CITY OF BUSSELTON
COASTAL MANAGEMENT PROGRAM
10 YEAR PLAN (2020 – 2030)

for City of Busselton.

October 2020

SCR1707

Executive Summary

The City of Busselton is located adjacent to the north facing sandy coast of Geographe Bay. This sandy coastline is both highly valued and naturally dynamic. Narrow coastal setbacks and low relief topography make this shore sensitive to changing environmental conditions. The historic record shows cycles of accretion and erosion that vary in scale and distribution along the shore and are influenced by sediment feeds from offshore sand bars and the construction of coastal protection structures along the foreshore (1).

There are 64 public coastal protection structures along the Geographe Bay foreshore. While coastal protection structures have stabilised the shoreline for many of the populated areas of the Geographe Bay foreshore, many areas of higher variability and erosion remain, particularly downdrift (east) of longer groynes or harbours and on beaches adjacent to migrating transverse sand bars. Many areas of the coast are vulnerable to damage or inundation during significant storm events.

The City of Busselton maintains an active coastal management program, and has consistently shown initiative in this space, including by commissioning a 2011 study into longer term climate change impacts on this coastline and developing and implementing the previous *Busselton Coastal Management Program (2014-2018)*.

Both community consultation and a review of the existing CMP highlighted the importance and value of a strategic approach to monitoring, investigations, sand nourishment, maintenance and coastal adaptation works.

An updated Coastal Management Program (2018-2028) was developed in 2018. This 10 year rolling program aims to facilitate ***strategic***, ***effective*** and ***sustainable*** coastal adaptation by the City of Busselton along the Geographe Bay foreshore. This report is the 2020 review of this program.

A "***whole of coast***" approach to coastal management along Geographe Bay is proposed with the definition of 6 Coastal Management Areas based on tertiary sediment cells and local management practices. This is a ***10-year plan*** to encourage a strategic approach to coastal management and adaptation.

Coastal Monitoring (Annual)

The City should continue the annual beach monitoring, including six monthly photo monitoring, oblique aerial photography and surveyed beach profiles. Photo monitoring is extended to include the Naturaliste settlements of Smiths Beach, Yallingup, Bunkers Bay and Eagle Bay. Fixed camera monitoring should be considered in selected areas. The development of an internal and public GIS interface for the coastal monitoring data is recommended. The annual coastal monitoring, together with monthly beach width measurements, informs the regional scale Peron Naturaliste Partnership (PNP) coastal monitoring program that extends from Cape Naturaliste through to Cape Peron.

Coastal Monitoring (Strategic)

The program recommends strategic monitoring at lower frequency using high density survey techniques. Monitoring would include detailed aerial beach surveys every two years commencing Year 2, a detailed hydrosurvey of the wider region in association with the PNP in Year 2 (10 years since the previous regional hydrographic survey), and installation of real time wave monitoring at Busselton Jetty.

Coastal Investigations

This program recommended a range of coastal investigations including research of Geographe Bay sediment dynamics, coastal stratigraphy, coastal inlet dynamics, modification of long groynes to improve bypassing, numerical modelling of coastal flooding (using June 2018 storm wrack line survey for model validation), coastal structures inspections; review of sand and rock sources and development of a GIS layer for emergency storm surge response.

Sand Nourishment

The City should continue the annual maintenance sand nourishment program at a similar scale to previous years and continue the practices developed in the previous program, including proactive summer sand nourishment, the use of erosion buffers to guide nourishment requirements and beach scraping at suitable sites. Sand nourishment should continue to be the primary response to coastal erosion following storms.

Sand Nourishment (Strategic)

Following completion of the strategic monitoring surveys and investigations of Geographe Bay sediment dynamics, a large "pulse" sand nourishment is proposed on a 5 yearly basis. Initially, this is likely to need to address long-term depletion of sediment volume in the West Busselton Coastal Management Area.

Maintenance of Coastal Protection Structures

The City should continue the maintenance and renewal schedule for existing coastal protection structures, with a renewed focus on maintaining all structures in a management area before proceeding to structures in an adjacent management area. Initially, maintenance of the West Busselton seawall along Geographe Bay Rd is proposed.

Coastal Management and Adaptation

Managed retreat of public assets threatened be erosion should continue to be undertaken along Geographe Bay in discrete areas where it is the most effective and sustainable coastal adaptation option. However, coastal stabilisation is likely to be the predominant coastal adaptation option along Geographe Bay during the next 10 years, whilst sediment supply is available; and whilst stabilisation is effective locally and sustainable regionally. This maximises the use of natural sand distribution.

The proposed coastal adaptation works in the program include coastal stabilisation works in Abbey (Forth St), West Busselton (Broadwater, Mill Rd, Gale St) and Wonnerup (East Wonnerup), and projects to mitigate the risk of coastal flooding (coastal dunes & drain modifications).

Additional 'watch' sites may be identified during coastal monitoring. This may include sites where sand nourishment becomes increasingly ineffective and unsustainable, sites where there are narrow erosion buffers and sites where high rates of erosion may develop (i.e. downdrift of groyne fields, adjacent to migrating transverse sand bars, adjacent to drain outlets).

Review of the program is recommended every 2 years and the City should ensure works are suitably funded and resourced.

Relevant coastal monitoring information and investigations should continue to be provided to the City's Local Emergency Management Committee, the Department of Transport, other relevant authorities and agencies, and the community.

The recommendations of this Coastal Management Program should be considered in the development of the City of Busselton's longer term Coastal Adaptation Strategy.

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Acknowledgements

This report for the City of Busselton was part funded by the Western Australian Planning Commission Coastal Management Plan Assistance Program.

Limitations of this Report

This report and the work undertaken for its preparation, is presented for the use of the client. The report may not contain sufficient or appropriate information to meet the purpose of other potential users. Shore Coastal does not accept any responsibility for the use of the information in the report by other parties.

Rev	Issues Description	By	Review	Date
A	Draft report	ML/OS	SB, MJE	17 April 2018
B	Revised Draft following Client Review	OS	SB	30 May 2018
0	Final following Stakeholder Input	SB	HD	10 August 2018
1	2020 Review	SB	HD, MW	30 October 2020

1 Introduction

The City of Busselton is located adjacent to Geographe Bay, which is a large, relatively shallow north facing coastal embayment sheltered from the prevailing south-westerly waves by Cape Naturaliste. The Bay forms the southern limit of the largely west facing coast of south and central Western Australia from Busselton to Shark Bay (Figure 1.1).

Narrow coastal setbacks and low relief topography make this shore sensitive to changing environmental conditions, including intense storm events, seasonal cycles and more gradual fluctuations brought about by climate variation. The historic record shows cycles of accretion and erosion that vary in scale and distribution along the shore and are influenced by sediment feeds from offshore sand bars and the construction of coastal protection structures along the foreshore (1).

Figure 1.1 City of Busselton – Geographe Bay Coastal Management Areas

Geographe Bay has a predominantly sandy shore, comprised of a thin offshore sand sheet and a series of parallel beach ridges. The coastal sediments are geologically recent, mainly developed along the Geographe Bay foreshore during the last 5,000 years. They form a thin veneer overlaying Pleistocene units including Busselton Limestone and/or Geographe Clay (2).

Within the beach ridges are a series of largely shore parallel estuaries and coastal lagoons, with an extensive low lying coastal floodplain further landward (3). The residential population of Busselton was 36,686 in 2016 (growth rate of 3.3%) (4). Based on these growth rates, there are expected to be more that 40,000 resident as of 2020, with the majority living on the coastal barrier near the coast (Figure 1.2).

The majority of residential development along the coastline is sited on the coastal barrier below 3.0mAHD, and in some localities below 2.0mAHD. These coastal areas are exposed, to a variable degree, to present day storm surges and longer term sea level rise.

There are 64 public coastal protection structures along the Geographe Bay foreshore including low profile rock groynes, rock revetments, timber groynes and granite training walls for various regional drain outlets. More recent structures include geotextile sand container groynes and revetments, and concrete revetments adjacent to the Busselton Jetty. This approach has been feasible due to an ongoing net supply of sand from west to east along Geographe Bay over recent decades.

Figure 1.2 Oblique aerial photograph of Geographe Bay and coastal residential areas looking east (L) and typical sandy shoreline (R).

The City of Busselton maintains an active coastal management program, including monitoring, investigations, sand nourishment and coastal adaptation in targeted areas of the coastline. While coastal protection structures have stabilised the shoreline for many of the populated areas of the Geographe Bay foreshore, many areas of higher variability and erosion remain, particularly downdrift (east) of longer groynes (e.g. Siesta park, Holgate Rd) or harbours (Port Geographe), and on beaches adjacent to migrating transverse sand bars (Figure 1.3). Additionally, multiple areas of the coast are vulnerable to damage or inundation during significant storm events.

Figure 1.3 Broadwater Beach - Holgate Road Groyne. In 2020 this structure was refurbished and shortened by 20m to improve supply of sand to Broadwater Beach

Coastal Management Framework

The City of Busselton's Strategic Community Plan 2017 highlighted "*managing our dynamic coastline*" as a key priority and states Council will "*continue to work with key partners to manage our dynamic coastline, including potential adverse impacts arising from climate change*" (5). This includes "*better planning for coastal erosion impacts*", which recognises the need for active management in the short and medium term, which is a focus of this *Coastal Management Program (2018-2028).*

This *program* builds on the City's previous *Coastal Management Program (2014-2018)* (6), which was one of the first integrated coastal management programs by a local government in Western Australia. The 2014 -2018 program evolved in the following context:

- Storms in 2007, which resulted in widespread beach erosion and the collapse of concrete promenades along the Busselton foreshore.
- High rates of erosion at the Locke Estate campsites where timber groynes constructed 20-years previously had failed.
- The high costs of sand nourishment at Scout Road associated with downdrift impacts from the Busselton foreshore groynes, constructed in response to the 2007 storms.
- Northeasterly storms in 2012, which eroded many areas of the Dunsborough foreshore.
- Ongoing erosion issues at Wonnerup associated with Port Geographe.
- The desire for a more proactive and integrated approach to managing coastal erosion along Geographe Bay.

The 2014-2018 program was also developed in the context of a 2011 assessment of longer term climate change impacts on the Geographe Bay coastline (7), which identified;

"the existing strategy involves the adoption of a 'defendable line', which is expected to be feasible over the next 50 years through the maintenance and further development of coastal protection structures between Quindalup and Wonnerup".

Demonstrating the City of Busselton's initiative in this space, the 2011 study preceded the WA Department of Planning's 2014 Coastal Hazard Risk Management and Adaptation Planning Framework (8) and considered many of the coastal hazard and adaptation planning approaches in this framework. This included the potential application of the State Coastal Planning Policy (9) in developed regional townsites, and integration with existing practices (10).

The 2014-2018 program included coastal monitoring and investigations, which have *improved the knowledge base for planning* for the next five years and beyond. The 2014-2018 program also recommended appropriate maintenance and capital works to *protect valued community assets (including the sandy beach)*, the majority of which have been successfully completed.

Coastal Management is used broadly in this report to cover the activities of the Engineering and Works Services Directorate in the City of Busselton. This includes coastal monitoring, coastal investigations, sand nourishment, maintenance of coastal protection structures and a range of coastal adaptation works. Coastal monitoring undertaken for the Peron Naturaliste Partnership (PNP) is integrated into the City of Busselton annual coastal monitoring activities.

Coastal management is undertaken in the context of the wider coastal planning activities of the City, which includes the progressive development of a longer term Coastal Adaptation Strategy.

2 Aim and Target Actions

2.1 Aims

This Coastal Management Program (2020-2030) aims to facilitate ***strategic***, ***effective*** and ***sustainable*** coastal adaptation by the City of Busselton along the Geographe Bay foreshore over the next 10 years.

The specific aims of this Coastal Management Program are:

- ***Strategic Coastal Adaptation:*** Whole of bay approach to coastal adaptation based on strategic monitoring and investigations. Identification of strategic coastal management areas based on local sediment cells. Early identification of potential problems to allow for better planning and for a greater range of adaptation options to be considered.
- ***Effective Coastal Adaptation:*** Improved knowledge of coastal processes resulting in better design of coastal adaptation works. Adaptation should be cost effective, resolve the immediate issue and consider downdrift erosion and coastal flooding risk.
- ***Sustainability:*** Coastal adaptation that recognises the dynamics of the coastal system being managed, the longer term behaviour the coast, and the potential impacts of future sea level rise.

2.2 Target Actions

Target actions refer to aspects of the coastal management program where a particular focus is required. The basis of these target actions is outlined in this program. These target actions include:

- Strategic 'whole of coast' management based on defined coastal management areas, sediment cell concepts, and a 10-year rolling coastal management program.
- Continue annual coastal monitoring with the agility to incorporate new monitoring technologies, adapt the timing and extent of surveys, continue to integrate PNP monitoring, and inform the public through making monitoring data available online.
- Undertake higher resolution regional scale strategic coastal monitoring including aerial scans and hydrographic survey.
- Install real time wave monitoring instrument on the Busselton Jetty.
- Complete a range of coastal investigations with a particular focus on sediment dynamics within Geographe Bay.
- Continue the annual maintenance sand nourishment program at a similar scale to previous years, and continuing the practices developed in the previous program including proactive summer sand nourishment and the use of erosion buffers to guide nourishment requirements.
- Sand nourishment should continue to be the primary response to coastal erosion following storms.
- Plan and implement a large "pulse" sand nourishment (25,000m^3- 40,000m^3) every 5 years, subject to survey. Initially, this is likely to need to address long-term depletion of sediment volume in the West Busselton coastal management area.
- Continue the maintenance and renewal schedule for existing coastal protection structures, with a renewed focus on maintaining all structures in a management area before proceeding to structures in an adjacent management area.
- Undertake coastal adaptation works following the guidance provided in this program, including responses to both coastal erosion and coastal flooding.
- Review the program every 5 years, with consideration of the longer term Coastal Adaptation Strategy.
- Ensure works are suitably funded and resourced.
- Ensure consultation with stakeholders and wider community maintained.

3 Community Consultation

Community consultation is a key component of this program. Shore Coastal partnered with Carolyn Walker Public Relations Pty Ltd in 2017 to develop a consultation process that involves stakeholders in the decision making process and encourage ownership of the outcomes.

Initially, an issues paper was circulated to stakeholders in September 2017 background to the Coastal Management Program.

A workshop was held with a Stakeholder Reference Group on October 18, 2017 with 12 participants. Participants were initially provided with the general background to coastal management in Busselton. There was a clear consensus among participants about the high value placed on the sandy beaches of the Geographe Bay foreshore.

3.1 Site visits

Shore Coastal selected four sites within a 10km section of coastline that had different issues and different management options (sand management, managed retreat, seawall, groynes). At each site, participants were briefed about the history, including showing where the beach had previously been located to understand the erosion, and the cause of the erosion. Coastal processes at each site were discussed, as well as the options used for erosion management. Discussions occurred as to why some options were chosen and not others, as well as the recreational and other uses of the sites and surrounding land.

Table 3.1 Summary of Sites Selected for Consideration at the Community Consultation Workshop

SITE	COASTAL ADAPTATION
Locke Estate	Historic managed retreat. Construction and maintenance of coastal protection structures.
Broadwater Beach	Significant erosion down-drift of large groyne. Sand nourishment, minor protective works.
King Street	Combination of a seawall and sandbags. Managed retreat and protection.
Busselton Foreshore	Activation space around the longest jetty in the southern hemisphere for recreational activities. Rock, concrete and sand container protection as well as sand nourishment.

Figure 3.1 Stakeholder Site Visits and Problem Solving (2017)

3.2 Problem Solving

A technical presentation on coastal processes, and the management of coastal erosion by the City of Busselton over the last 5 years, was provided to participants. Three sites were then selected and participants were placed into groups to focus on prioritising coastal values with management options. The aim was to determine what they valued and how they would manage sites into the next five years, and to report back to the wider group.

Participants developed an understanding of the complexities of coastal planning and decision making as they considered a wide range of options for each site. The participants' recommendations for each site are contained in the workshop summary and fed into the consideration of options within this Coastal Management Program. These values and a synopsis of the management options considered are summarised in Table 3.2

Table 3.2 Stakeholder Values and Management at Key Coastal Erosion Sites

Site	Summary of Stakeholder Values	Synopsis of Management Options Considered
Broadwater Beach	- Tourist resorts exist and employ locals, important to economy – exist because beaches are here. - Dual Use Path is a well-used facility – people can cycle from Busselton to Dunsborough. - Natural wide vegetation – beach: large vegetated zone; wildlife habitat; breathing space to protect from wind/ salt etc. - Dogs/ exercise/ swimming.	- Reconfigure Holgate Rd groyne. - Relocate dual use path – bring it back. - No to a seawall. - Continuous coastal monitoring as to whatever we do and how it will impact the beach. - Geotextile bags as groynes – hotspots.
King St	- Public foreshore assets highest – car park is high usage. - Hospital high value. - Private assets – consider existing structures (private). - Coastal reserve – high value/possum corridor.	- West to east – buffer for hospital. - Hard protection needed for several locations. - Seawalls or groynes to protect assets. - Shared funding scheme – work with planning, EPA, landowners – not fair all ratepayers have to pay for a small group of landowners. - Need carpark – without carpark, dune erodes and lose car park. Marker for future to maintain dune structure and road.
Wonnerup	- Good fishing, boating, fishing but significant environmental issues. - Housing. - Two main entries and exits – Bussell Highway, Layman Road. - Bushland – home to rare possums. - Ramsar wetland. - Flood risk. - Beach quality – coffee rocks eroding – beach unusable. - Water quality (dredging Port Geographe). - Drain. - Aboriginal heritage.	- Extend groynes further out to trap sand and extend them up the beach. - Raise Layman Road. - Pump sand from Port Geographe. Trucks currently do this. - Extend seawall. - Buy land, managed retreat and move Layman Road. - Beach sweeper to improve amenity. - Maintain/monitor groynes and seawall. - Monitor northern section.

3.3 Stakeholder Feedback

A technical presentation on managing coastal erosion along Geographe Bay into the future was provided to participants. Feedback was sought and stakeholders expressed appreciation for the workshop. They also reflected the importance of an integrated approach to coastal management and concerns about ongoing funding.

A full summary of the workshop, as distributed to participants, is in Attachment B. A summary of the stakeholder feedback is provided in Table 3.3.

The draft Coastal Management Program was issued to stakeholders for comment in June 2018 and feedback incorporated in this report.

Table 3.3 Stakeholder Feedback

Coastal Monitoring	Coastal Management	Management Sites / Priorities
- Performance assessment of what is working from the 5-year plan and what is not? - Beach photo monitoring, with use of volunteers. -Consider use of drones. - Identify data sources (public availability).	- Maintain beaches in front of resorts. - Tourism is our bread and butter, look after attractors. - Assess high risk areas -beaches are one part of the wider environment. - Build sand dunes instead of placing sand in the ocean. - Preserve beach areas (tourism / lifestyle). - What is the economic value of the beach? - Beaches are a part of Busselton (fishing, environment, events).	- Need to consider management along the whole bay. - Piece it together.

