 CLIMATE CHANGE

According to the IPCC's latest report (IPCC, 2018) human activities have likely caused an estimated global warming of 0.8 – 1.2 ^{o}C, with a further 0.5 ^{o}C likely to be reached between 2030 and 2052. The primary impact on the Geraldton foreshore from these changes is expected to be sea level rise, although other environmental variables may also be affected.

Sea level rise has been recorded at Fremantle since records began, with an estimated increase of 1.54 mm/yr between 1897 and 2004 (DoT, 2010). The rate of rise appears to have increased, with a change of 4.0 mm/yr recorded between 1992 and 2008. These values do not account for vertical land movement (estimated to be -0.1 to +0.3 mm/yr in WA) or longer cyclical effects unrelated to greenhouse gas induced warming. As more data is collected worldwide the predictions and impact of climate change will become clearer.

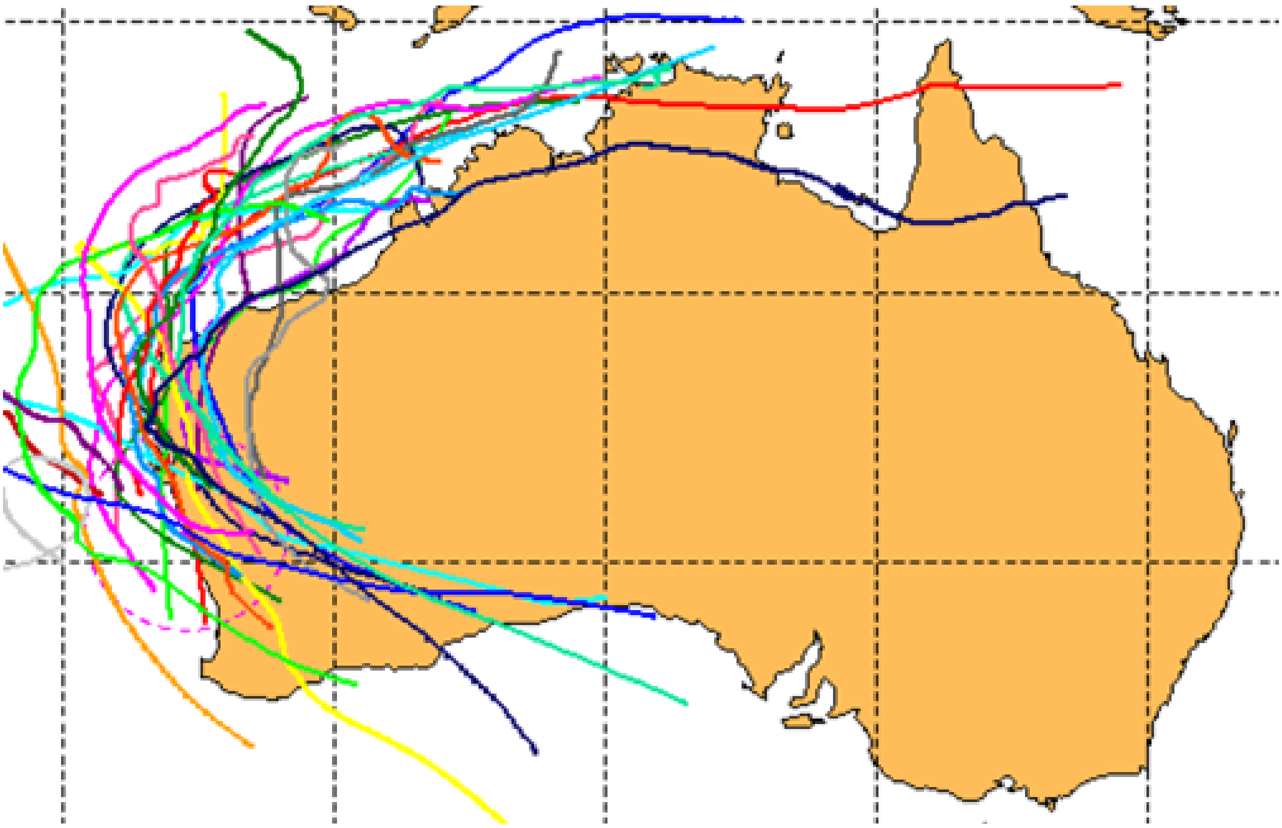

FIGURE 3. CYCLONES THAT PASSED WITHIN 300 KM OF GERALDTON SINCE 1960

At present, 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, Figure 4). The City's coastal studies (MRA 2015, MRA 2016, MRA 2017) and CHRMAP (Baird, 2019) have used these projected values to determine the relative hazards from erosion and inundation due to climate change over the next century.

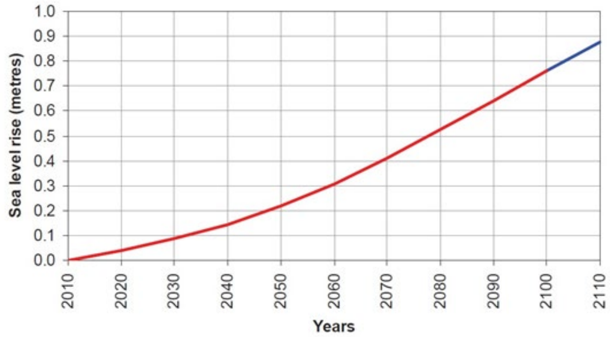

FIGURE 4. RECOMMENDED ALLOWANCE FOR SEA LEVEL RISE IN COASTAL PLANNING FOR WA (DOT, 2010)

The primary projected impacts of mean sea level rise are its contribution to increased shoreline erosion and inundation. The projected erosion and inundation allowances have been calculated by MRA in accordance with State Planning Policy 2.6 (SPP2.6). For erosion, a scale factor of 1:100 is recommended, i.e. for each 1 cm of sea level rise there will correspondingly be 100 cm of horizontal shoreline erosion (Figure 5). For inundation, the contribution of sea level rise is added to the other components of water level, so it has also been included in MRA's assessment of inundation levels.

Apart from sea level rise, there are numerous other processes that may be influenced by climate change (IPCC, 2018), although the magnitude (and even the direction) of these changes can be very difficult to predict.

Some key variables that may be affected include:

- Storm frequency and intensity
- Ocean currents and temperature
- Wind climate
- Wave climate
- Rainfall
- Air temperature

The combined impact of these variables will vary around the WA coast and require consideration on a local scale. Geraldton would expect to see an increase in cyclonic activity as ocean surface temperatures progressively rise. As outlined in Section 1.2 (Climate), a long-term decrease in rainfall has already been observed in the region with this trend expected to continue in the future. The combined impact of these variables varies along the coastline and require consideration on a local scale.

FIGURE 5. SCHEMATIC REPRESENTING THE HORIZONTAL EROSION ALLOWANCE FROM PROJECTED VERTICAL SEA LEVEL RISE – A FACTOR OF 100 (COASTADAPT, 2017)

1.4.3 COASTAL PROCESSES

Sediment Cells

A hierarchy of sediment cells is used to assist coastal planning, management, engineering, science, and governance along the WA coast. Sediment cells are areas of the coast within which marine and terrestrial landforms are likely to be connected through sediment transport. They include areas of sediment inputs (sources), sediment loss (sinks), and the sediment pathways linking them (Stul et al., 2015). Figure 6 depicts some typical components of a sediment cell.

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 high-level guidance on the potential impact zone of coastal projects;
- 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 by Stul et al. (2015) using a hierarchy of primary, secondary, and tertiary levels to represent three space and time scales; long term, inter-decadal, and inter-annual. 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. 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 (Stul et al., 2015). Tertiary cells are most relevant for this Foreshore Management Plan.

The City's coastline is wholly contained within Primary cell RO7F and includes Secondary cells 14 and 15 which join at Point Moore. The study area is further divided into the following Tertiary cells, all shown in Figure 7.

- Cape Burney South (Greenough River mouth) to Separation Point
- Separation Point to Point Moore
- Point Moore to Geraldton West (Geraldton Port)
- Geraldton West to the Chapman River
- Chapman River to Glenfield (Drummond Point)
- Glenfield to north of Drummond Cove (limit of study area)