3.4 Public Availability of Coastal Management Data

The City have collated historic coastal management data for a Coastal Management Layer in their internal GIS systems.. This data will be progressively being many available on the public Intrampas system.

In June 2018, high resolution videos of the Geographe Bay shoreline following a severe storm were taken using a UAV video. This has been integrated with coastal engineering interviews and storm footage into a short video that will be made publicly available. This is part of the City's commitment to ongoing consultation with regard to their Coastal Management Program.

Figure 3.2 Post Storm UAV Imagery (2018)

3.5 2020 Residents Survey

The City undertook a wider resident survey in June 2020. The *"management and protection of our coastline from erosion"* was identified as the most important local project and issue by City of Busselton residents. It is noted that the survey timing followed a severe erosion event and there were 15% of respondents who identified this issue as the "1st most important". Selected comments outlining concerns of residents with regard to coastal management and beach erosion included the following:

- "Ensuring the coastline is managed to protect its beauty for future generations"
- "Better management of the beaches during winter storms i.e. control erosion and prevent seaweed build up".
- "Tackle coastal erosion. Continue to re-vegetate coastal areas".
- "Protect the coastline and beautiful beach"
- "Coastal protection structures are the most critical".
- "Improve the preservation of beach area that recedes every year in storms".
- "Unfortunately we are losing far too much of our foreshore to storm damage, I have lived here all of my life and the changes in our weather patterns are marked. I think our beaches are our biggest asset and unless we get serious about protecting them there won't be much left in 20 years".
- "We need to start planning and building seawalls all around our bay".
- "Coastal erosion is a problem that is getting worse over time".
- "Protect and maintain our most important asset our coastline and waterways".

Figure 3.3 2020 Residents Survey – Coastal Management Identified as Most Important Issue (Markyt 2020).

4 Coastal Management Program (2014-2020)

The Busselton Coastal Management Program has guided monitoring, investigations, sand nourishment, maintenance and capital works for coastal adaptation along the Geographe Bay Foreshore since 2014. This section summarises works completed since 2014.

4.1 Coastal Monitoring

Strategic coastal monitoring has been undertaken by the City of Busselton since 2013/14 (Table 4.1) Monitoring includes six monthly beach surveys, photo monitoring and oblique aerials.

Table 4.1 City of Busselton Strategic Coastal Monitoring Program (2014 - 2020)

Monitoring Year	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7	
Survey	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Season	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Date	Dec -13	May -14	Dec -14	May -15	Dec -15	May -16	Dec -16	May -17	Dec -17	May -18	Dec -18	May -19	Dec -19	May -20
Photo Monitoring (32 sites)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Strategic Beach Profiles (20 profiles)	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Targeted Beach Profiles Wonnerup/Broad water									✓	✓	✓	✓	✓	✓
Oblique Aerial	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coastline Movements	✓		✓	✓			✓		✓		✓		✓	

State government agencies also have monitoring programs for meteorologic data, metocean data (waves & tides), aerial photography and survey; which are available to the City for coastal management. Several state government agencies have made coastal data available publicly online in recent years. Whilst this data is only available up to about 2015 from most agencies, more recent data is available via direct request to relevant agencies.

The following sections outline the data collected by the City and available from these agencies. In addition, this section also outlines other available data sources.

Metocean Data

The City of Busselton does not directly collect metocean (wave and tide) data. Relevant ongoing and historic water level, wave and wind data collection campaigns are undertaken by the Department of Transport and Bureau of Meteorology with the location of metocean monitoring instrumentation illustrated in Figure 4.1.

The Busselton AWAC (7km NW of Busselton Jetty) has been in-place for more than 20 years but will be removed in October 2020, with a new instrument deployed near Port Geographe (D Hanson, DoT, pers comm). Whilst the CMP includes the installation of a wave recorded on the Busselton Jetty, there will be no strategic monitoring of nearshore waves in Geographe Bay in the interim.

Figure 4.1 Historic and Ongoing Metocean Monitoring Locations

Hydrographic and Topographic Data

Historic survey data is available from the Department of Transport online through their online data portal. This includes point survey data from 1973 to 2012 and a composite surface of the whole of Geographe Bay based on LiDAR data flown in 2009. An indication of coverage is illustrated in Figure 4.2 (excluding LiDAR data). Note that some surveys were completed over multiple days, and only one date is shown in the figure below to represent that survey.

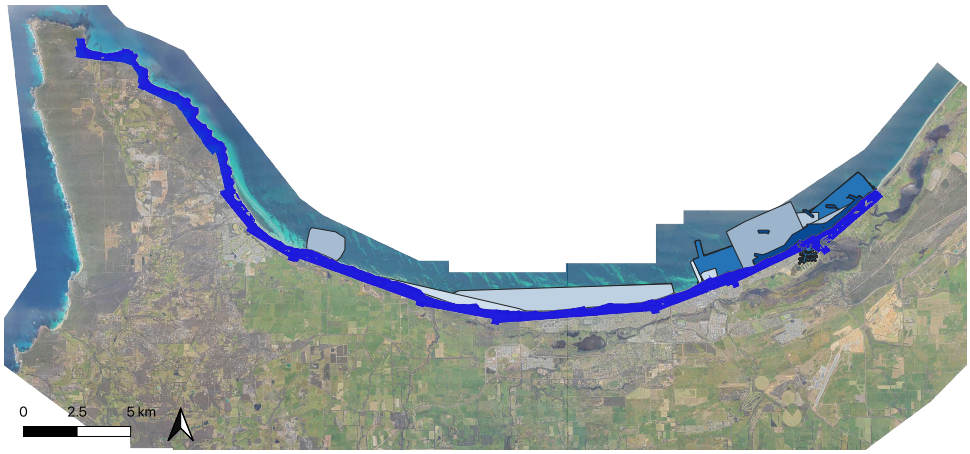


Figure 4.2 Beach and Hydrographic Survey Coverage in Geographe Bay

More recent point survey data is available through direct request to the Department of Transport. In addition, more recent survey data has been collected by the City as part of the previous CMP. The main detailed surveys for coastal monitoring undertaken in the last 10 years include:

- 2009 LIDAR Bathymetric Survey with complete coverage of Geographe Bay (Department of Transport) and LIDAR land survey of Busselton (Department of Water). This provides a detailed baseline survey to monitor coastal change.
- 2014 Detailed beach aerial scan of Geographe Bay foreshore by City of Busselton.
- 2012-2014 Hydrosurveys including Dunsborough multibeam (2014), Broadwater single-beam (2012) and East Busselton/Wonnerup multibeam (2014) that have been used as a basis for developing a detailed sediment budget for Geographe Bay (11).
- 2015-2017 Annual beach scan and multibeam hydrosurveys from Busselton Jetty to Wonnerup Inlet (Department of Transport).
- December 2019 Lidar covering the beach from approximately 0m AHD to 300m behind the vegetation line, from Dunsborough Jetty to Wonnerup.

As part of the 2014-2018 program beach profiles are taken at 21 sites around Geographe Bay to monitor erosion buffers to assets and dune crest levels. These surveys were taken annually between 2013 and 2015 and bi-annually from 2015 to present. A summary of the beach profile locations is shown Attachment A.

In addition to the biannual beach cross-section surveys, monthly beach width measurements are also taken as part of the PNP monitoring campaign (12). The location of the sites is outlined in Attachment A.

Aerial Photography

Vegetation and water lines have been interpreted for the Geographe Bay shoreline from aerial photography dating back to 1941. There is a series of plans showing 8 dates of photography from 1941 to 2008 for the sandy coastline from Dunsborough through to Wonnerup (DPI 433 series). Historic vegetation and water lines are available for 1941, 1975, 1985, 1993, 1999, 2001, 2003, 2004 and 2008.

In more recent years Landgate has undertaken high resolution vertical aerial photography capture at least annually. This has allowed for the interpretation of vegetation and water lines more frequently as part of the annual beach monitoring works using guidance outlined in (13). As such the coastline movement plots have been updated and include aerial interpreted coastal demarcation lines from Nov 2013 through to 2019. Additional aerial imagery and coastal demarcation lines are also available between 2010 and 2013 although these are not included on the coastline movement plans. Additional imagery is also available commercially through Nearmap

1.1.1 Oblique Aerial Photography

The City undertakes an oblique aerial photographic run twice a year, once at the beginning of summer and once at the beginning of winter. Between 2013 and 2015 this covered the coastline from Wonnerup Estuary to Old Dunsborough. In 2016/17 the flight path was extended to provide baseline imagery of the coastline to Cape Naturaliste. Figure 4.3 provides an example of the oblique aerial imagery captured.

An oblique aerial photo run is also undertaken as part of the PNP monitoring twice a year. These photos are taken on a different flight path in comparison to the City's and may therefore not be suitable for direct comparison.

Figure 4.3 Oblique Aerial photograph of Busselton Jetty (Dec 2013 and Jan 2019)

1.1.2 Beach Photography

Since December 2013 beach photo monitoring has been formalised at 32 sites as part of the annual monitoring (Figure 4.5). Photo monitoring is undertaken every 6 months at these sites as part of the annual beach monitoring.

Continued development of monitoring techniques during the last 5 years of coastal monitoring have included the innovative use of panorama and photospheres at each monitoring site. These allow for a more immersive experience and show the wider context for each monitoring site. They also provide a more relatable data set for interaction with the wider general public.

Figure 4.4 Dunsborough Foreshore December 2013 (left) and December 2018 (right)

In addition to the annual beach monitoring, photo monitoring has also been undertaken as part of the PNP monitoring at 16 sites on a monthly basis (Figure 4.5, Attachment 1). This PNP monitoring includes beach width measurements.

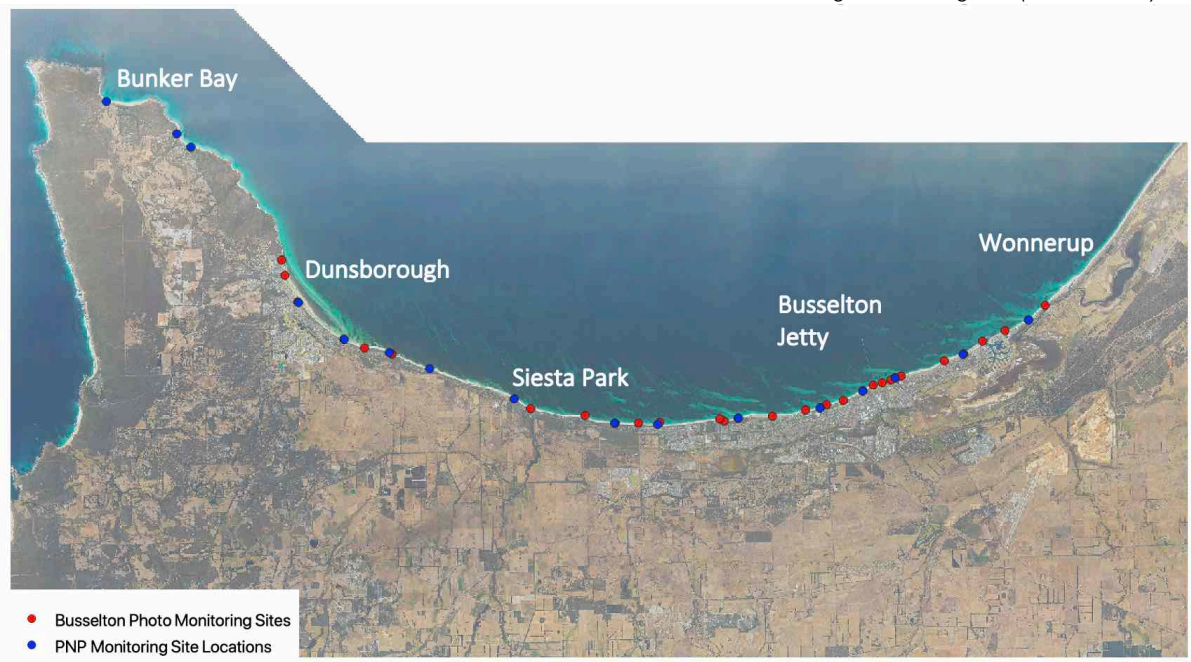


Figure 4.5 Location of the 32 City of Busselton monitoring sites, and 16 PNP monitoring sites.

Fixed Camera Monitoring

A fixed camera was installed at the Busselton Jetty in November 2018 for a trial 12-month period. The camera takes a daily photo of the beach to the west of the Jetty (14). Fixed camera monitoring is also undertaken by DoT to monitor seagrass wrack accumulation on the Western Beach and Port Geographe, and beach behaviour at Wonnerup.

Figure 4.6 Busselton Jetty Fixed Camera Monitoring showing wave runup (b) and wrack deposition associated with TC Marcos (c) and localised scour downdrift of groyne (d)

4.2 Coastal Investigations

A summary of the coastal investigations completed since 2013, including type and coverage, is outlined in Table 4.2. Investigations prior to 2012 are summarised in (15) & (16). These include strategic bay-wide coastal investigations to improve the knowledge base (sediment budgets, stratigraphy), strategic coastal management investigations for sand nourishment, coastal structures and rock supply, numerical modelling of storm surge inundation and the potential impacts and response, and more site specific investigations associated with coastal adaptation projects.

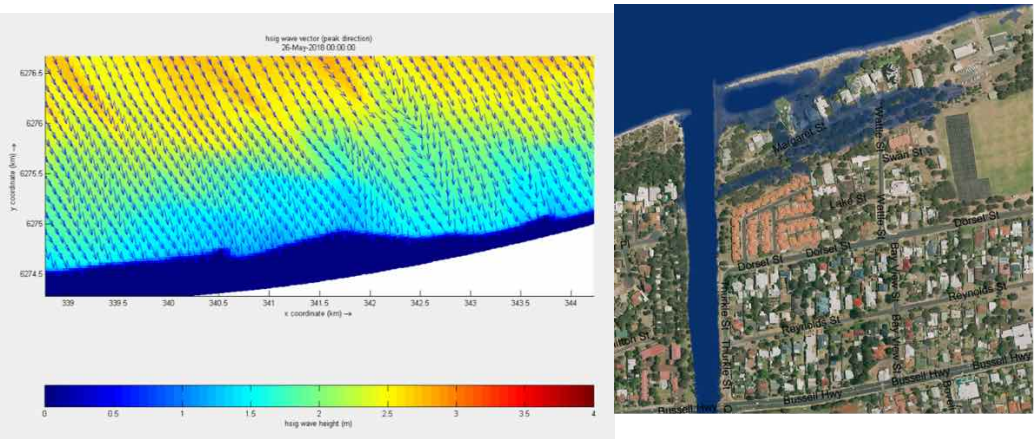


Figure 4.7 Wave Modelling (left) and Flood Modelling (right) along Geographe Bay

Table 4.2 Coastal Investigations and Design (2012-2020)

				Coastal Management Area						Study Type				
				1	2	3	4	5	6					
ID	Year	Author	Report Title	Dunsborough	Quindalup	Siesta Park	Abbey and Broadwater	West and East Busselton	Port Geographe and Wonnerup	Monitoring	Investigations	Nourishment Sand	Maintenance Works	Capital Works
1	2012	UWA	Seagrass Research Study	1	1	1	1	1	1		1			
2	2012	UWA	Seagrass Modelling						1		1			
3	2012	Damara	Port Geographe Design Condition						1		1			
4	2012	Manly Hydraulics Laboratory	Busselton Seawall 2D Physical Model					1			1			
5	2013	Shore Coastal	Busselton Foreshore Seawall - Revised Preliminary Design (Queen St)					1						1
6	2013	Damara WA Pty Ltd	Bunbury & Busselton Tide Gauge Records DRAFT C	1	1	1	1	1	1		1			
7	2013	UWA	Sediment Transport Modelling						1		1			
8	2013	Seashore Engineering	Tech Note - Seagrass						1		1			
9	2013	Seashore Engineering	Tech Note - Sand						1		1			
10	2013	Shore Coastal	Locke Estate Coastal Works (Stage 1) - Technical Specification			1								1
11	2013	Shore Coastal	Scout Road Coastal works - Design Basis					1						1
12	2013	GHD	Busselton East Foreshore Design and Drawings					1						1
13	2013	DEC	Ngari Capes Marine Park Management Plan	1	1	1	1	1	1					
14	2013	Worley	Port Geographe Breakwater Reconfiguration - Design and Drawings						1					1
15	2014	Shore Coastal	Busselton Detailed Survey - Summary Report RevA 140528	1	1	1	1	1	1	1				
16	2014	Shore Coastal	Busselton Foreshore Seawall - Preliminary Design Options					1						1
17	2014	Shore Coastal	Busselton Coastal Management Program_ Beach Monitoring (Year 1) - Final Report	1	1	1	1	1	1	1				
18	2014	Geoscience Australia	Current and future climate inundation modelling for Busselton, Western Australia.	1	1	1	1	1	1		1			
19	2014	M P Rogers & Associates Pty Ltd	Broadwater Beach - Coastal Erosion Investigation				1				1			
20	2014	Manly Hydraulics Laboratory	Busselton Foreshore Seawall 2D Physical Model					1			1			
21	2014	BMT Oceanica	Port Geographe EMMP						1					
22	2015	Shore Coastal	Busselton Coastal Management Program_Beach Monitoring (Year 2) - Annual Report	1	1	1	1	1	1	1				
23	2015	Shore Coastal	King Street Seawall - Technical Specification					1						1
24	2015	Damara WA Pty Ltd	Peron Naturaliste Partnership Region Coastal Monitoring Program	1	1	1	1	1	1	1				
25	2015	Shore Coastal	Geographe Bay - Sediment Budget	1	1	1	1	1	1		1			
26	2015	Shore Coastal	Busselton Storm Surge Response Plan	1	1	1	1	1	1		1			
27	2015	Shore Coastal	Geographe Bay - Coastal Stratigraphy	1	1	1	1	1	1		1			
28	2015	GHD	Coastal Structures Review - Report on Sources of Rock for Armour Stone	1	1	1	1	1	1		1			
29	2015	Shore Coastal	Busselton Sand Nourishment Review	1	1	1	1	1	1			1		
30	2015	GHD	Coastal Structures Review - Geotextile Sand Container Report	1	1	1	1	1	1				1	
31	2015	GHD	Coastal Structures Review - Condition Assessment Report	1	1	1	1	1	1				1	
32	2016	Shore Coastal	Busselton Coastal Management Program_Beach Monitoring (Year 3) - Annual Report	1	1	1	1	1	1	1				
33	2017	Shore Coastal	Wonnerup Coastal Stabilisation Trial - Drawings						1					1
34	2017	Shore Coastal	Busselton Coastal Management Program_Beach Monitoring (Year 4) - Annual Report	1	1	1	1	1	1	1				
35	2017	Shore Coastal	East Wonnerup (Baudin Reserve) Coastal Erosion - Technical Note						1		1			
36	2017	Damara	Naturaliste Coast Hazard Assessment	1							1			
37	2017	Shore Coastal	Wonnerup Coastal Stabilisation Trial - Close-out Report						1					1
38	2017	Cardno	Busselton Central Core Foreshore Design and Drawings					1						1
39	2018	Shore Coastal	Busselton Storm Surge Risk Response and Mitigation	1	1	1	1	1	1		1			
40	2018	Shore Coastal	Busselton Coastal Management Program_Beach Monitoring (Year 5) - Annual Report	1	1	1	1	1	1	1				
41	2018	Shore Coastal	Broadwater Beach Coastal Adaptation Review – Desktop Review				1				1			
42	2019	Shore Coastal	Busselton Coastal Management Program_Beach Monitoring (Year 6) - Annual Report	1	1	1	1	1	1	1				
43	2019	Shore Coastal	Broadwater Coastal Adaptation Options				1				1			
44	2019	Shore Coastal	Wonnerup Rock Groyne Maintenance - Technical Specification						1				1	
45	2019	Shore Coastal	West Busselton - Craig Street Rock Coastal Protection - Technical Specification					1					1	
46	2020	Department of Transport	Port Geographe Wrack - Technical Working Group Report						1	1	1			
47	2020	Shore Coastal	May 2020 Storm Surge Event - Post Storm Inspection	1	1	1	1	1	1		1			
48	2020	Shore Coastal	May 2020 Storm Surge Event - Review of Warnings and Emergency Response	1	1	1	1	1	1		1			
49	2020	Shore Coastal	Coastal Adaptation Works 2019/20 Broadwater and Wonnerup - Technical Specification				1		1				1	1
50	2020	M P Rogers & Associates Pty Ltd	Busselton Coastal Management Program_Beach Monitoring (Year 7) - Annual Report	1	1	1	1	1	1	1				

4.3 Sand Nourishment

During the 2014-2018 program the City maintained more detailed records of sand nourishment. This includes records of sand nourishment source, quantity and destination. A summary of sand nourishment activities was also documented in (11) from 2008 to 2014. Table 4.3 presents a collation of the sand nourishment works conducted by the City in each management area between 2008 and 2020. This table does not include sand nourishment undertaken by DoT at Wonnerup.