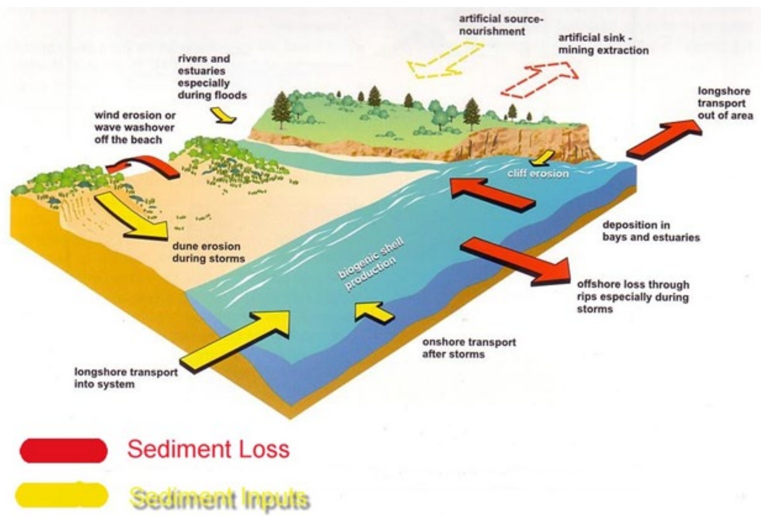

FIGURE 6. TYPICAL SEDIMENT TRANSPORT PATHWAYS IN THE NEARSHORE ENVIRONMENT (NEWMAN, 2020)

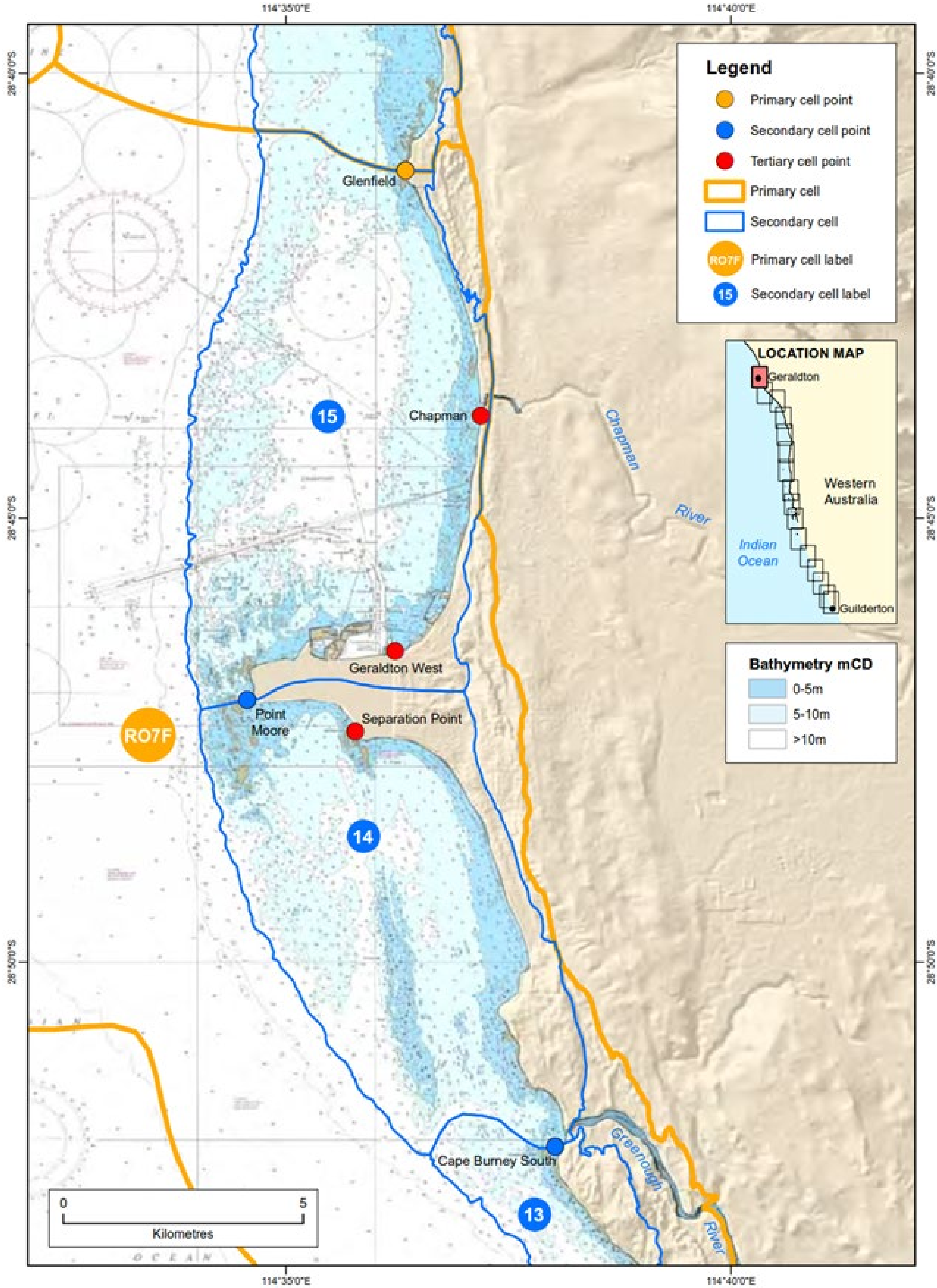

FIGURE 7. SEDIMENT CELLS FOR THE GERALDTON FORESHORE

Sediment Transport

Sediment transport in the region is driven in three primary ways that can all act as sources or sinks. They are:

- Longshore transport (along the coast)
- Cross-shore transport (towards or away from the coast)
- Wind driven (aeolian) transport

Both longshore and cross-shore transport occur in the ocean as suspended particles are moved by water, while wind driven transport occurs onshore. Seagrass wrack can be affected by all three processes as it generally floats near the surface.

Longshore sediment transport primarily occurs when waves break at an angle to the coastline. This drives a nearshore current in the direction of the wave propagation which transports sediment suspended by wave breaking. In summer, the persistent sea breeze drives sediment to the north, of which the cumulative effect can be greater than 100,000 m3/yr along the Midwest WA coast. This transport is partially balanced by strong southerly pulses of sediment driven by winter storm activity resulting in a net northerly transport on the order of 10,000 m3/yr to the north. MRA (1997) estimated sand accumulation on the beaches around Point Moore and the Port to be between 20,000 m3/yr and 30,000 m^3/yr.

At any point longshore sediment transport could vary significantly due to natural or artificial controls. This includes features such at Point Moore, Geraldton Port, the port channel, and river mouths. Generally, these features reduce but do not eliminate longshore transport, which can move offshore to bypass hard features. Tecchiato et al. (2016) found that Point Moore was a permeable boundary between sediment cells.

Cross-shore transport (onshore or offshore) occurs when sediment moves either towards and onto the beach face or is removed from the beach face and transported to deeper waters. This results in either a gain or loss in shoreline position at the beach. Offshore transport generally occurs during energetic storm events when short period steep waves and high-water levels rapidly erode the beach and transport material away. Onshore transport occurs during low energy periods when smaller longer period waves persistently move sand towards the coast.

According to Tecchiato et al. (2016), cross-shore in the Geraldton study area is controlled by numerous features which drive significant variation along the coast. Spatially variable controls include sediment type, bathymetry, geomorphology, benthic habitats (seagrass, reef, etc.), and bedform characteristics.

Offshore transport can happen very rapidly, with beaches losing tens of metres of width during severe storms. Onshore transport is a gradual process which dominates over the summer or between winter storms at Geraldton. Much of the sand moved offshore during a recent storm may be deposited in sand bars nearshore and may be returned relatively quickly when there are no impedances, such as another storm. In severe cases, such as a strong cyclone, it may be years before a beach can recover to its pre-storm condition. Coastal development and pressure from sea level rise may result in sections of coast never fully recovering without artificial renourishment.

Wind driven transport refers to when sand is moved overland, typically from the beach into the dunes or vice versa. Given Geraldton experiences strong onshore sea breezes often it is likely that this is a significant mechanism for building dunes and beach recovery. When combined with healthy stabilising vegetation wind transport can lead to consistent dune development. However, when vegetation is limited (or removed) wind can cause ‘blowouts’ where scouring occurs through the dune creating a weak point for storm erosion. For this reason, any development or vegetation removal (e.g. for an access path) should be well managed and monitored.

Coastal Stability

Coastal stability is a result of the balance or imbalance of sediment pathways driven by the transport mechanisms described previously. The combination of these sand transport mechanisms, together with natural and artificial controls, leads to the long-term development of Geraldton's coastline.

Tecchiato et al. (2016) examined shoreline data from 1942 to 2010 to determine how the local shoreline was responding over time. They found that between 1942 and 2001 the shoreline was either stable or accreting, with small areas of exception between Southgate and Tarcoola Beaches, and around Glenfield and Sunset Beaches (Figure 8 top).

In recent years development of the Geraldton coastline has increased leading to greater physical control and less longshore transport from the Town Beach area to the north. In addition, increases in flood control and river water extraction for irrigation has reduced the influx of sediment from both rivers in the area.

Analysis of shoreline movements between 2001 and 2010 found that the erosion area around Glenfield and Sunset Beaches had expanded and intensified (Figure 8 bottom). It is likely that reduced transport from southern beaches and the Chapman River have contributed to this erosion. Tecchiato et al. (2016) also indicated that increased recession in this area coincided with a reduction in dune vegetation and significant blowouts. It is likely that dune revegetation efforts as well as greater consideration of the sediment pathways to the area would result in less erosion in the area.

Renourishment and coastal stability work at Town Beach mean that the accretion here does not represent a natural process. This analysis agrees with previous work undertaken by MRA (1996) that indicated a trend of accretion for all beaches south of the port breakwater, but this work only assessed movement from 1942 – 1992.

Tecchiato et al. (2016) concluded that the Southgate dune system was an important source of sediment to the region. They suggested that this source not be significantly interrupted to maintain the present condition of downstream beaches to the north (the entire study area). They also concluded that the seagrass meadows were an important source of sediment and provided coastal stability and should be managed accordingly. Tecchiato et al. (2016) summarised the sediment transport and shoreline stability for the study area in a sediment budget model (Figure 9).

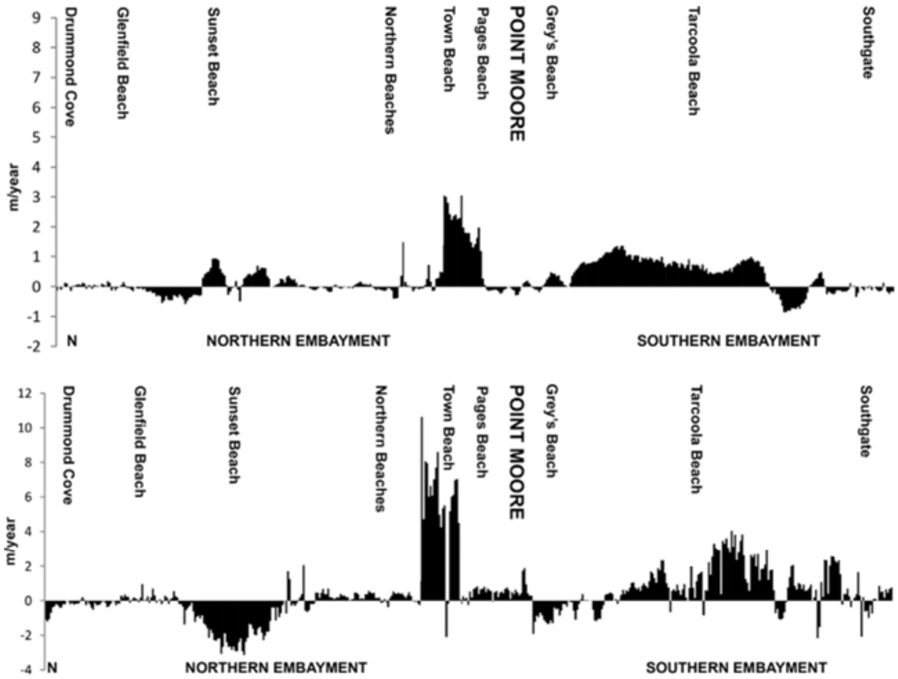

FIGURE 8.
SHORELINE CHANGE RATE DEVIATIONS ALONG THE GERALDTON COASTLINE FROM (TOP) 1942 – 2001, AND (BOTTOM) 2001 – 2010 (TECCHIATO ET AL. 2016)