The City has placed 30,000m^3 of sand on the foreshore associated with capital works projects (coastal groynes) to mitigate downdrift impacts, and an average of 4,700m^3/yr for maintenance distributed across 14 sites. It is noted a third of the maintenance sand nourishment occurred at Scout Road prior to construction of the groyne field in 2013. Maintenance sand nourishment in this area has not been required since construction of the groyne field.

Similarly, Busselton Foreshore and Locke Estate both received sand nourishment during construction works but have not had any sand nourishment since. Dunsborough Foreshore had 1,700m^3 prior to the realignment of the seawall and had 6,000m^3 as part of the works in 2011, with just over 2,000m^3 placed since construction. The majority of the sand nourishment placed at Norman Road, where there has not been significant capital works, has been since 2015.

Table 4.3 Sand Nourishment Works (2008 – 2020)

Management Area	Site	Volume (m^3)	Capital Nourishment (m^3)	Maintenance Nourishment (m^3)
Dunsborough	Bayview Crescent (South)	1,810	0	1,810
	Dunsborough Foreshore	11,324	6000	5,324
Quindalup to Siesta Park	Siesta Park ROW	287	0	287
Locke Estate to Abbey	Locke Estate	11,509	11439	70
	Forth Street	4153	0	4,153
	Abbey Boat Ramp	500	0	500
Broadwater to Busselton	Norman Road	12,905	0	12,905
	Alan Street	7,450	0	7,450
	Mill Rd	2,838	0	2,838
	Margaret St	171		171
	King St	1,924	0	1,924
	Gale St	94		94
	Busselton Foreshore	7,500	7500	0
East Busselton	Scout Road	23,700	5000	18,700
Wonnerup	n/a	0		0
	Subtotal	86,164	29,939	56,225

4.4 Coastal Adaptation Works

The current status of coastal adaptation works is outlined in Table 4.4. This includes works completed since 2008. The works have been organised according to the coastal management area in which they took place. The table also shows the type of works that took place and an assessment of the erosion cause, using types of erosion defined by Seashore Engineering in a state-wide strategic assessment of coastal erosion for the Department of Planning (17).

Coastal adaptation works are categorised as:

- Coastal protection (new structures) – for when structures have been constructed where none previously existed.
- Coastal protection (replacement/upgrade) – where a structure previously existed but was near the end of its design life and has been replaced/upgraded with a new structure to a higher standard.
- Maintenance – where a structure has had minor maintenance to repair back to original standards.
- Temporary/Emergency works – Works that occurred in response to the potential loss of assets during storm events, usually with minimal design standard.
- Foreshore Enhancement – where coastal protection structures have been integrated with wider works to enhance public experience of the foreshore.
- Beach Amenity – where works have sought to maintain the beach amenity.
- Manage Retreat – where assets have been relocated to allow for a wider erosion buffer.

Documentation (designs, specifications, investigations) associated with completed works since 2014 are summarised in Section 4.2.

Table 4.4 Coastal Adaptation Works Completed (2008-2020)

Year	Structure Name	Description	Sector						Works Type							Cause of Erosion				
			Dunsborough	Quindalup - Siesta Park	Locke Estate - Abbey	Broadwater - West Busselton	East Busselton	Wonnerup	Coastal Protection (new structures)	Coastal Protection (replacement/ upgrade)	Maintenance	Temporary/ Emergency Coastal Works	Foreshore Enhancement	Beach Amenity	Managed Retreat	Influence of Artificial Structures	Local Instability due to Geomorphology	Variable Sediment Supply	Nearshore Structures Cannot Withstand Erosion	Projected Coastal Change
Busselton Foreshore - Coastal Works (2008 - 2013)																				
2008	Busselton Foreshore Groynes	Replacement of three Timber Groynes with Groynes made of 2.5cu.m GSC at the Busselton Foreshore				1				1					1				1	
2008	Busselton Foreshore temporary GSC Seawall	Construction of a 50m long temporary GSC seawall at the Busselton Foreshore to replace failed concrete seawall				1						1							1	
2010	Busselton Jetty Rock Abutment	Refurbishment of the Busselton Jetty Rock Abutment				1				1			1	1					1	
2011	Broadwater Beach Trial GSC Groynes	Construction of 2 new trial groynes using 0.75cu.m GSCs				1						1				1	1			
2011	Holgate Road Groyne	Maintenance of the trunk section of the Holgate Road Groyne and extension using 0.75cu.m GSCs				1					1			1		1			1	
2011	Busselton Foreshore Rock Seawall	Construction of a 440m long Granite Rock seawall to replace the existing rock seawall				1				1			1						1	1
2011	Abbey Boat Ramp Rock Wall	Extension of the Abbey Boat Ramp rock wall on the western side of the boat ramp.			1						1								1	
2011	Busselton Foreshore Groynes	Construction of 2 short new groynes at the western end of the rock seawall from 2.5cu.m GSCs salvaged from Busselton Foreshore temporary GSC seawall				1			1					1					1	
2012	Abbey Boat Ramp Rock Wall	Upgrade works to the Abbey Boat Ramp seawall as part of the refurbishment and upgrade of the Abbey Beach Boat Ramp Works			1					1			1	1					1	
2012	Dunsborough Foreshore Seawall	Replacement of Dunsborough Foreshore Seawall with GSC structure and removal of car park	1							1			1	1	1					1
Busselton Foreshore - Coastal Works (2013 - 2017)																				
2013	Scout Road Groynes	Construction of 4 new groynes from 2.5cu.m GSCs adjacent to Scout Road east of the Busselton Jetty					1		1	1				1	1	1	1			1
2013	Locke Estate Groynes	Removal of assets within 10m of vegetation line, replacement of Groynes 3 and 4, construction of an additional groyne at the eastern end of Locke Estate. I			1				1	1	1			1	1	1			1	1
2013	Harvest Road Groyne	Maintenance of Harvest Road Rock Groyne			1						1			1		1			1	
2013	West Abbey Beach Timber Groynes	Maintenance of two timber groynes on the beaches of West Abbey			1						1			1		1			1	
2013	King Street Foreshore Seawall	Emergency works for construction of a new seawall in front of the King Street car park and toilet block from 0.75cu.m GSCs				1						1						1	1	
2013	Quindalup Sea Rescue Trial GSC Groyne	Construction of new groyne from 0.75cu.m GSCs updrift of Quindalup Sea Rescue Boat Ramp		1					1											
2014	Locke Estate Groynes	Replacement of timber groynes 1, 2 and 4 with rock groynes			1					1				1	1	1			1	1
2014	Abbey Timber and Rock Groynes	Refurbishment of rock groynes 3 and 5 and replacement of timber groyne 2 with rock groyne on the beaches adjacent to Abbey Resorts			1					1	1			1		1			1	
2015	Busselton Foreshore Seawalls	Replacement of concrete seawalls at the Busselton Foreshore to the east of the jetty					1			1			1				1		1	1
2016	Beachlands East and West Timber Groynes	Refurbishment of 2 timber groynes on the beaches adjacent to Beachlands in West Busselton				1					1			1					1	
2017	Baudin Reserve GSC Groynes	Construction of 2 groynes from 2.5cu.m GSCs on the beaches adjacent to Baudin Reserve.						1				1		1	1	1	1	1		1
2017	Busselton Foreshore Seawalls	Replacement of concrete seawalls at the Busselton Foreshore to the west of the jetty				1				1			1				1		1	1
2017	King Street Foreshore Seawall (west)	Replacement of 0.75cu.m bag GSC seawall with 2.5cu.m bag GSC seawall and realignment of front edge of car park to allow larger dune buffers				1				1			1		1			1	1	1
Busselton Foreshore - Coastal Works (2017 - 2020)																				
2018	King Street Seawall (east) Maintenance	Maintenance to existing GSC seawall that protects existing toilet block and grassed/ planted area.				1				1								1	1	1
2019	Wonnerup Coastal Protection Stage 1	Refurbishment of 4 low profile rock groynes using granite						1		1						1	1	1	1	1
2019	West Busselton - Craig Street Rock Coastal Protection Refurbishment	Refurbishment of a 200m laterite seawall and groyne. Granite was used on the crest of the groyne, while large laterite armour was used along the seawall.				1				1								1	1	
2020	Wonnerup Coastal Protection Stage 2	Construction of three GSC groynes at Wonnerup/Baudin (two type B and one Type A)						1	1							1	1	1		1
2020	Broadwater Beach Coastal Adaptation Works	DUP path realigned in 2019. Refurbish Holdgate Rd groyne with reduced length (20m) and granite crest, construct one GSC groyne west of Holgate Rd Groyne to mitigate updrift aeffects, sand nourishment.				1			1	1						1	1			
2020	Abbey Timber Groyne maintenance	Maintenance and extension of timber groynes damaged in May 2020 storms.			1						1					1	1		1	

4.5 Maintenance of Coastal Structures

Coastal structures along Geographe Bay were initially inspected in 2010 (18). This formed the basis of a strategic maintenance program for these structures. A 5-yearly inspection of the coastal structures was undertaken in 2015 (19) to assess their condition and function and prioritise maintenance.

Table 4.6 outlines the available information on the condition and maintenance priority of coastal protection assets. The structures have been classified by sector and by structure type. Of the 61 structures, the City manages 53, with the majority (38) located between Siesta Park Groyne and the Busselton Jetty. The City manages 22 rock groynes, 17 GSC groynes, 9 timber groynes, 6 rock seawalls, 3 GSC seawalls and 2 concrete seawalls. Table 4.6 generally reflects the structures list from the 2015 inspection report by GHD. The table includes a number of structures not in the original report as they were constructed since 2015 or were buried during inspection. These include:

- Quindalup Sea Rescue Trial Groyne.
- Broadwater Beach Trial Groynes 1 and 2.
- King Street Seawall.
- Busselton Jetty Rock Seawall GSC Groynes 1 and 2.
- The Busselton Foreshore Concrete Seawall has been split into east and west sections.
- Baudin Reserve Trial Groynes 1 and 2.

The table excludes some structures listed by GHD, notably the unconstrained drain outlets at Lennox River and Station Gully (as these are managed but are not structures than can be maintained) and the Dolphin Road boat ramp (as this is not a coastal adaptation structure).

The table also presents the condition and function rating attributed by GHD. We note, however that this is likely to have changed since the completion of the report, as a number of the structures have been repaired, maintained or replaced. Structures that have been repaired/replaced since the completion of the 2015 inspection include:

- Busselton Concrete Foreshore Seawalls.
- West Busselton Timber Groynes.
- Locke Estate Groynes 1, 2 and 5.

Maintenance works were undertaken in 2017/18 on the GSC groynes on the Busselton foreshore and the Baudin Reserve Trial Groynes.

Some of the structures identified do not have a condition or function rating. This is either because they were omitted from the original review as outlined above or because they were buried and not available for assessment during inspection (i.e. Quindalup stone revetment). GHD also provided a maintenance priority list for the structures reviewed with maintenance priority categorised as low, medium and high based on the condition and function rating of the structure and an assessment of the design life versus actual remaining life of the structure. The structures with medium and high priority are outlined below.

Table 4.5 GHD 2015 Medium and High Maintenance Priority Structures

Maintenance Priority (2015)	Structure Description
High	Siesta Park Groyne, Abbey Groyne 6 (Holgate Rd Groyne)* .
Medium	West Busselton Seawall (Beachlands), Craig Street Groyne & Seawall*, Dunsborough Buried GSC Seawall, Busselton Jetty Rock Seawall*, Wonnerup Groyne 5 & 6.*

*Structures since maintained or refurbished.

Table 4.6 Coastal Protection Structures

Busselton Foreshore - Coastal Structures and Maintenance

No.	ID	Structure Description	Year Constructed	Year Maintained/ Replaced/ Upgraded	GHD 2015 Condition Rating	GHD 2015 Function Rating	Ownership	Sector						Structure Type							
								Dunsborough	Quindalup - Siesta Park	Locke Estate - Abbey	Broadwater - West Busselton	East Busselton	Wonnerup	Rock Seawall	GSC Seawall	Concrete Seawall	Rock Groyne	GSC Groyne	Timber Groyne	Boat Ramps/Jetties	Training Wall/Outlet
1	1_1	Old Dunsborough - Greenacres Groyne	n/a		Very Poor	Marginal	CoB	1													
2	1_2	Dunsborough Buried GSC Seawall	1970s	2012	Good	Good	CoB	1							1						
3	2_1	Quindalup stone revetment	1973				CoB		1					1							
4	3_1	Quindalup timber groynes	1982				CoB		1										1		
5	3_2	Quindalup Sea Rescue Trial Gorune	2013				CoB		1									1			
6	6_1	East Lennox Groyne 1	1960s		Poor	Marginal	Private		1										1		
7	6_2	East Lennox Groyne 2	1960s		Very Poor	Poor	Private		1										1		
8	6_3	East Lennox Groyne 3	1960s		Marginal	Marginal	Private		1										1		
9	6_4	East Lennox Groyne 4	1960s		Poor	Poor	Private		1										1		
10	6_5	East Lennox Groyne 5	1960s		Very Poor	Marginal	Private		1										1		
11	7_1	Jetty Groyne at "Serena" (Siesta Park)	1950s		Poor	Fair	Private		1											1	
12	8_1	Siesta Park Groyne	1965 - 1967		Poor	Marginal	CoB		1								1				
13	9_1	Locke Estate Groyne 1	1988 - 1992	2015	Poor	Fair	CoB			1							1				
14	9_2	Locke Estate Groyne 2	1988 - 1992	2015	Fair	Fair	CoB			1							1				
15	9_3	Locke Estate Groyne 3	1988 - 1992	2014	Good	Good	CoB			1								1			
16	9_4	Locke Estate Groyne 4	1988 - 1992	2014	Good	Good	CoB			1								1			
17	9_5	Locke Estate Groyne 5	1988 - 1992	2015	Poor	Fair	CoB			1							1				
18	9_6	Locke Estate Groyne 6	2014		Good	Good	CoB			1								1			
19	9_7	Locke Estate Seawall	1988 - 1992	2014	Marginal	Fair	CoB			1				1							
20	10_1	Buayanup Drain Training Wall	1985		Fair	Fair	DoW			1											1
21	11_1	Abbey West Timber Groyne		2012/2013	Good	Good	CoB			1									1		
22	12_1	Abbey Boat Ramp Headland	1978	2011 - 2013	Good	Good	CoB			1				1							
23	13_1	Abbey Groyne 1	1990s	2013	Good	Good	CoB			1									1		
24	13_2	Abbey Groyne 2	1990s	2014	Fair	Good	CoB			1								1			
25	13_3	Abbey Groyne 3	1990s	2014	Fair	Good	CoB			1								1			
26	13_4	Abbey Groyne 4	1990s	2013	Good	Good	CoB			1								1			
27	13_5	Abbey Groyne 5	1990s	2014	Fair	Good	CoB			1								1			
28	13_6	Abbey Groyne 6	1990s	2011	Marginal	Fair	CoB			1								1			
29	13_7	Broadwater Trial Groyne 1	2011				CoB				1								1		
30	13_8	Broadwater Trial Groyne 2	2011				CoB				1								1		
31	15_1	West Busselton Groyne 1 (Beachlands)	1995	2016	Poor	Good	CoB				1									1	
32	15_2	West Busselton Groyne 2 (Beachlands)	1995	2016	Very Poor	Good	CoB				1									1	
33	15_3	West Busselton Misc Groynes (3) (Beachlands	1980s				CoB				1									1	
34	15_4	West Busselton Seawall (Beachlands)	1970s		Fair	Fair	CoB				1			1							
35	15_5	West Busselton 'Longard Tubes' (Beachlands)	1977				CoB				1				1						
36	16_1	Craig Street Groyne	1999		Fair	Fair	CoB				1								1		
37	16_2	Craig Street Seawall	1970s		Fair	Fair	CoB				1			1							
38	17_1	Vasse Diversion Outlet Training Wall	1983		Fair	Good	DoW				1										1
39	17_2	King Street Car Park Seawall	2013	2017			CoB				1				1						
40	18_1	Busselton Jetty Rock Seawall Groyne 1	2011				CoB				1							1			
41	18_2	Busselton Jetty Rock Seawall Groyne 2	2011				CoB				1							1			
42	18_3	Busselton Jetty GSC Groyne 1	2008		Good	Good	CoB				1							1			
43	18_4	Busselton Jetty GSC Groyne 2	2008		Good	Good	CoB				1							1			
44	18_5	Busselton Jetty GSC Groyne 3	2008		Good	Good	CoB				1							1			
45	18_6	Busselton Jetty Concrete Seawall West	1960s or 1970s	2017	Poor	Marginal	CoB				1					1					
46	18_7	Busselton Jetty Concrete Seawall East	1960s or 1970s	2015	Poor	Marginal	CoB				1					1					
47	18_7	Busselton Jetty Rock Seawall		2011	Good	Good	CoB				1			1							
48	18_8	Scout Road Groyne 1	2013		Good	Good	CoB					1						1			
49	18_9	Scout Road Groyne 2	2013		Good	Good	CoB					1						1			
50	18_10	Scout Road Groyne 3	2013		Good	Good	CoB					1						1			
51	18_11	Scout Road Groyne 4	2013		Good	Good	CoB					1						1			
52	19_1	East Busselton Groyne Field (6 groynes)	1970s				CoB					1					1				
53	20_1	Guerin St Groyne (removed)	1974				CoB					1					1				
54	21_1	Wonnerup Groyne 1	2006		Fair	Fair	CoB						1				1				
55	21_2	Wonnerup Groyne 2	2006		Fair	Fair	CoB						1				1				
56	21_3	Wonnerup Groyne 3	2004		Fair	Fair	CoB						1				1				
57	21_4	Wonnerup Groyne 4	2004	2011	Good	Good	CoB						1				1				
58	21_5	Wonnerup Groyne 5	2004		Marginal	Marginal	CoB						1				1				
59	21_6	Wonnerup Groyne 6	2004		Marginal	Marginal	CoB						1				1				
60	22_1	Baudin Reserve Groyne 1	2017				CoB						1					1			
61	22_2	Baudin Reserve Groyne 2	2017				CoB						1					1			
62	22_3	Baudin Reserve Groyne 3	2020				CoB						1					1			
63	22_4	Baudin Reserve Groyne 4	2020				CoB						1					1			
64	13_7	Abbey Groyne 7	2020				CoB			1								1			

5 Review of Coastal Management Program (2014-2020)

The Busselton Coastal Management Program has guided monitoring, investigations, sand nourishment, maintenance and capital works for coastal adaptation along the Geographe Bay Foreshore since 2014. This section reviews the effectiveness of this program.

5.1 Coastal Monitoring

The monitoring in the CMP provides the knowledge base for coastal adaptation and improved the understanding of sand migration in Geographe Bay. This is critical to coastal stabilisation works, which depend upon a net supply of sand along the coast from west to east. Monitoring has been effective in:

- ✓ Allowing the establishment of quantitative management triggers for sand nourishment, based on minimum dune buffers.
- ✓ Distinguishing storm erosion (short term) from coastal recession (long term).
- ✓ Prioritising adaptation works through improved understanding of annually based on shoreline movement and storm erosion.
- ✓ Assessing the success of coastal protection works in terms of coastal stabilisation (locally) and downdrift impacts.
- ✓ Developing a data set for communication with stakeholders.
- ✓ Responding to ratepayer concerns regarding coastal erosion.
- ✓ Providing a basis for the securing of $2.4M of coastal grants since 2007.

An item from the previous CMP that has yet to be implemented is the installation of a near real-time wave/water level monitoring device on the Busselton Jetty to improve data capture of inshore waves and water levels and monitor storm surges.

Coastal monitoring data allows the relative storminess to be compared between years. It is noted that the years preceding the 2014 -2018 program were relatively stormy, whilst conditions during the program have been relatively calm (Figure 5.1.).

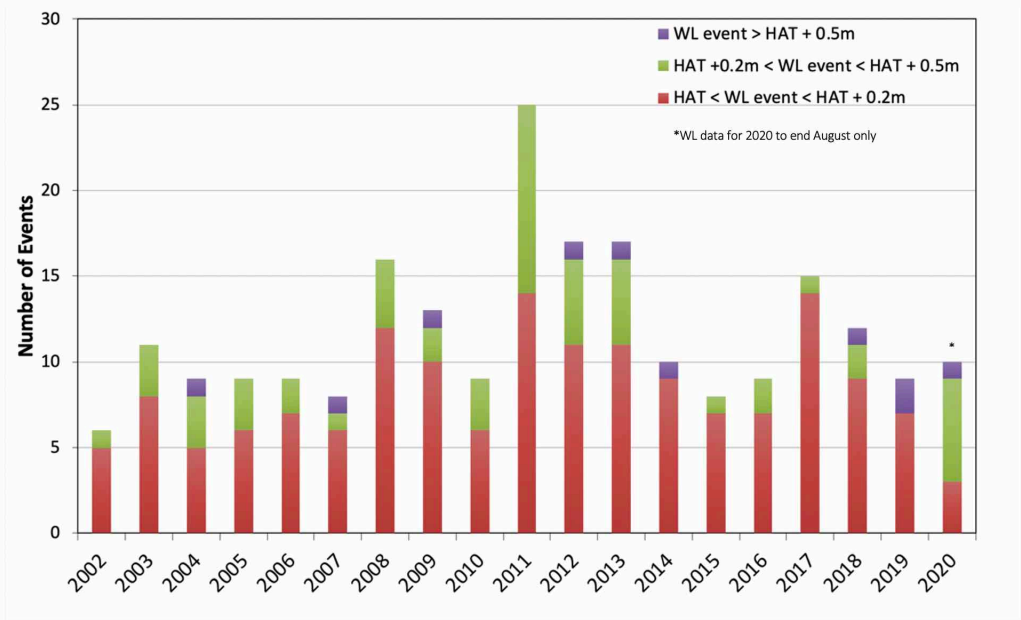


Figure 5.1 Relative Storminess in Geographe Bay based on Number of High Water Level Events Recorded at the Port Geographe Tide Gauge Each Year.

5.2 Coastal Investigations

Coastal investigations have been effective in:

- ✓ Improving the capacity of the City and of the Emergency Services to respond to a future storm surge event.
- ✓ Ensuring foreshore developments at Dunsborough and Busselton were sited and designed to limit adverse impacts on the beach and protect newly constructed public assets.
- ✓ Limiting maladaptation associated with coastal groyne fields by balancing updrift and downdrift impacts, and allowing for the influence of transverse sand bars.
- ✓ Strategic identification of future rock armour supply sources.

Further understanding of sand migration in Geographe Bay is required going forward, in particular the supply of sediments around Cape Naturaliste, the behaviour of the Dunn Bay bar, the influence of the larger coastal groynes on sediment transport rates, the influence of migrating transverse sand bars on local beach erosion, and biogenic sand supply.

5.3 Sand Nourishment

The strategic approach of the 2014-2018 program and regular monitoring have allowed the City's sand nourishment program to be more accurately targeted, with a focus of proactive nourishment (i.e. reasonable buffers going into winter) rather than reactive nourishment (post-storm responses). A detailed investigation of sand nourishment was completed in 2014 (11). Tracking of sand nourishment quantities, together with the CMP monitoring, will continue to support evaluation of sand nourishment and other potential adaptation options in the next CMP.

Contributions of the CMP sand nourishment program have included:

- ✓ Maintaining continuity throughout the 2014-2018 program.
- ✓ Providing a first response to coastal erosion with limited adverse impacts.
- ✓ Supplying sand to sites at reasonable unit rates.
- ✓ A progressive shift from reactive (winter) to proactive (summer/autumn) nourishment where feasible.
- ✓ Developing a minimum buffer concept as a quantitative basis for nourishment.

Ongoing challenges with sand nourishment include increasing unit rates for sand, volatility in grant funding and management of community expectations.

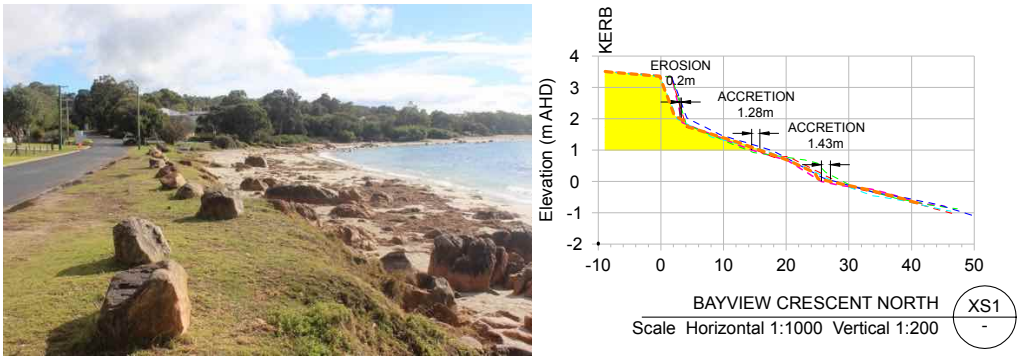


Figure 5.2 Bayview Crescent North Annual Monitoring Beach Profile Survey December 2017. Note Minimum Buffer to Assets Shaded in Yellow

5.4 Coastal Adaptation Works

Coastal adaptation works have been effective in the following aspects:

- ✓ Relocation (managed retreat) of assets to limit requirements for coastal protection. This included:
  - Relocation of foreshore carparks at Dunsborough and King St.
  - Relocation of the dual use paths at Alan St, Scout Rd and East Wonnerup.
  - Removal of buildings at campsites in Locke Estate.
- ✓ Implementation of an innovative collaborative coastal protection project at Locke Estate that was co-financed by leaseholders, the City of Busselton and the State. This has avoided the social and economic effects of failure of a protection structure (as had previously occurred at Locke Estate) and supported financially efficient maintenance works.
- ✓ *The average age of coastal protection structures along the Busselton Foreshore is now less than 10 years.* Without completed maintenance works it would have been 33 years (Figure 5.3).
- ✓ *The average age of coastal protection structures from Locke Estate to Abbey is now less than 5 years.* Without completed maintenance works would have been 28 years (Figure 5.3).
- ✓ *The typical cost of a coastal GSC groyne has almost halved over 10-years due to improvements in design and reduction in material costs.*
- ✓ The length of coast protected by a groyne field has increased significantly, by increasing the spacing between structures and monitoring their performance.
- ✓ Failed timber groyne fields have been repaired or replaced.
- ✓ Coastal protection projects have not resulted in the direct loss of the adjacent beach.

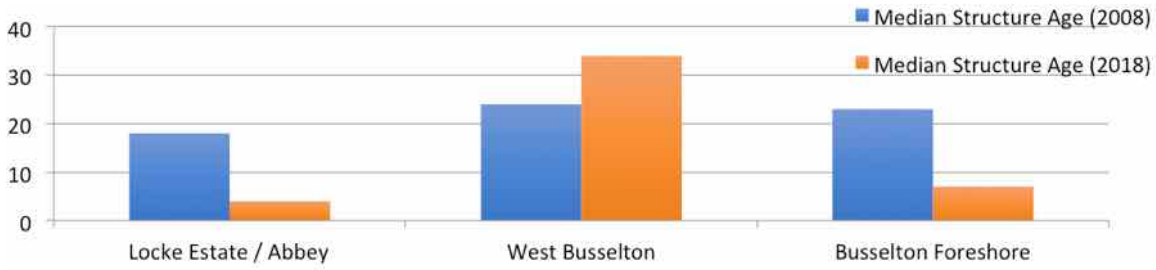


Figure 5.3 Average Age of Coastal Protection Structures in 2008 and 2018 showing reduced structure age in areas maintained.

Coastal erosion remains of significant concern at Broadwater Beach and East Wonnerup and will require active coastal adaptation over coming years. This requires careful consideration of regional sediment supplies and local sediment cells. Additionally, whilst the major realignment of the Port Geographe breakwaters has improved wrack bypassing, sand bypassing and other sand management has not been sufficient to mitigate high rates of erosion at East Wonnerup.

Following the works conducted in the Locke Estate/Abbey and the Busselton Foreshore areas during the previous CMP, a significant proportion of the works to coastal protection structures in the current CMP will be in the West Busselton area.

Busselton Foreshore and Scout Road - Case Study

The Busselton Foreshore is a very popular community area for both locals and visitors to Busselton. This precinct has undergone significant upgrades over the last decade, with coastal protection measures allowing the development of valuable community space. In 2008 a GSC groyne field was constructed to replace timber groynes. These timber groynes were not maintained and had deteriorated, resulting in beach erosion and collapse of a concrete promenade in July 2007 winter storms. While these 35-45m long groynes increased the width of the swimming beach west of the jetty, they also reduced sand supply to the beaches to the east. By the time the CMP (2014-18) was prepared, it was evident adaptation and protection measures would be required at Scout Rd and to the east.

The strategic approach of the CMP (2014-18) encouraged the use of a refined groyne design and consideration of transverse sand bars and onshore sand feeds. This reduced the cost of protection and reduced the potential for impact further downdrift. Coastal monitoring was continued to measure success. The Scout Road GSC groyne extended eastward to an accretion lobe at Georgette St and a transverse sand bar which was identified in an earlier sediment budget study as an onshore sand feed. Further strategic investigations of these transverse sand bars along Geographe Bay is proposed in the current CMP.

Coastal stabilisation has allowed the foreshore on both sides of the jetty to extensively redeveloped, with tourism, community and commercial infrastructure.

5.5 Sustainability

The sustainability of some of the key coastal protection projects completed by the City over the last few years has been assessed in terms of the net change to the erosion rate of the protected area and the downdrift area (Figure 5.4).

The following is noted:

- Managed retreat projects (Dunsborough/King St) have resulted in net erosion in the protected area (as a structure is removed and a beach is allowed to realign), but net accretion in downdrift areas, as the cause of localised erosion (the structure) is removed or re-located landwards.
- Maintenance projects at Locke Estate and Abbey have stabilised the shoreline without shifting the erosion further east. This is a result of maintenance designs focussing on relatively low profile and short groynes that optimise bypassing, and including sand nourishment where required.
- The Busselton foreshore groynes resulted in accretion in the protected area, but shifted the erosion to the east at Scout Road. The subsequent extension of the groyne field to an accretionary lobe and potential onshore sand feed associated with a transverse sand bar, and sand nourishment, has stabilised this shoreline with limited net downdrift effects in the 4 years since construction.
- The groynes at Wonnerup (Baudin Reserve) have shifted the erosion away from the area with higher value assets to the foreshore reserve to the east. This requires ongoing monitoring.

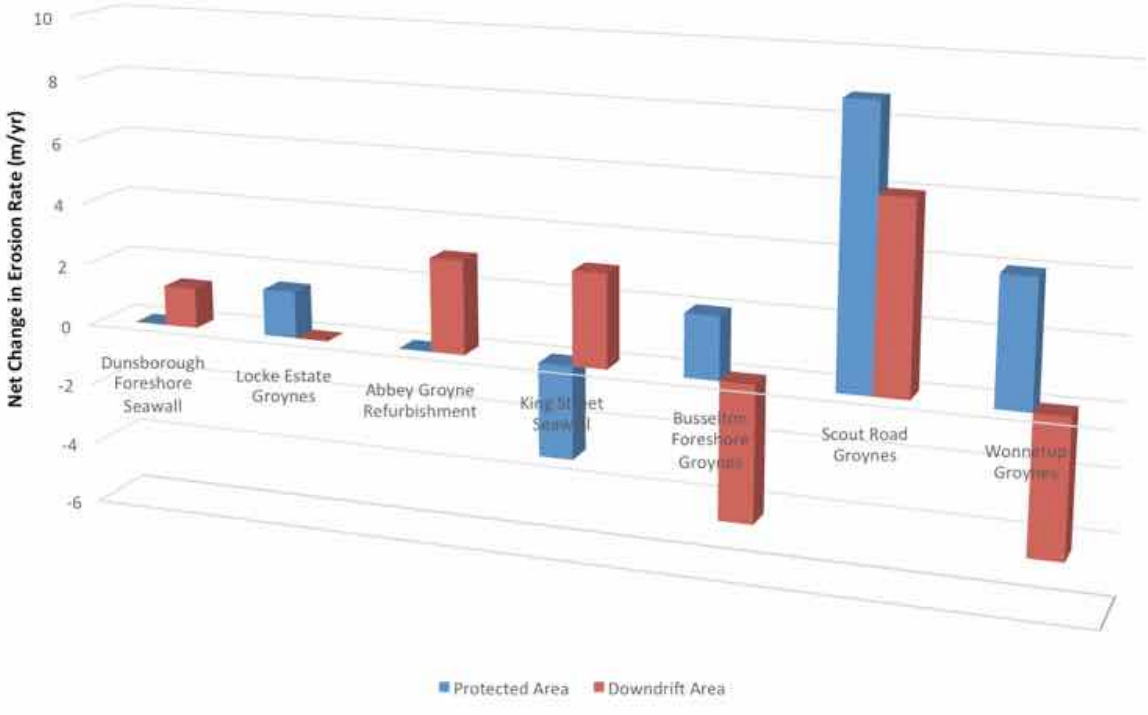


Figure 5.4 Net Change to Erosion Rate for Protected Area and Downdrift Areas Associated with Coastal Protection.

5.6 Cost Effectiveness

A first pass cost- benefit assessment has been undertaken for a number of coastal protection projects based on unit rates derived from the economic valuation of various land-use types and beaches by ACIL for the PNP Study (20). This assessment is based on the value of assets within an area defined by the underlying erosion rate (prior to stabilisation) and the design life of the structures. Nominally, this represents assets within the predicted area of erosion for a 15-25yr planning period. The following is noted within the limitations of this first pass assessment:

- Coastal stabilisation projects at Locke Estate, Busselton Foreshore and Scout Road have a favourable Cost-Benefit ratio due to the value of community infrastructure and the adjacent beach.
- Maintenance of the Abbey groyne field has a relatively high cost benefit ratio due to the low cost of maintaining coastal structure relative to the economic value of protected recreational areas and the beach.
- Managed retreat projects at Dunsborough and King St have a lower cost benefit ratios they have been generally more focussed projects in areas of localised erosion.

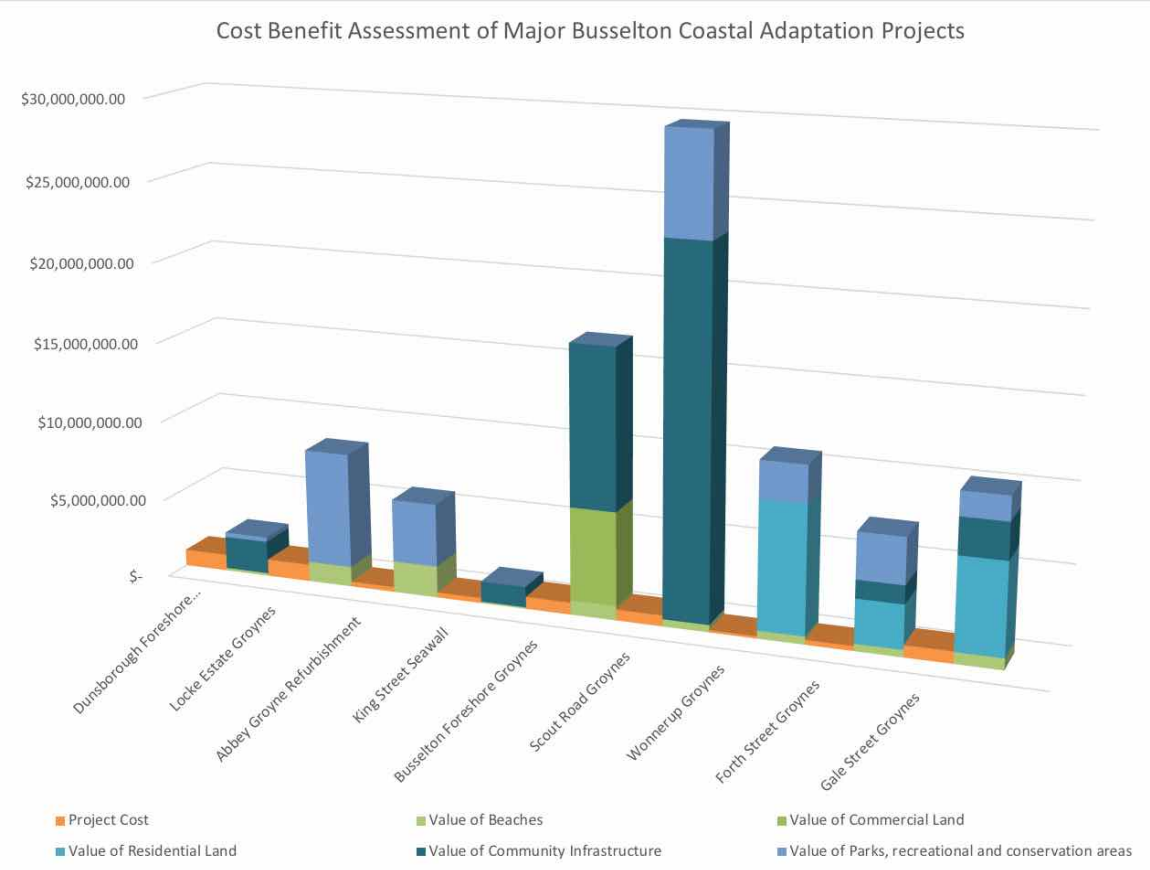


Figure 5.5 Coastal Adaptation – First Pass Cost Benefit Assessment

5.7 Status of Target Actions

The status of the 14 Target Actions identified in the Coastal Management Program (2014-2018) is summarised in Table 5.1. This identifies 12 of the 14 Target Actions being completed by 2018.