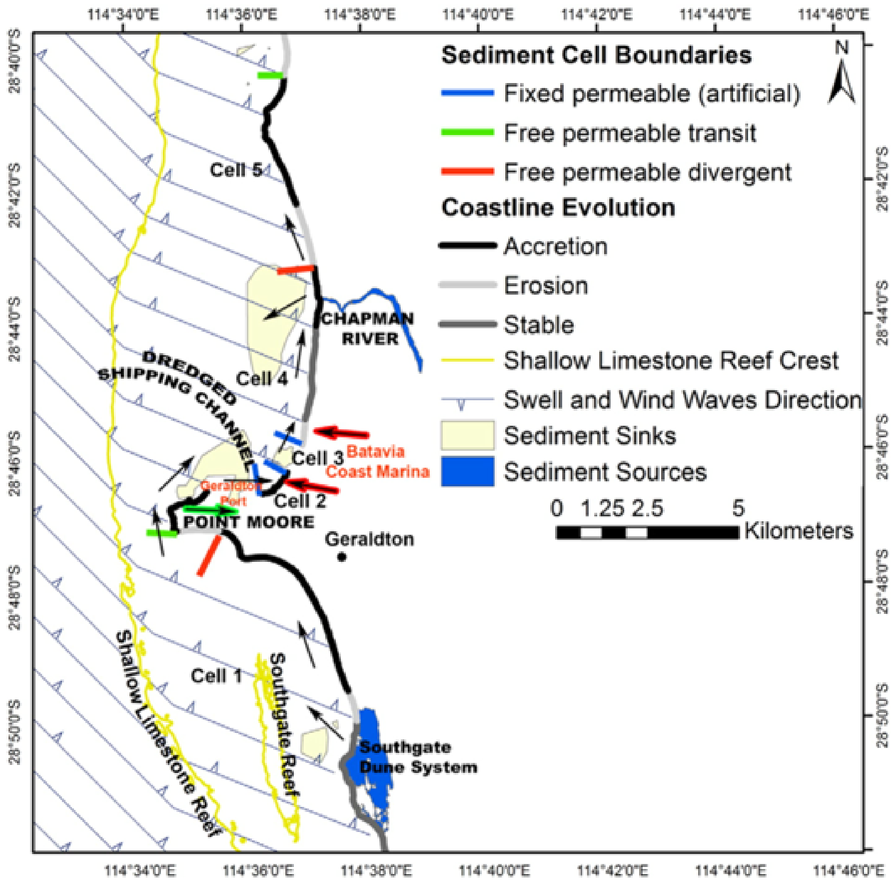

FIGURE 9.
SEDIMENT BUDGET MODEL FOR THE GERALDTON COASTAL ZONE, DEVELOPED BY TECCHIATO ET AL. (2016).

1.5 SURFACE WATER FEATURES

The study area includes the outflows of both the Chapman River and the Greenough River, which forms the southern boundary of the study area. The Chapman River head is at Yuna, approximately 60 km northeast of Geraldton and meanders for around 110 km until it reaches the coastline just north of Bluff Point (DWER, 2001). The Greenough River flows for 240 km from the east towards the coast (DWER, 2001).

Both rivers exhibit highly seasonal flows due to the rainfall distribution over the year, typically only flowing into the ocean during winter. Annual mean flow for the Chapman and Greenough rivers was around 15 and 24 GL respectively, although high rainfall years can produce more than five times as much outflow (DWER, 2020). During the dry summer months, or during particularly dry winters the rivers are sustained by groundwater which is not sufficient to maintain constant flow. The river mouths are closed during these periods and tidal influence in the estuarine areas near the coast is restricted.

These rivers are important considerations for the coastal geomorphology at Geraldton as they are seasonal sources of sediment for the localised outflow area (Tecchiato, 2016), although they are not a significant source of sediment overall (Short, 2010). This supply can be highly variable depending on rainfall and can be restricted by river developments and flood control systems.

1.6 VEGETATION

The vegetation of the coastal area for the full length of the study area was surveyed as part of the 2005 FMP.

Since 2005, none of the species present have been Declared Rare or Priority Flora species. No DRF or Priority species are expected to occur in the Geraldton-Greenough coastal area. Where there is lack of vegetation especially in dune areas, they are more prone to shifting and rapid change.

1.6.1 CONSERVATION VALUES

All of the native vegetation in the study area is considered to have conservation value, mostly due to the fact that a large proportion of the vegetation has already been cleared for development. The values also include their use for fauna habitat and important function in stabilising the fragile dunes from coastal erosion and wind erosion.

Areas of highest conservation value are considered to be the following:

1. The Sporobolus virginicus wetland at Greys Beach. This is the only basin type wetland observed in the Geraldton-Greenough foreshore, and although very small in area, is an unusual vegetation type in very good condition.
2. The Melaleuca huegelii/Acacia rostellifera Scrub at the northern end of Southgate near the Tarcoola border is the only area within the foreshore of the study area that contains this vegetation type.
3. Point Moore/Greys area. This area has a relatively high number of different vegetation types that relate to past and recent erosion and accretion processes. The scientific and educational value of the vegetation in the Point Moore/Greys Beach area is high from this point of view.
4. Chapman River Mouth. The mouth of the Chapman River that is within the foreshore area is part of the Chapman River Regional Park. The Park has high ecological, scientific, cultural and recreational values.
5. Links to inland reserves. Potential links of the coastal vegetation to inland vegetated areas to protect transition between vegetation are located at Drummond Cove, Glenfields, Tarcoola (southern section) and Southgate (northern boundary and southern area).