Table 5.1 Status of Coastal Management Plan Target Actions (2014-2018)

No	Target Action	Status	Comment
1	Clarify approvals required for coastal works.	✓	Generally streamlined to regional DBCA approval.
2	Design criteria for coastal works.	~	Partially established but remains project specific.
3	Cost benefit assessment for coastal works.	✓	PNP Economic Analysis (20).
4	Develop and maintain a coastal monitoring program for Geographe Bay.	✓	Delivered annually since 2014.
5.	Develop a 5-year rolling sand nourishment program for coastal protection.	✓	Delivered annually since 2014.
6.	Develop a 5-year rolling maintenance program for coastal protection structures.	✓	Delivered annually since 2014.
7.	Develop a 5-year rolling program for coastal protection capital works.	✓	Delivered annually since 2014.
8.	Ensure works are suitably funded and resourced.	✓	City has secure $2.4M grant funding from DoT over 36 coastal projects since 2007.
9.	Ensure integration with 30-year strategic plan, particularly in relation to future sea level rise.	✓	Initial 5yr and present 10yr program guided by 2014 study of potential longer-term sea level rise impacts. Further integration with 2018 coastal adaptation strategy.
10.	Ensure the community is suitably engaged and informed in regard to coastal protection works.	✓	Consultation ongoing, with stakeholder workshops and site visits guiding present 10yr program.
11.	Review and secure suitable supplies of rock armour.	✓	GHD 2015 report and planning approval to use non-quarry ironstone rock for public works has improved supply and mitigated cost.
12.	Undertake relevant coastal investigations at key erosion sites.	✓	Completed at relevant sites including Dunsborough, Locke Estate, Broadwater Beach, King St, Busselton Foreshore, Scout Rd and Wonnerup.
13.	Establish a real-time wave and water level monitoring station at the Busselton Jetty.	✗	Part of current 10yr plan. Costs of instrumentation have significantly reduced in recent years.
14	Ensure relevant coastal monitoring data and investigations identified in this plan are provided to the Cities LEMC, in relation to implementing Recommendations 17 and 18 of the Cape-to-Cape Emergency Services Review (storm surge study and response plan).	✓	Completion of Storm Surge Response Plan, presentation to LEMC, scenario planning by LEMC (Exercise Deep Water) and inundation modelling for risk, response and mitigation report. Further modelling recommended in this 10yr plan.

6 Coastal Management Program (2020-2030)

The Busselton Coastal Management Program is a rolling 10 year program of monitoring, investigations, sand nourishment, maintenance and capital works for coastal adaptation along the Geographe Bay Foreshore since 2014. This section outlines the proposed approach to coastal management and works proposed from 2020 to 2030.

6.1 Definition of Coastal Management Areas

The Coastal Management Program (2014-2018) identified 11 Coastal Protection Areas that were the basis for strategic coastal monitoring and management. Whilst the management of coastal erosion occurs at discrete sites along the coast, community consultation emphasised the need for the City to '*consider management along the whole bay*' and to '*piece it together*'. In particular, this reflects the need to consider the continuity of sand migration (littoral transport) along the Bay and the concept of sediment cells.

Coastal sediment cells are identified as

> "*A length of coast and adjacent areas within which the movement of sediment is apparent through identification of land features that function as sediment sources, transport pathways and sediment sinks. Typically, sediment exchange to adjacent cells is restricted, although cells are rarely isolated completely*." (21).

Geographe Bay is at the southern end of a primary sediment cell, identified between Cape Naturaliste and Moore River (22). *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. Within this area secondary and tertiary sediment cells have been identified for Geographe Bay. *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 beachface.

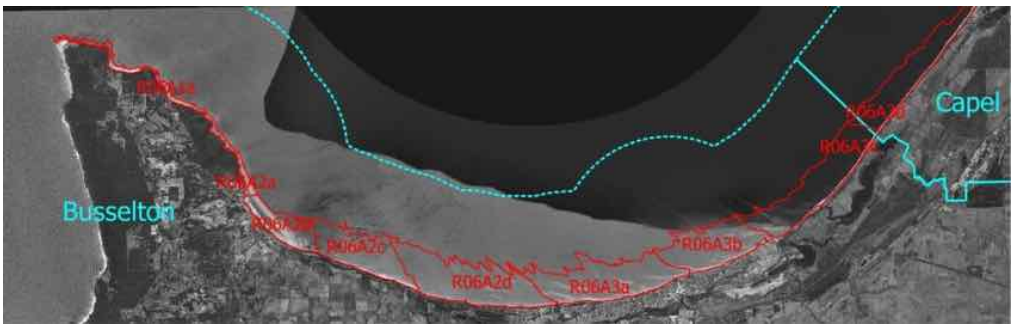


Figure 6.1 Geographe Bay Sediment Cells (22)

Coastal Management Areas have been identified in this coastal management program based on previously identified tertiary sediment cells (22), coastal protection areas defined in the 2014-2018 program, and the use of familiar locality names. The intent is for works within one sediment cell (e.g. coastal protection) to consider the influence to/from adjacent areas.

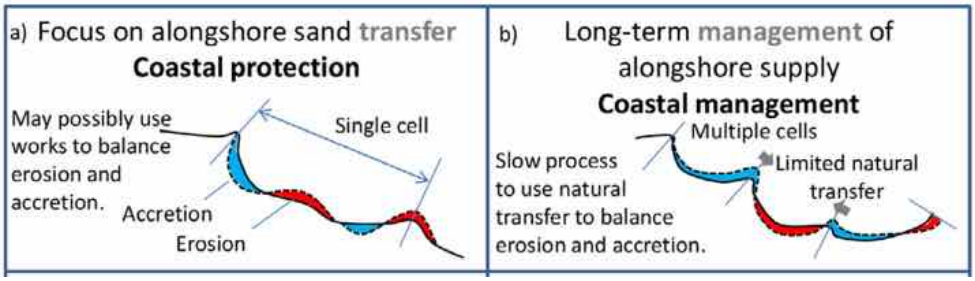


Figure 6.2 Example of Coastal Management within and between Sediment Cells (21)

Table 6.1 Coastal Management Areas (2020-2030)

Coastal Management Area	Western Boundary	Length of Coast (m)	Coastal Orientation	Description
1. Dunsborough	Old Dunsborough	5.4	NE	Rocky coast of Old Dunsborough, the Dunn Bay bar and the Dunsborough foreshore beaches inshore of the bar.
2. Quindalup-Siesta Park	Dunn Bay Bar	8.5	NNE	Undulating sandy coastline that includes boating facilities, a number of coastal inlets and private coastal residences.
3. Locke Estate-Abbey	Siesta Park Groyne	5.2	N	Sandy coastline with >12 coastal structures including Locke Estate campsites, Buayanup Drain and the Abbey foreshore and boat ramp and commercial tourism developments.
4. Broadwater-West Busselton	Holgate Rd Groyne	6.2	N	Sandy coastline including eroding Broadwater Beach, West Busselton foreshore including the regional hospital, managed erosion sites (Mill Rd, King St), narrow setbacks and the Busselton foreshore west of the Busselton Jetty.
5. East Busselton	Busselton Jetty	4.3	NNW	Sandy coastline including foreshore east of Busselton Jetty, Scout Rd, Georgette St boat ramp, East Busselton foreshore and wrack accumulations on western beach of Port Geographe.
6. Wonnerup	Port Geographe (to Wonnerup Inlet)	4.4	NW	Sandy coastline including Wonnerup Beach, East Wonnerup (Baudin Reserve) and Wonnerup Inlet.

Figure 6.3 Geographe Bay Coastal Management Areas

6.2 Program Basis

This Coastal Management Program (2020-2030) aims to facilitate ***strategic***, ***effective*** and ***sustainable*** coastal adaptation by the City of Busselton along the Geographe Bay foreshore over the next 10 years.

This program has been developed with consideration of:

- Stakeholder feedback from the workshop and 2020 residents survey.
- The social, environmental and economic value of the sandy beach.
- The social, environmental and economic value of the coastal reserves and public infrastructure within these reserves.
- The present state of the coast as outlined in the latest coastal monitoring report.
- The status of target actions from the 2014-2018 and 2018-2020 program and the effectiveness of works undertaken during that program.
- The vulnerability of low lying coastal areas to coastal flooding and the importance of the coastal dunes in providing protection from coastal flooding.
- The longer-term response of the Geographe Bay coastline to sea level rise.
- Stage government guidelines for Coastal Hazard Risk Management and Adaptation.

In this context, recommended coastal monitoring, investigations, sand nourishment, structure maintenance and coastal adaptation from 2020 to 2030 include:

- Annual coastal monitoring that aims to meets the immediate needs of the City in terms of day-to-day coastal management along Geographe Bay.
- Strategic coastal monitoring with a focus on sediment transport. This recognises the sensitivity of the 'defendable line' strategy upon net accretion within Geographe Bay, and the potential for coastal adaptation in one management area to influence the alongshore sediment supply to adjacent management areas.
- Strategic coastal investigations that inform effective and sustainable coastal adaptation.
- Sand nourishment being the preferred initial response to coastal erosion.
- Maintenance and adaptation of the coastal protection structures (groynes & seawalls) along Geographe Bay.
- Coastal stabilisation requirements at sites with high ongoing coastal erosion.

Figure 6.4 Coastal Management Process

6.3 Coastal Monitoring

Annual Coastal Monitoring

This project will continue to monitor coastal change along Geographe Bay foreshore through the gathering of photo, survey and oblique aerial photos using the established sites from the 2014-2018 program. This will provide a 6-monthly photographic record of the shoreline at more than 30 sites along the Geographe Bay foreshore, six monthly oblique aerials and surveyed beach profiles at 18 specific locations along the shoreline (23). The required scope is similar to previous years, but extended to include photo monitoring at the Naturaliste settlements of Smiths Beach, Yallingup, Bunkers Bay and Eagle Bay. The program retains flexibility to adapt to changing conditions. This scope should include the requirements of the wider PNP survey program (beach widths and photo monitoring).

Real Time Wave and Water Level Monitoring at Busselton Jetty

The Department of Transport monitor wave, water level and currents in Geographe Bay. However, this data is only available every 3-months when divers retrieve the AWAC instrument from the seabed.

The establishment of a real time wave and water level monitoring station would greatly enhance storm erosion management, storm surge response planning and any maritime construction works. A three-month overlap of data would be required to ensure data continuity. This was proposed in the 2014-2018 program but has yet to be funded. However, instrumentation costs have reduced in recent years.

Detailed Beach Survey

A detailed beach survey is proposed every 2 years using aerial scanning methods from the 2014 survey (24). This should be undertaken at lower tides and extend from Forrest Rd through to Cape Naturaliste. This would provide high-resolution beach and nearshore survey data to allow sediment transport behaviour on the beaches across Geographe Bay to be assessed every 2 years. The scope should include survey analysis and interpretation. This also provides updated topography for numerical modelling of coastal flooding. The latest detailed survey was undertaken in December 2019.

Detailed Hydrosurvey

A detailed beach and hydrosurvey is proposed in 2024. This would be 15 years after the 2009 LIDAR survey by Department of Transport. It is proposed that this is undertaken at a regional scale through the Peron Naturaliste Partnership, due to high cost of survey and the regional benefit of hydrosurvey on a 10-15 year cycle at the primary and secondary sediment cell scale.

Fixed Camera Monitoring

The continuation of the fixed camera monitoring at the Busselton Jetty (West) is proposed with consideration of the establishment of new sites at Busselton Jetty (East), Broadwater Beach and Wonnerup.

Coastal Monitoring GIS

The collation of existing coastal monitoring data into an integrated GIS system is proposed. This would be updated every 6 months and include a public interface through the City of Busselton's Intramaps GIS system.

Peron Naturaliste Partnership Monitoring

The Peron Naturaliste Partnership undertakes a monitoring program from Point Peron to Cape Naturaliste, including in the City of Busselton (refer final sheet in Attachment A). The City should continue to integrate its monitoring with the PNP monitoring.

6.4 Coastal Investigations

Research of Geographe Bay Sediment Dynamics

A collaborative research study is proposed into the potential alongshore and biogenic supply of sand to the beach and nearshore system within Geographe Bay. This follows from previous work by Searle and Logan (2) and a number of separate projects undertaken by the University of Western Australia and Curtin University. The particular focus on this proposed collaborative research project would be:

- The nature, quantity and variability in alongshore supply of material into the primary sediment cell around Cape Naturalist.
- Alongshore transport rates within Geographe Bay.
- Biogenic supply of material to the nearshore system.
- The nature, quantity and variability in onshore supply of material to the coast through transverse sand bars.

Coastal Inlet Dynamics.

Desktop study to assess the behaviour of coastal inlets in terms of their natural opening regimes, impacts on inlet water quality and management. In particular erosion of the beaches adjacent to the Buayanup River outlet (Locke Estate, Forth St) and the Vasse Diversion Drain (Margaret St, Mill Rd) requires careful consideration of coastal inlet dynamics.

Modification of Long Groynes to Improve Bypassing.

At the western end of Geographe Bay, sand arrives from offshore around Cape Naturaliste. While variable weather conditions cause significant variation in the short term movement of sand, the average annual movement is to the east. Sand migrates along pathways such as the coast or offshore sandbars. Interruptions to this migration of sand have significant effects on the erosion and accretion of beaches both at the location of the interruption and downdrift (east) of the interruption to the sand supply.

The shortening of groynes at Siesta Parka, Holgate Road and Wonnerup periodically arises in community consultation as a potential solution to mitigate downdrift erosion. The Holgate Rd groyne was refurbished in 2020 and was reduced in length by 20m (Figure 6.5).

Figure 6.5 Holgate Rd Groyne Refurbishment 2020

An investigation is proposed to assess the potential modifications required, volume of sand released and longer-term updrift and downdrift impacts. The scope is likely to include a requirement for sediment transport modelling, and would be required prior to any consideration of shortening the Siesta Park groyne.

Numerical Modelling of Coastal Flooding

Numerical modelling was undertaken by Geoscience Australia in 2014 (25) for ocean water levels of 1.8mAHD and 3.4mAHD. Shore Coastal interpolated flooding extents for a 2.6mAHD water level and subsequently completed numerical modelling for East Busselton and West Busselton for a wider range of water levels. Further modelling is proposed at 'mid-level' water levels to better understand the extent of flooding and emergency responses. Surveyed wrack lines in June 2018 storm events provide a data set for model validation.

Coastal Flooding Emergency Response - GIS Contours

The City should implement a simple GIS system to identify potential areas of coastal flooding based on available 0.1m land contours. This was proposed by DFES following the May 2020 storm event, allowing a simple relationship between forecast storm surge levels and potential risk areas.

Coastal Structure Inspections

There are 64 public coastal protection structures along the Geographe Bay shoreline. Condition inspections were last undertaken in 2008. A coastal engineer should inspect the condition of these structures in 2020. It is recommended that the U.S. Army Corps of Engineers (USACE) Repair Evaluation Maintenance and Rehabilitation (REMR) methodology be adopted for this exercise.

Buried seawall structures at Abbey, West Busselton and Wonnerup should be inspected. This will require the use of an excavator or backhoe loader to locate the ends of the seawalls as they are usually buried. These seawalls are important coastal protection structures and strongly influence coastal planning setbacks, however their extent and condition are currently unknown.

Review of Sand and Rock Sources.

A review of available sand sources and ironstone rock armour deposits within and adjacent to the City of Busselton is proposed, with particular focus on ironstone gravel pits held by the City of Busselton, smaller stockpiles in farmer's paddocks and commercial sources for beach grade sand. The ironstone rock has been used to construct and maintain many coastal protection structures along Geographe Bay and sand is used for nourishment.

Coastal Stratigraphy

Dating cores from the coastal dunes and wetlands would provide further information on the geologic development of the Geographe Bay foreshore and, potentially, records of coastal flooding or 'washover' events. Initial reconnaissance sampling was undertaken in (26) and a more thorough investigation is proposed.

6.5 Sand Nourishment

Annual Sand Nourishment

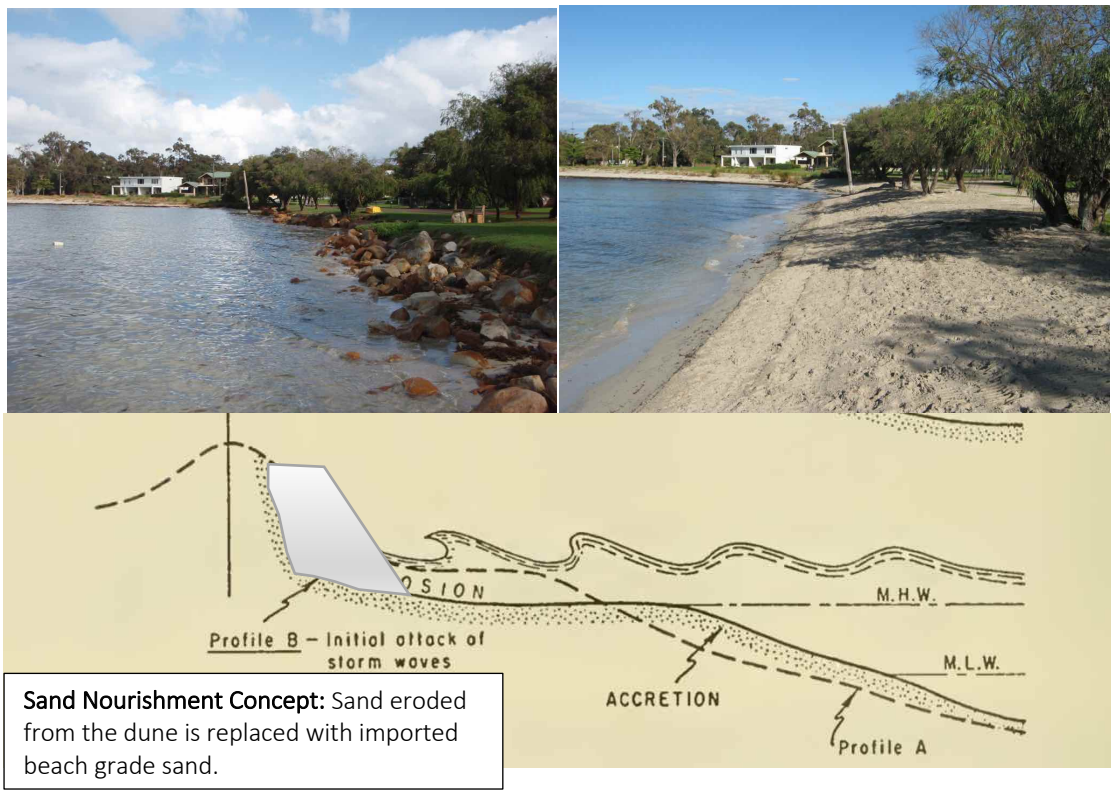
Sand nourishment should continue to be undertaken regularly by the City of Busselton along the Geographe Bay as required and form the primary management response to coastal erosion. This provides a rapid response to storm erosion and with reasonable planning should have minimal negative impacts.

The annual cost of these works is entirely dependent upon the winter storm season. An annual budget of $100,000 ExGST is proposed, to allow for 5,000m^3 to 8,000m^3 of sand nourishment each year depending upon the cubic meter rate obtained. Consideration should be given to maintaining any surplus from a calm year in the Beach Protection Reserve Fund to allow unspent funds to be available when required in stormy years.

Table 6.2 Planned Sand Nourishment

Coastal Management Area	Planned Sand Nourishment	Nominal Quantities (m^3)
Dunsborough	Monitor requirements of beaches along Old Dunsborough (Bayview Crescent) and Dunsborough Foreshore.	1,000-1,500
Quindalup to Siesta Park	Quantity subject to monitoring.	0
Locke Estate to Abbey	Monitor requirements at Locke Estate and Forth St.	500 – 1,000
Broadwater to West Busselton	Monitor requirements at Broadwater Beach (Norman Rd), Mill Rd, Margaret St, King St & Gale St.	3,000-4,500
East Busselton	Monitor requirements updrift (Gale St) and downdrift (Scout Rd) of Busselton foreshore.	500-1,000
Wonnerup	Sand nourishment or bypassing by DoT.	0
	Total	5,000-8,000

The flow chart below illustrated a decision-making framework for transitioning from sand nourishment to Maintenance or Capital Works (Figure 6.7). For example, Broadwater Beach continues to be nourished with sand, however concepts have been developed for asset relocation and coastal stabilisation following a coastal adaptation review and multi-criteria analysis.



Sand Nourishment Concept: Sand eroded from the dune is replaced with imported beach grade sand.

Figure 6.6 Sand Nourishment at Dunsborough (2012) and General Schematic of Concept

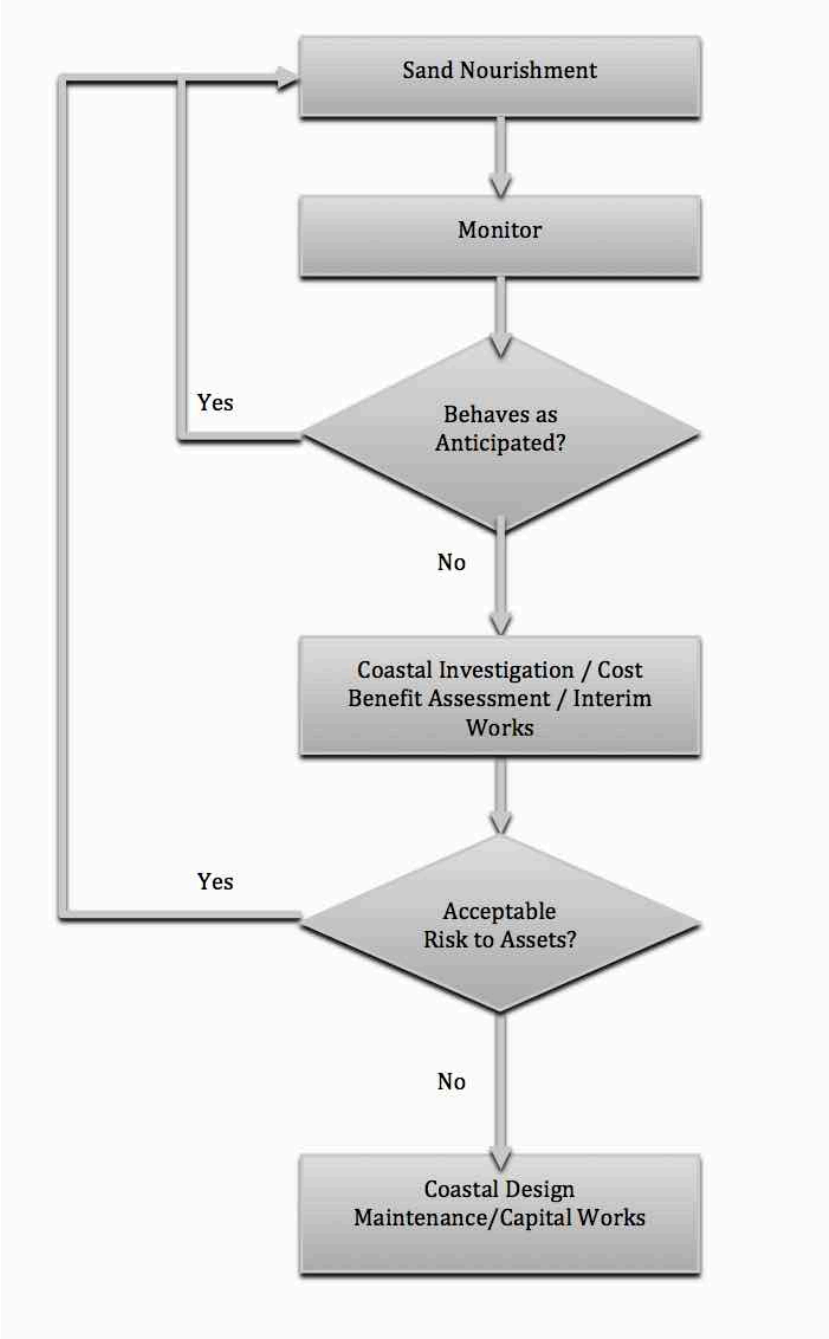


Figure 6.7 Flow Chart for Transitioning from Sand Nourishment to Coastal Stabilisation

Strategic Sand Nourishment

Strategic sand nourishment planned at 5-years intervals in this program. This concept is based on a larger scale 'seeding' of the littoral transport system with large pulses of sediment in strategic locations. Nominally this is based on nourishment of 25,000m^3 to 40,000m^3 every five years. This would be subject to coastal monitoring, approvals and a suitable methodology which could include import from commercial sand suppliers, relocation of sand from accreting areas along the foreshore (e.g. East Busselton) or pumping from offshore with a dredge.

The placement of material updrift of coastal management areas or sediment cells that are showing a net deficit of material is proposed. Nominally the focus would be on the West Busselton coastal management area for the initial strategic sand nourishment (Figure 6.8).

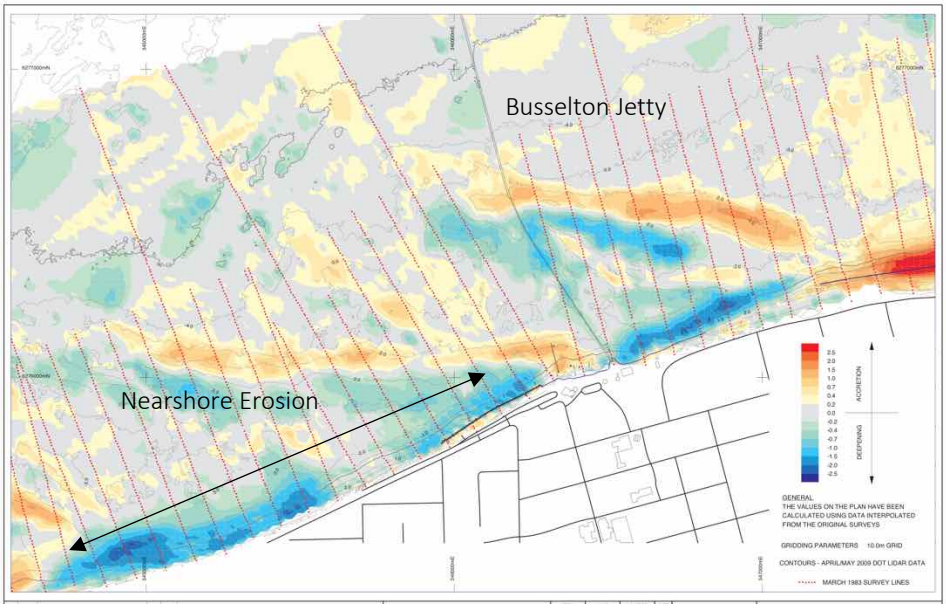


Figure 6.8 Strategic Sand Nourishment may be required to mitigate West Busselton Beach and Nearshore Erosion (shown above from 1983 to 2009).

6.6 Maintenance of Coastal Protection Structures.

A strategic maintenance program for coastal protection structures was developed in 2015 (19). Priorities were based on existing condition, mode of failure, and capacity to package works, existing buffers and asset protection. The proposed maintenance works in this plan are based on a continuation of the 2013 program.

Previous maintenance works have 'jumped' from one section of the coast to another resulting in a degree of inefficiency in implementing works. The proposed maintenance schedule for the 2018-2028 program is based on GHD 2013 but proposes completing the maintaining all relevant structures in a management area before proceeding to structures in an adjacent management area, commencing at West Busselton, where works are planned in 2020/21, and moving west. This larger scale approach gives greater clarity to the maintenance scheduling and should also bring cost savings due to the proximity of works scheduled together.

Maintenance works completed in recent years include the refurbishment of the Craig St ironstone rock seawall (200m) and groyne (with the use of granite armour on the crest of the groyne), refurbishment of four groynes at Wonnerup. In 2020, the Holgate Rd groyne was refurbished with a 20m reduction in length to improve sediment supply to Broadwater Beach.

The program allows for the potential shorting of the Siesta Park groyne to improve sand supply to Locke Estate, which have been identified as high priority for maintenance. This is proposed to be undertaken during refurbishment, subject to coastal monitoring and investigations outlined in Sections 6.3 & 6.4. The nominal program is:

- Year 1: West Busselton (Stage 1)
- Year 2: West Busselton (Stage 2)
- Year 4: Abbey
- Year 6: Siesta Park
- Year 8: Dunsborough
- Year 10: Wonnerup

6.7 Coastal Adaptation

Abbey – Forth St

The erosion at Forth St in Abbey continues to be associated with the longer term effects of the construction of the Siesta Park groyne in the 1960s, and the interruption of alongshore sediment supply up to 3km to the east of the groyne. Historic period of accretion have been associated with deposition of material from the erosion Locke Estate foreshores which has since been largely stabilised. In recent years, erosion rates at Forth St have been in the order of 1,000m^3/yr and focussed on a 250m section of shoreline.

The adjacent Buayanup River outlet and training wall increase the complexity of the erosion response. Sand nourishment has mitigated the extent of erosion in recent years, however buffers to significant community assets (carpark, coastal path, Geographe Bay Road) are low and these structures are vulnerable to erosion in the 2021 winter.

Sand nourishment and beach scraping are being undertaken in the short term to maintain the foredune buffer. A new GSC groyne is proposed in Year 1, with subsequent stages in Year 2 and Year 4, subject to monitoring

West Busselton - Broadwater Beach

In recent years the coastal path at Allen St that was subject to ongoing erosion has been realigned away from the coast. The refurbishment of the Holgate Road groyne was completed in 2020 with a 20m reduction in the length of the groyne intended to increase the supply of sand to Broadwater Beach. This was Stage 1 of planned coastal adaptation works. This also required construction of a GSC groyne to the west to ensure the coastal path in that area remained protected. Sand nourishment occurred in Stage 1 in 2020 to provide a supply of sand to the beaches to the east, and maintenance sand nourishment will continue in the future.

Future stages of Coastal Adaptation works at Broadwater Beach are subject to coastal monitoring of Stage 1. However, Stage 2 (2 x GSC groynes) is programmed for Year 3, and Stage 3 (1 x GSC groyne) for Year 5. These works will shift the erosion further east however there is a potential onshore supply of sand in this area that may mitigate impacts.

West Busselton - Mill Rd

Relocation of the edge of the carpark by installing bollards further back from the coast and modification of fencing is proposed to increase the erosion buffer.

West Busselton – Gale St

The foreshore at Gale St has been subject to foredune erosion over an 800m length of coast from King St to Queen St. There are very narrow buffers to carparks at the western end and the scale of erosion has meant only targeted sand nourishment has been feasible. Further coastal investigation is required into the extent of erosion (typically ~1.0m/yr) and longer term mitigation.

A trial Beach Scraping exercise was completed in 2020 to reinstate the foredune. However, there is a long term depletion of sediment for the West Busselton coastal management area and coastal adaptation works are allowed for in Year 3, 4 & 6.

Wonnerup - East Wonnerup

Four low profile geotextile sand container groynes have been constructed by the City of Busselton at Wonnerup since 2017. These structures have stabilised the coast locally, but will progressively shift the erosion further to the east. The extent of further erosion and adaptation works required depend upon the sand bypassing regime implemented by Department of Transport for Port Geographe. The sand supply to these beaches continues to be blocked by Port Geographe and whilst sand nourishment has mitigated erosion at Wonnerup, sand has not been bypassed from the beaches to the west of the harbour since 2012.

Mitigation of Coastal Flooding (Coastal Dunes)

Adaptation measures for coastal dunes were recommended in the coastal flooding risk, response and mitigation report (27) and have been included in the 2018-2028 program. The coastal dunes are the primary defence against coastal flooding of residential areas along the beach ridge. The following was recommended:

- Beach access paths should have a meandering planform, and a surface near the crest of dunes that limits erosion due to foot traffic.
- The boat ramps that require cuttings through the dunes have a paved raised crest generally above 2.5mAHD at their approach and suitable stormwater drainage to limit risk of coastal flooding.
- Erosion of foredunes should be minimised where feasible to maintain the integrity of the natural dune field along Geographe Bay.

Mitigation of Coastal Flooding (Drain Modifications)

Adaptation measures for coastal drains were recommended in the coastal flooding risk, response and mitigation report (27) and have been included in the 2018-2028 program. The following potential modifications to the drainage infrastructure should be investigated:

- The City should undertake an audit of coastal open drains to determine their function (i.e. the local network they drain), pipe dimensions and invert levels, and maintenance and installation of flap valves.
- The potential to raise the embankments of these coastal open drains to mitigate coastal flooding locally should be considered following this audit.
- Flood modelling results for West Busselton (Vasse Diversion Drain) should be forwarded to the Water Corporation for their consideration.

Broadwater Coastal Adaptation - Case study

The Abbey groyne field was constructed in the 1990's to protect the residential and commercial areas from coastal erosion. This transferred the erosion to Broadwater Beach where a former beach carpark is now located nearly 100m offshore with erosion rates up to 10m/yr.

Managed retreat is identified in the State Coastal Planning Policy as the preferred response to coastal erosion. Nominally, this places a low value on foreshore reserve that is allowed to erode. In many cases this assessment differs from the relatively high social and environmental value the community places on these natural areas. At Broadwater Beach this *social value* includes a popular Dual Use Path (DUP) along the foreshore used by cyclists and walkers, the foreshore reserve and the beach. The *environmental value* of the foreshore reserve including coastal peppermint woodland, which is a known habitat for the western ringtail possum that is recognised as a threatened species under State and Commonwealth legislation. The *economic value* of the sandy beach has been identified in previous economic studies (20) as $32M.

In 2018, at the observed rates of erosion (5m/yr) the consequences of ongoing erosion were potentially loss of DUP within 1 year, erosion of private property within 2 years, erosion of peppermint woodland (habitat for the threatened western ringtail possum) within 3 years and complete erosion of the foreshore reserve and associated habitat within 15 years.

In recent years the coastal path at Allen St that was subject to ongoing erosion has been realigned away from the coast. The refurbishment of the Holgate Road groyne was completed in 2020 with a 20m reduction in the length of the groyne intended to increase the supply of sand to Broadwater Beach. This was Stage 1 of planned coastal adaptation works. This also required construction of a GSC groyne to the west to ensure the coastal path in that area remained protected. Sand nourishment occurred in Stage 1 in 2020 to provide a supply of sand to the beaches to the east, and maintenance sand nourishment will continue in the future.

Future stages of Coastal Adaptation works at Broadwater Beach are subject to coastal monitoring of Stage 1. However, Stage 2 (2 x GSC groynes) is programmed for Year 3, and Stage 3 (1 x GSC groyne) for Year 5. These works will shift the erosion further east however there is a potential onshore supply of sand in this area that may mitigate impacts.

Larger scale sand nourishment is programmed for 2022/23 due to limited alongshore littoral supply to the West Busselton sediment cell. Monitoring and investigations are proposed to better understand this longer term requirement.

7 Coastal Management Areas

7.1 Dunsborough

Key issues:

- *Behaviour of Dunn Bay bar, which is the major sediment transport pathway for Geographe Bay.*
- *Migration of sand lobes and drain outlets along the beaches inshore of the Dunn Bay bar.*
- *Sand nourishment of beaches and exposure to northeast storms.*
- *Elmore Rd lagoon behaviour*

This management area extends from Point Daking (Dunsborough Golf Club) to the south-western end of the Dunn Bay sand bar (east of the Dunsborough Beach house YHA).

Sand migrating to the south-east is split between the sand bar and the coast itself. While there are some coastal protection structures in this area, they are mostly buried seawalls, and cause limited interruption to sand migration. However, migration of sand lobes and drain outlets result in local areas of accretion and erosion.

Various public and private assets are close to narrow coastal buffers in this area, particularly along the pocket beaches and rocky coast of Old Dunsborough.

Coastal management in this area during the previous CMP primarily consisted of monitoring and sand nourishment.

Ongoing monitoring is required to track the behaviour of the Dunn Bay bar, which is a major sediment supply pathway for Geographe Bay (Figure 7.1). The rate of supply of sand will not always balance the rate of migration of sand away to the east due to variability of natural processes.

Figure 7.1 Dunn Bay Bar in 2008 (left) and 2018 (right) showing variability of sediment supply

Table 7.1 Dunsborough Coastal Management Actions

Year	Action
Annual	Beach Monitoring
Annual	Sand Nourishment – nominally 1000-1500m^3 per year at Old Dunsborough and Dunsborough Foreshore.
2 yearly	Detailed Aerial Beach Survey
10 yearly	PNP Hydrosurvey – 2021/22.
2027/28	Maintenance: Dunsborough Coastal Protection Structures.