It will be integral to ensure the implementation of any works has the consideration and emphasis on retention of vegetation and ecologies. Vegetation plays a big part in the stabilisation of dune and foreshore systems.

1.7 COASTAL HAZARDS

As the coastline of Geraldton has some low lying and areas more prone to risk of Inundation, flooding and storm surges that can cause extreme flooding events. Often these coastal hazards are naturally occurring events that cannot be predicted as illustrated by the recent 2021 Cyclone. Coastal Hazard Risk has been researched and outlined in the Geraldton CHRMAP.

These include but not limited to:

- Natural coastal processes
- Natural Climatic events
- Recent human activity and developments
- Erosion and inundation
- Human use and recreation

In the CHRMAP Coastal Hazards were evaluated and presented as a Coastal Management Unit (CMU). These CMUs correspond directly to areas included in this FMP and were thoroughly investigated through Coastal Hazard Mapping, Section 5.0. A high-level summary is provided with how some of the hazards identified effect each CMU.

1.8 PLANNING

As the population is expected to grow in Geraldton in future overarching policies such as the State Planning Policy 2.6, Coastal Setback Strategy and Guilderton to Kalbarri Sub-Regional Planning Strategy will assist to ensure the pressures along the coastline are minimised will be essential to ensuring the longevity for Geraldtons Foreshore.

The localised strategies that assist in supporting the goal of retaining the Coastline and Foreshore as an asset are:

- CHRMAP
- Public Open Space Strategy
- Strategic Community Plan; and
- Local Planning Strategy

The Local Planning Strategy has set out Vision principles around, Community, Environment, Economy and Governance and recognises opportunities to provide planning incentives and provisions to protect and enhance remnant vegetation and landscape features on freehold land.

The guidance provided in the South Greenough to Cape Burney Coastal Planning Strategy had more of a targeted approach to help manage the increased pressures from human activity, other pressures and climate change to ensure the coastal environment and the invaluable ecosystems service and functions are upkept.

In essence state and local level policies and strategies are supportive of ensuring the longevity of the foreshore for the community into the future.

1.9 RECREATION

Recreation is an important aspect of any Foreshore Management Plan. Community surveys undertaken as part of the POS and CHRMAP indicated the types of uses along the foreshore and the activities that occur. Open spaces in close proximity of the beaches were most popular and where the participants spent most of their time.

- Point Moore, Glendinning Park, Bluff Point Beach and Drummond Cove Beach were some of the more popular areas mentioned.
- Facilities mentioned that were needed were better maintained public toilets, shade, shelter, seating and barbeques, all of which could be found throughout the foreshore.
- Since the Foreshore was outlined as extremely popular, it can be assumed that a portion of the 42% respondents visited these sites daily and 49% visited weekly that they were visiting the Foreshore.
- Not specific to the foreshore but common barriers that hindered people from using the POS were the lack of toilets or poor toilets, no shelter or shade or the space is unappealing.
- The areas outlined that have significant social, cultural or historic values, it was the CGGs many beaches and river foreshores as they provide immense value to the community.

Other surveys such as the cycling survey outlined that end of trip facilities were desired especially in the foreshore, and the routes along the foreshore were the most popular.

Unregulated 4wd access as noted at a few local projects as an issue, and will need to be considered in the future with any initiatives.

1.10 TERRESTRIAL VEGETATION & FLORA

No change since 2005.

1.11 FAUNA

No change since 2005.

1.12 NEARSHORE ENVIRONMENT

1.12.1 HABITATS

The nearshore habitats around Geraldton are comprised of limestone reefs, patchy seagrass meadows, sandy areas and mixed sandy, seagrass and seaweed areas. The seaweeds found here are small and do not form dense communities. Seagrass meadows are common to approximately 10m depth. The other key features are shallow limestone reefs and sand bar systems, which indicate areas of sediment accumulation (Tecchiato et al., 2015).

1.13 WATER QUALITY

Desktop review of available information has not found any significant coastal water quality concerns in the study area.

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3 REVIEWED DOCUMENTS

3.1 POLICY AND STRATEGIC CONTEXT

The reviewed and referenced documents include:

- **Greenough – Geraldton Coastal Strategy and Foreshore Management Plan 2005**
  The 2005 FMP is still largely relevant and still has objective and initiatives to be considered into the future.