Figure 7.2 Dunsborough Coastal Management Area

7.2 Quindalup to Siesta Park

Key issues:

- *Management of sand accumulations at Quindalup boating facilities.*
- *Monitoring and management of coastal inlets entrances.*
- *Migration of sand lobe at Smith St.*
- *Private Seawalls along Siesta Park.*
- *Siesta Park Groyne refurbishment and/or modification.*

This management area extends from the south-western end of the Dunsborough Bay sand bar to the Siesta Park Groyne, which is a major influence of sediment supply to the east.

Downdrift of the Dunsborough Bay bar, sand migration is generally eastward along the coast. There are no significant offshore sandbars intersecting the coast in this area, but there are lobes moving east along the coastline at Toby Inlet and Smith Street. Several waterways enter the coast in this management area, but none of these have training walls. While there is various public and private boating infrastructure, sand migration is largely unhindered until it reaches the Siesta Park Groyne at the eastern end of this area, which is the first significant groyne along Geographe Bay.

Along the western (Quindalup) side of this management area, private infrastructure is located behind the fringing dunes, and public infrastructure on the coast is mostly confined to boating infrastructure. Along the eastern (Marybrook) side of this management area, there are numerous private properties fronting onto the beach reserve. A number of these have constructed private seawalls. A migrating sand lobe is currently in front of properties at Smith Street, meaning that although they were among the properties most affected by Cyclone Alby, they currently have a greater coastal buffer than other properties to the east.

Coastal management in this area during the previous CMP primarily consisted of monitoring and the sourcing of sand from the Quindalup Sea Rescue Boat Ramp for nourishment. A small trial sand bag groyne updrift of this boat ramp was also installed and monitored.

Ongoing monitoring is required to identify when erosion occurs, in particular coastal inlet entrances. The influence of the Siesta Park groyne on the wider Geographe Bay sediment dynamics requires investigation, together with potential adverse updrift and downdrift impacts associated with refurbishment or modification of this structure.

Table 7.2 Quindalup to Siesta Park Coastal Management Actions

Year	Action
Annual	Beach Monitoring.
2 yearly	Detailed Aerial Beach Survey – first survey 2021/22.
10 yearly	PNP Hydrosurvey – 2021/22.
2025/26	Maintenance: Siesta Park Coastal Structures.

Figure 7.3 Siesta Park Groyne (Dec 2017)

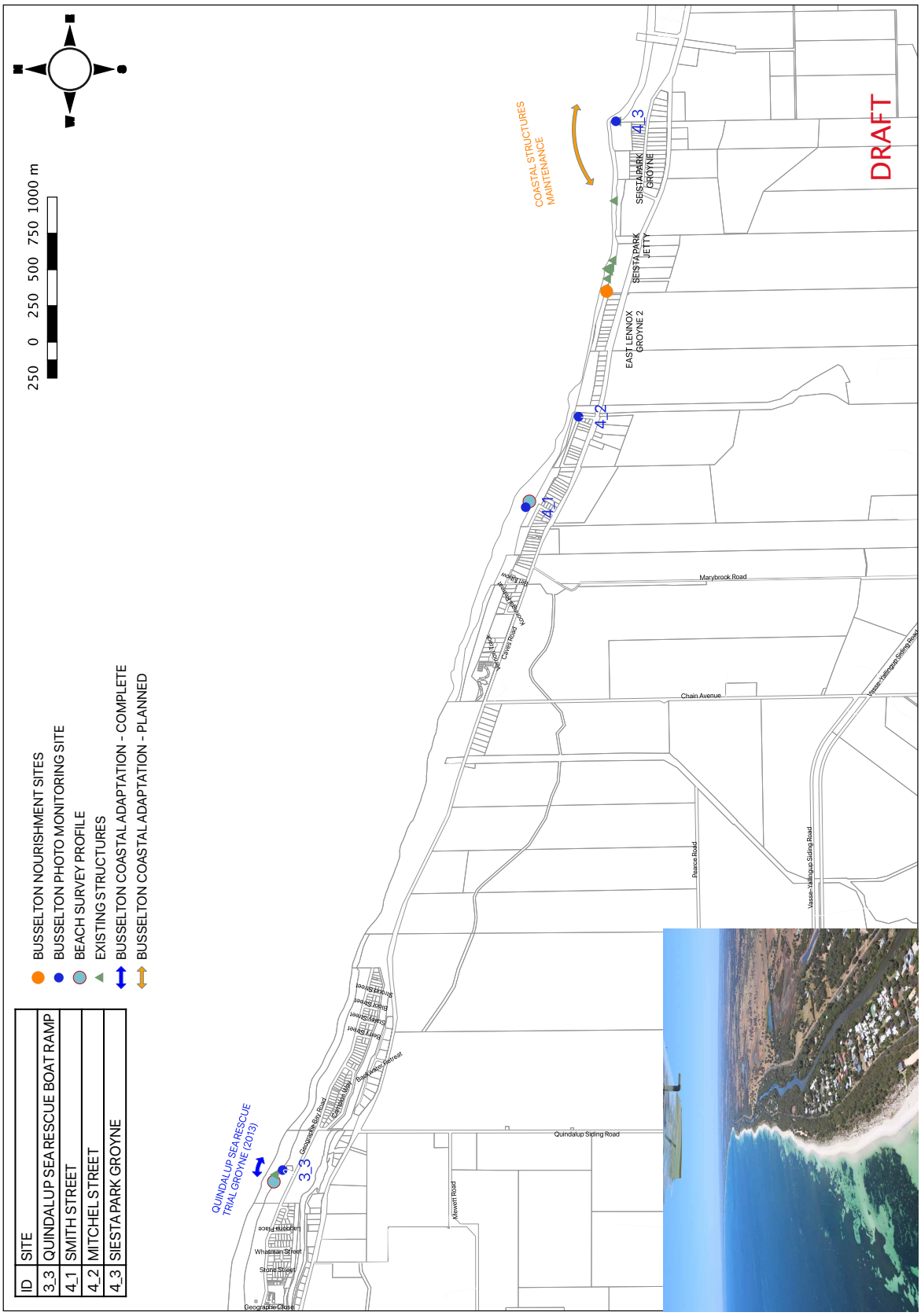


Figure 7.4 Quindalup to Siesta Park Coastal Management Area

7.3 Locke Estate- Abbey

Key issues:

- *Annual sand nourishment of beaches and potential for a major 'pulse' nourishment in Year 5.*
- *Behaviour of beaches adjacent to Buayanup Drain*
- *Management of sand accumulations at Abbey boat ramp*
- *Holgate Groyne Refurbishment and/or Modification.*

This management area extends from the Siesta Park Groyne to the Holgate Road Groyne.

The construction of the Siesta Park Groyne in 1965 interrupted the supply of sand to this management area, resulting in significant erosion, including recession of the coastline at Locke Estate by hundreds of metres. Since that time at least a dozen coastal protection structures have been constructed in this management area, including groyne fields at Locke Estate and Abbey, a training wall for the drainage outlet at Forth Street, protection for the boat ramp at Abbey and the longer Holgate Road Groyne at the eastern end of this management area. During times when Locke Estate or other areas were eroding, this would have increased the sand supply to the region east of these areas.

Capital works in this area during the previous CMP included renewal of the groyne field at Locke Estate, protecting the privately leased campsites. Maintenance works were undertaken on three groynes in the Abbey groyne field, which protects the housing and public assets adjacent to the coast in the eastern half of this maintenance area. Monitoring was important for evaluating the performance of these structures and variations of sand and seagrass around the Abbey Boat ramp.

Works undertaken under the previous CMP mean less capital investment will be required in this management area during the current plan. Some maintenance works will be required, and monitoring will be important to review the ongoing performance of the groyne fields in maintaining the coastal buffer. It will also be worth investigating options for renewal and possible modification to the large groynes at either end of this management area, considering the most effective adaptation for the areas both updrift and downdrift of these groynes.

Table 7.3 Locke Estate to Abbey Coastal Management Actions

Year	Action
Annual	Beach Monitoring.
Annual	Sand Nourishment – nominally 500-1000m^{3}pa at Locke Estate and Forth St.
2 yearly	Detailed Aerial Beach Survey – first survey 2021/22.
5 yearly	Major sand nourishment – first nourishment 2022/23. Location subject to monitoring.
10 yearly	PNP Hydrosurvey – 2021/22.
2020/21	Coastal Adaptation: Forth Street Stabilisation (Stage 1)
2021/22	Coastal Adaptation: Forth Street Stabilisation (Stage 2)
2023/24	Coastal Adaptation: Forth Street Stabilisation (Stage 3)
2023/24	Maintenance: Abbey Coastal Structures

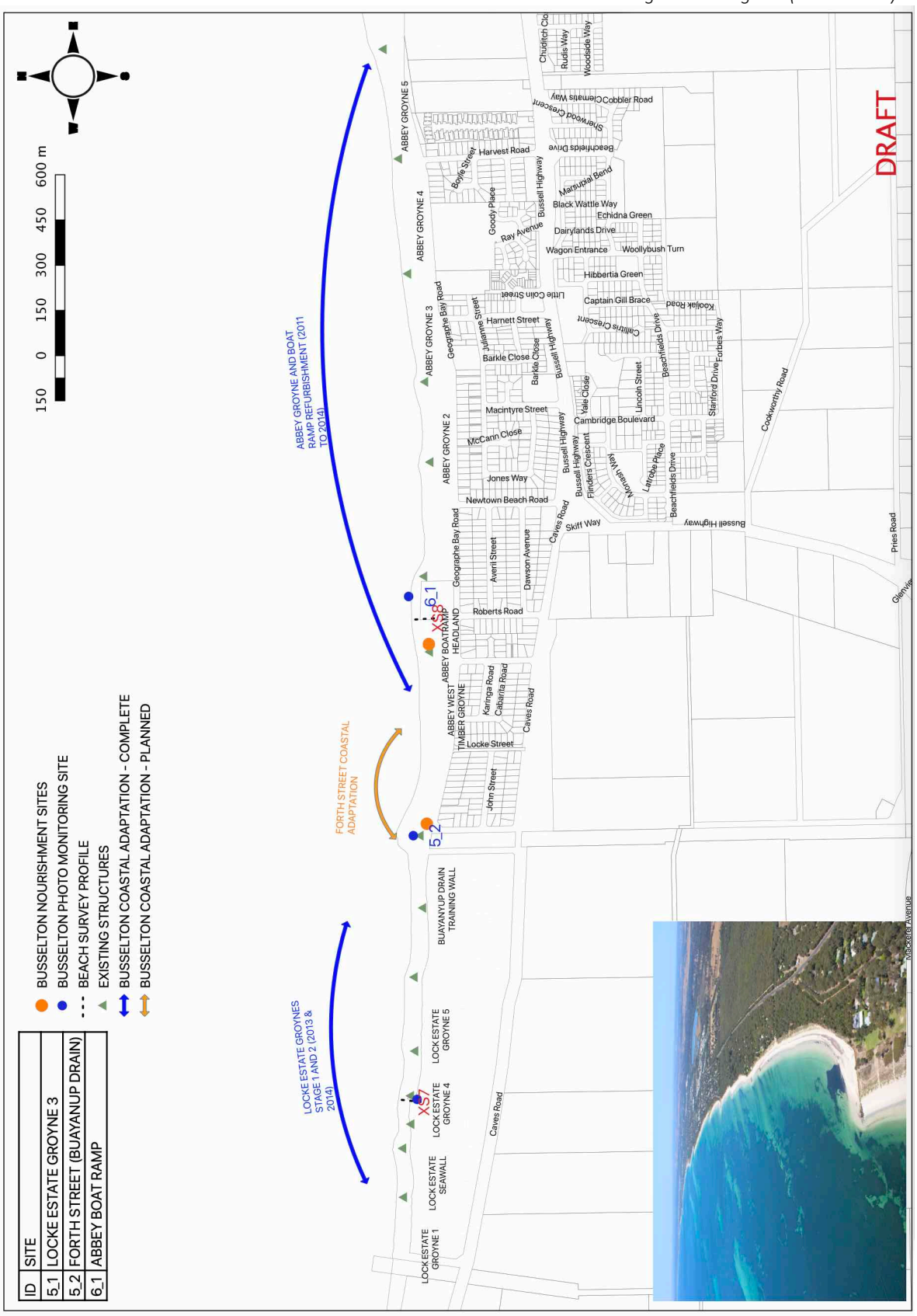


Figure 7.5 Locke Estate to Abbey Coastal Management Area

7.4 Broadwater- West Busselton

Key issues:

- *Monitoring and management of alongshore sand supplies to this coastal management area.*
- *Annual sand nourishment of beaches and potential for a major 'pulse' nourishment in Year 5.*
- *Broadwater Beach Coastal Adaptation and West Busselton coastal structure maintenance*
- *Exposure to coastal flooding and management of coastal dunes and open drains.*
- *Monitoring and management of King St and narrow coastal buffers to Geographe Bay Rd to the east.*
- *Busselton foreshore monitoring and management.*

This management area extends from the Holgate Road Groyne to the Busselton Jetty. Significant erosion has occurred at Broadwater Beach and this area is likely to be a significant focus of the coastal management program.

Several offshore sandbars intersect the coast in this management area, including one which joins at a significant sand lobe east of the erosion at Norman Road and Alan Street. It is unclear whether historical formation of this sand lobe was due to effects of the sand bar, sand migrating from the areas eroded downdrift of the Holgate Road and Siesta Park groynes, or from other sources of supply. Similarly, it is unclear whether the improved retention of sand due to works undertaken in the Locke Estate – Abbey management area during the previous CMP have reduced sediment supply to this area.

Between Earnshaw Road and the Busselton Jetty groyne field, buffers between public and private infrastructure and the coast are very narrow. A number of groynes, seawalls and the Vasse Diversion Drain training wall have been constructed in this area, culminating in the significant groyne field at the Busselton Jetty. During the period of the previous CMP, monitoring identified erosion requiring additional capital works at King Street and additional nourishment at Mill Road and Alan Street. Refurbishment of key coastal protection structures at Craig Street were completed under the previous CMP in 2019, with future stages to the west planned in future works.

The foreshore at Gale St has been subject to foredune erosion over an 800m length of coast from King St to Queen St in recent years. Further coastal investigation is required into the extent of erosion (typically ~1.0m/yr), and longer term mitigation.

This management area has significant vulnerabilities to be assessed and addressed within this CMP, starting with managed retreat of local assets at Mill Road. Works undertaken under the previous CMP completed Stage 1 of work at Broadwater Beach, including relocation of the DUP at Alan Street landward and refurbishment and shortening of Holgate Rd Groyne.

Further studies and monitoring will be required to determine how much other vulnerabilities should be addressed through sand nourishment, planning measures and capital works. This area may require the large "pulse" sand nourishment outlined in this program, to improve the sand supply in this management area.

Table 7.4 Broadwater to West Busselton Coastal Management Actions

Year	Action
Annual	Beach Monitoring.
Annual	Sand Nourishment – nominally 3,000-4500m^{3}pa at Broadwater Beach, Mill Rd, King St and Busselton Foreshore.
2 yearly	Detailed Aerial Beach Survey – first survey 2021/22.
5 yearly	Major 'pulse' sand nourishment – first nourishment 2022/23. Location subject to monitoring.
10 yearly	PNP Hydrosurvey – 2021/22.
2020/21	Coastal Adaptation: Mill Street Carpark Relocation.
2020/21	Maintenance: West Busselton Coastal Structures (Stage 1)
2021/22	Maintenance: West Busselton Coastal Structures (Stage 2, subject to monitoring)
2022/23	Coastal Adaptation: Broadwater Beach (Stage 2, subject to monitoring).
2022/23	Coastal Adaptation: Gale Street (Stage 1)
2023/24	Coastal Adaptation: Gale Street (Stage 2, subject to monitoring)
2024/25	Coastal Adaptation: Broadwater Beach (Stage 3, subject to monitoring).
2025/26	Coastal Adaptation: Gale Street (Stage 3, subject to monitoring)

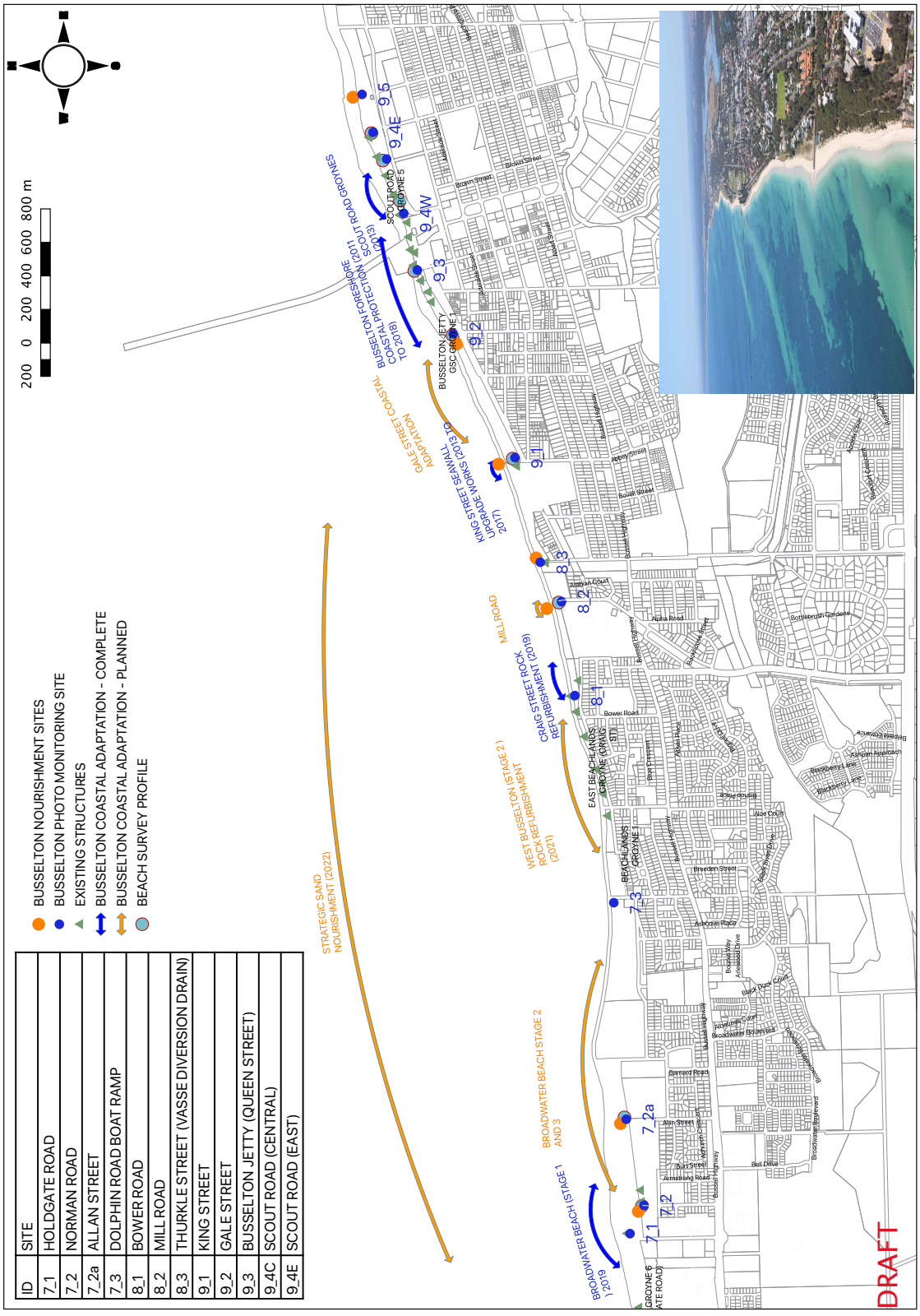


Figure 7.6 Broadwater to West Busselton Coastal Management Area

7.5 East Busselton

Key issues:

- *Monitoring and response to erosion downdrift of Scout Rd groynes.*
- *Exposure to coastal flooding and management of coastal dunes and open drains.*
- *Busselton foreshore monitoring and management.*
- *Department of Transport sand and wrack bypassing at Port Geographe.*

This management area extends from the Busselton Jetty to Port Geographe.