- **State Planning Policy 2.6: State Coastal Planning Policy**
  Underpins the guiding principles of this FMP and sections 5.5, 5.7 and 5.9 are the most relevant for consideration.

- **Geraldton Coastal Hazard and Risk Management and Adaptation Plan**
  Completed in 2019, it is a risk assessment-based approach that provides clear adaptation pathways for the full extent of this FMP

- **Coastal Planning and Management Manual**
  Published in 2003, the Coastal Planning and Design Manual covers a wide range of coastal environments. It understands coastal environments are 'highly dynamic and complex' and are 'subject to continuous and extensive changes in response to variations in weather, wave and sea conditions'. It makes considerations for the processes acting upon the landscape and its propensity to change. (CPMP 17) The document outlines a framework for developing Foreshore Management Plans and the considerations required to ensure it is successful, including important cultural considerations and requirements, along with design guidelines and techniques to deal with scenarios that can occur within the coastal zone. It is important to note that some of the guidance included in this manual has progressed since its creation, especially in terms of construction methodology.

- **Batavia Coastal Strategy**
  The Batavia Coast Strategy (BCS) was developed in 2001 to be a guide to decision making and provide a framework for planning and management matters at a regional and local level. It was adopted by five constituent local authorities and has guided and informed further strategies over the years and is still referred to today. It was developed prior to the 2005 GCSFMP, and clearly informed its development. BCS has reviewed and considered the overlapping nature of activities at different levels of government, bringing together a comprehensive understanding of the Batavia Coastal Area.

- **Guilderton to Kalbarri Sub-Regional Planning Strategy**
  The Strategy seeks to address a range of issues experienced through the coastal areas of Guilderton to Kalbarri. Published in 2019 it is inclusive of the Greater Geraldton Region. Within the document Section 10.5: Coastal Planning specifically addresses the study area for this FMP and noted at the time of publishing, the responses to recommendations have generally been adhoc. Its reference to CHRMAP Strategy as a guide to a community's adaptation measures is helpful to ensure the planning in the region is aligned in surrounding regions as Planned or managed retreat may be necessary in the FMP.

- **Geraldton Regional Plan**
  The Geraldton Region Plan developed in 1999, noted in section 9.9 that there were relatively limited areas of publicly owned regional space in comparison to other regional areas in Western Australia. It was recommended that further public space in Geraldton should be acquired. The Geraldton Regional Plan underpins the initiatives within the region that help to highlight an understanding of the importance of the Foreshore Reserve to the community.

- **Local Planning Strategy**
  - The CGG Community Strategic plan for 2017 – 2027 sets out visions and principles around, Community, Environment, Economy and Governance.
  - A national biodiversity hotspot is the sand plains between Geraldton and Shark Bay. This is under significant threat and looks to be addressed in the Cities Local Biodiversity strategy and should be considered within the coastal management strategy.

- The Local Planning Strategy recognises opportunities to provide planning incentives and provisions to protect and enhance remnant vegetation and landscape features on freehold land.
- Due to Urban Growth, it is essential to ensure this FMP is relevant for current and future context.

- **Public Open Space Strategy**
  Geraldton is the fastest growing regional population in Western Australia and as a result there is increased pressures on the use and provision of its parks, beaches and foreshore reserves. This document developed a strategic vision and framework that has assessed the communities need for public space and acts as a guide for future public space provision. Section 2.3 notes that while the foreshore is not considered within public open space under WPAC 'Liveable Neighbourhoods" it does play a major role within the Greater Geraldton Community and is considered within the larger Public Open Space Strategy report. (Page 8) To assist with establishing a quality open space network, the FMP addresses the public spaces and nodes within the Coastal area as well as the requirement for the implementation of environmental protection measures as this is an essential role of public open space.

- **South Greenough to Cape Burney Coastal Planning Strategy.**
  This strategy was developed in response to help manage the increased pressures from human activity, other demands and climate change to ensure the coastal environment and the invaluable ecosystems service and functions are upkept. While this document was not implemented the information produced was integrated into and informed other planning processes in the region. Community consultation informed the strategy and highlighted common values, common issues.

- **Masterplans, Strategies & Investigations for specific site areas along the study area**
  - Drummond Cove Beach Front – Design Guidelines
  - Drummond Cove Foreshore Masterplan
  - Drummonds Point Site Plan
  - Chapman River Estuary Management Plan
  - Pt Moore to Tarcoola Beach Foreshore Masterplan
  - MRA Technical reports, and Coastal Vulnerability Studies

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