The Busselton Jetty foreshore coastal protection was completed previous CMPs. The groyne field immediately west of the jetty, installed prior to the last CMP, interrupted sand migration. This contributed to the need for the Scout Road groyne field, which was installed as part of the last CMP. There is a sand lobe from the Georgette Street Sea Rescue eastward. Infrastructure is behind the fringing dunes. At the eastern end of this area the beach widens due to the effect of the Port Geographe breakwater and migration of coastal landforms.

Monitoring of this management area has been important during the period following the previous CMP, to allow for a timely response to potential hazards including downdrift erosion from Scout Road groynes and adaptation of coastal dunes to improve resilience to coastal flooding. Monitoring has suggested relative stability downdrift of Scout Road since the groyne field was constructed, but is still an important feature of this CMP. Monitoring is also an important feature to continue for the monitoring of wrack and any future sand bypassing at Port Geographe.

Table 7.5 East Busselton Coastal Management Actions

Year	Action
Annual	Beach Monitoring.
Annual	Sand Nourishment – nominally 500-1,000m^3 pa at Scout Rd.
2 yearly	Detailed Aerial Beach Survey – first survey 2021/22.
5 yearly	Major 'pulse' sand nourishment – first nourishment 2022/23. Location subject to monitoring.
10 yearly	PNP Hydrosurvey – 2021/22.
2024/25	Maintenance: East Busselton Coastal Protection Structures.

Figure 7.7 Impacts of Coastal Flooding in East Busselton following Tropical Cyclone Alby in 1978 (Source - Memories of Busselton).

ID	SITE
10_1	RUSSELL STREET
10_2	GUERIN STREET
11_1	PORT GEOGRAPHE WESTERN BREAKWATER
9_3	BUSSELTON JETTY (QUEEN STREET)
9_4C	SCOUT ROAD (CENTRAL)
9_4E	SCOUT ROAD (EAST)
9_4W	SCOUT ROAD (WEST)
9_5	GEORGETTE STREET BOAT RAMP

Figure 7.8 East Busselton Coastal Management Area

7.6 Wonnerup

Key issues:

- *Monitoring and response to erosion downdrift of East Wonnerup groynes.*
- *Department of Transport sand bypassing of Port Geographe and nourishment of Wonnerup Beach.*

This management area extends from Port Geographe to Wonnerup Inlet.

Sand supply to this management area is interrupted by the entrance channel and breakwaters at Port Geographe, which was redeveloped at the beginning of the previous CMP period. Sand bypassing has not occurred in recent year as the Department of Transport allow the western beach to build up to potentially improve wrack bypassing. Wonnerup Beach has been nourished on a number of occasions, and dredged sand pumps to the beach. However, high rates of erosion continue in East Wonnerup due to the DoT's sand bypassing regime for Port Geographe and migration of coastal landforms.

Interim coastal stabilisation structures were built by the City on 2017 at Baudin Reserve, followed by further works in 2020 involving maintenance to the low profiled rock groynes, and construction of new GSC groynes to the east. However, the success remains entwined with the sediment supply available through management of Port Geographe by DoT.

There is a reasonable buffer between the coast and both Layman Road and private properties but very high rates of historic erosion.

Monitoring and response to erosion downdrift of East Wonnerup groynes is a key focus, together with ongoing liaison with DoT regarding the managed sand supply.

Table 7.6 Wonnerup Coastal Management Actions

Year	Action
Annual	Beach Monitoring
2 yearly	Detailed Aerial Beach Survey – first survey 2021/22.
5 yearly	Major 'pulse' sand nourishment – first nourishment 2022/23. Location subject to monitoring.
10 yearly	PNP Hydrosurvey – 2021/22.
2026/27	Coastal Adaptation: East Wonnerup groyne field (Stage 3)

Figure 7.9 Trial Groyne at East Wonnerup (Aug 2017)

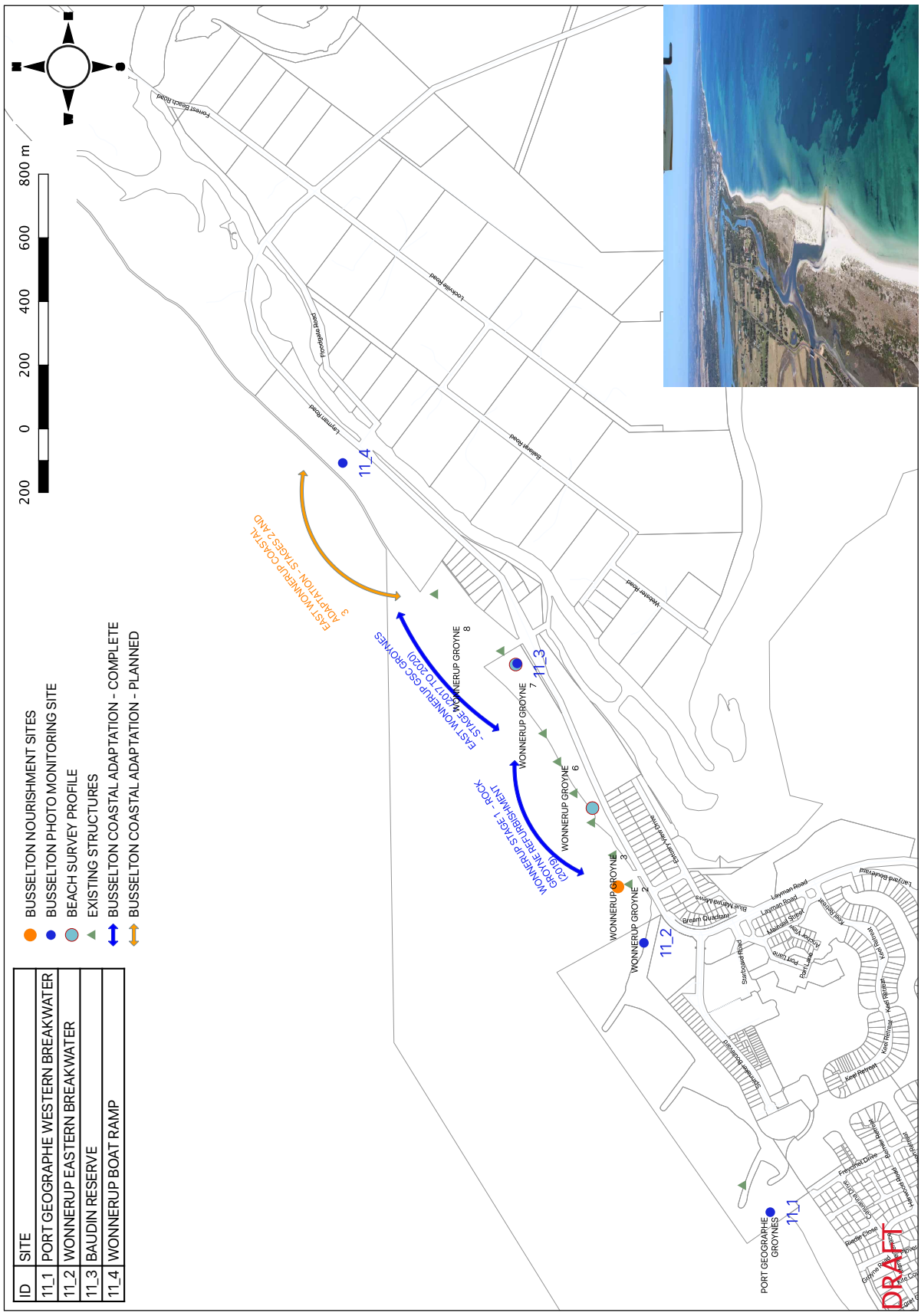


Figure 7.10 Wonnerup Coastal Management Area

8 Scheduled Works and Budget

The 10-year coastal management program scheduled works and budget is outlined in Figure 8.1 and Figure 8.2. The scheduled works include the following general items:

- Annual beach monitoring.
- Strategic beach monitoring including:
- Coastal investigations.
- Annual sand nourishment.
- Strategic sand nourishment.
- Maintenance of coastal protection structures.
- Coastal adaptation projects.

The annual budget ranges from approximately $400,000 to $1,800,000 in some years, with greater expenditure in the initial 5-year period. It is noted that the works program should be updated annually based on works completed and to allow for potential escalation of prices, monitoring and investigations, with a detailed review of the wider program every 5-years. The budget has been developed based on the following assumptions:

- Monitoring – nominal values based on experience with similar projects. Note the budget allowance for the 'PNP Hydrosurvey' is limited to the Geographe Bay area.
- Investigations – nominal values based on experience with similar projects.
- Annual Sand Nourishment – based on historic annual expenditure on sand nourishment.
- Strategic Sand Nourishment – based on volumes outlined in Section 6.5 and assuming a cost of $12.50/m^3 to $25.00/m^3. This has a value of ~$500,000 for the years 2022/23 and 2027/28.
- Maintenance – minimum budget of $100,000 per management area with further detail from the values outlined in (19).
- Coastal Adaptation – nominal values based on experience with similar works.

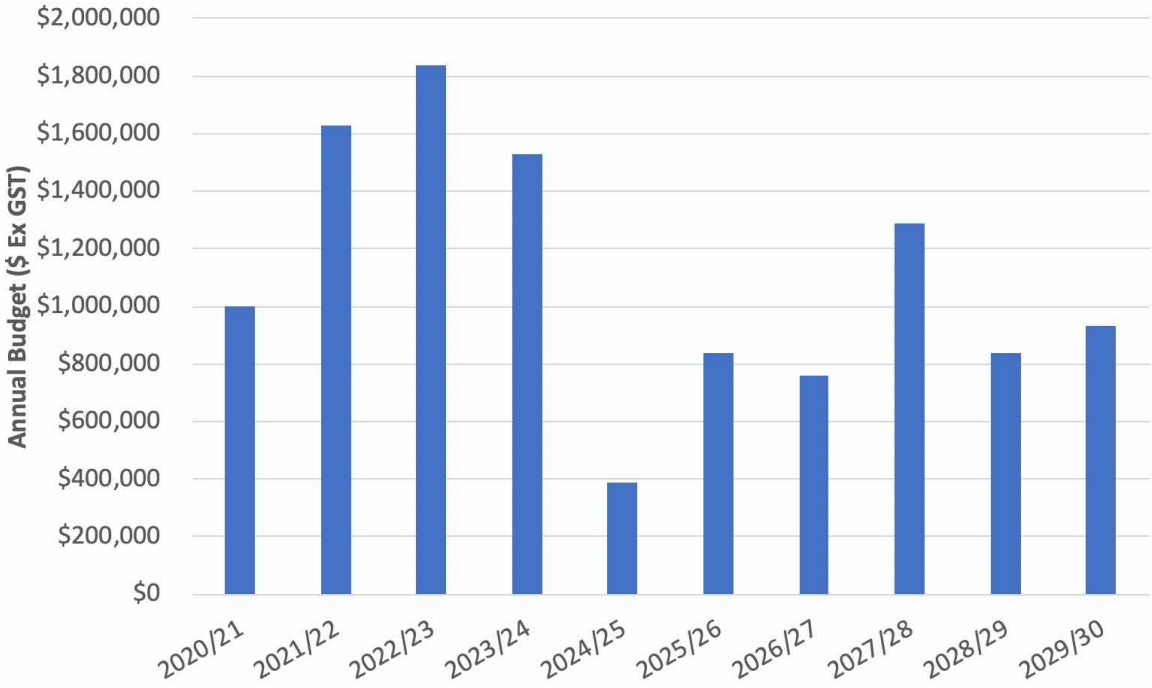


Figure 8.1 Coastal Management Program – Annual Budget

Figure 8.2 Coastal Management Program – Scheduled Works

9 Recommendations

The recommendation of the Coastal Management Program (2020-2030) are outlined in Table 9.1 .

Table 9.1 Coastal Management Program (2020-2030) - Recommendations

No.	Recommendation
1	*Strategic Management:* 1. A "*whole of coast*" approach to coastal management along Geographe Bay is recommended with the definition of 6 Coastal Management Areas based on tertiary sediment cells and local management practices. 2. This is a *10-year program* to encourage a strategic approach to coastal management and adaptation. The previous CMP was a 5-year program.
2	*Coastal Monitoring (Annual):* 1. The City should continue the annual beach monitoring, including six monthly photo monitoring, oblique aerial photography and surveyed beach profiles. Fixed camera monitoring should be considered in selected areas. The City should continue to integrate its monitoring with ongoing monitoring by the Peron Naturaliste Partnership. 2. The City should develop an internal and public GIS interface for the coastal monitoring data.
3	*Coastal Monitoring (Strategic):* Undertake strategic monitoring at lower frequency using high density survey techniques including: 1. Detailed aerial beach survey every two years commencing Year 2. 2. A detailed hydrosurvey of the wider region in association with the Peron Naturaliste Partnership in Year 2, which would be 10 years since the previous regional hydrographic survey. It is assumed this would be led by PNP with a contribution from the City for the Geographe Bay area. 3. Installation of real time wave monitoring at Busselton Jetty.
4	Coastal Investigations: This program recommended a range of coastal investigations including: 1. Research of Geographe Bay sediment dynamics. 2. Coastal stratigraphy. 3. Coastal inlet dynamics. 4. Modification of long groynes to improve bypassing 5. Numerical modelling of coastal flooding 6. Coastal structures Inspections 7. Review of sand and rock sources. 8. GIS Layer for Emergency Storm Surge Response

No.	Recommendation (cont…)
5	*Sand Nourishment:* The City should continue the annual maintenance sand nourishment program at a similar scale to previous years, continuing the practices developed in the previous program including proactive summer sand nourishment, the use of erosion buffers to guide nourishment requirements and beach scraping at suitable sites. Sand nourishment should continue to be the primary response to coastal erosion following storms.
6	*Sand Nourishment (Strategic):* Following completion of the strategic monitoring surveys and investigations of Geographe Bay sediment dynamics, a large "pulse" sand nourishment is proposed on a 5 yearly basis. Initially, this is likely to need to address long-term depletion in the West Busselton coastal management area.
7	*Maintenance of Coastal Protection Structures:* The City should continue the maintenance and renewal schedule for existing coastal protection structures, with a renewed focus on maintaining all structures in a management area before proceeding to structures in an adjacent management area.
8	*Coastal Adaptation: Managed retreat* of public assets threatened by erosion should continue to be undertaken along Geographe Bay in discrete areas where it is the most effective and sustainable coastal adaptation option. However, *coastal stabilisation* is likely to be the predominant coastal adaptation option along Geographe Bay during the next 10 years, whilst sediment supply is available, and whilst stabilisation is *effective locally* and *sustainable regionally*. The following coastal adaptation works are proposed: 1. Forth St Coastal Stabilisation 2. Broadwater Beach coastal stabilisation and asset relocation. 3. Managed retreat for local assets at Mill St. 4. Gale St coastal stabilisation. 5. East Wonnerup coastal stabilisation. 6. Mitigation of coastal flooding (coastal dunes). 7. Mitigation of coastal flooding (drain modifications). 8. Short terms responses to storm erosion (typically sand nourishment). 9. Additional 'watch' sites identified during coastal monitoring. This may include sites where: • Sand nourishment becomes increasingly ineffective and unsustainable. • There are narrow erosion buffers. • High rates of erosion may develop (i.e. downdrift of groyne fields, adjacent to migrating transverse sand bars, adjacent to drain outlets).
9	Review: Implement the strategic approach outlined in this CMP, and review the program every 5 years.
10.	*Funding:* Ensure works are suitably funded and resourced.
11.	*Consultation:* Ensure relevant coastal monitoring information and investigations are provided to the City's Local Emergency Management Committee, the Department of Transport, other relevant authorities and agencies, and the community.
12.	*Coastal Adaptation Strategy:* The recommendations of the Coastal Management Program should be considered in the development of the City of Busselton longer term Coastal Adaptation Strategy.

10 Glossary

Source: Modified from USACE 2003 Glossary of Coastal Terminology, EM1110-2-1100

Accretion	May be either natural or artificial. Natural accretion is the build-up of land, solely by the action of the forces of nature, on a beach by deposition of water- or airborne material. Artificial accretion is a similar build-up of land by reason of an act of man, such as the accretion formed by a GROYNE, BREAKWATER, or beach fill deposited by mechanical means.
Artificial Nourishment	The process of replenishing a beach with material (usually sand) obtained from another location.
Bar	A submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents.
Bathymetry	The measurement of water depths in oceans, seas, and lakes; also information derived from such measurements.
Beach	The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach--unless otherwise specified--is the mean low water line. A beach includes foreshore and backshore.
Beach Berm	A nearly horizontal part of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.
Beach Erosion	The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.
Breakwater	A man-made structure protecting a shore area, harbour, anchorage, or basin from waves. A harbour work.
Chart Datum	The plane or level to which soundings (or elevations) or tide heights are referenced (usually LOW WATER DATUM). The surface is called a tidal datum when referred to a certain phase of tide. To provide a safety factor for navigation, some level lower than MEAN SEA LEVEL is generally selected for hydrographic charts, such as MEAN LOW WATER or MEAN LOWER LOW WATER.
Coast	A strip of land of indefinite width (may be several kilometres) that extends from the SHORELINE inland to the first major change in terrain features.
Coastal Processes	Collective term covering the action of natural forces on the SHORELINE, and near shore seabed
Coastal Protection	Coastal managements works to protect the coast. This may include sand nourishment, maintenance of coastal structures (groynes, seawalls) or the construction of new coastal structures. Works are generally undertaken to protect foreshore infrastructure or beach amenity and access.

Cusp	One of a series of short ridges on the FORESHORE separated by crescent-shaped troughs spaced at more or less regular intervals. Between these *cusps* are hollows. The *cusps* are spaced at somewhat uniform distances along beaches. They represent a combination of constructive and destructive processes.
Crest	CREST Highest point on a beach face, BREAKWATER, or SEAWALL.
Downdrift	The direction of predominant movement of littoral materials.
Erosion	The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.
Groyne	Narrow, roughly shore-normal structure built to reduce longshore currents, and/or to trap and retain littoral material. Most groins are of timber or rock and extend from a SEAWALL, or the backshore, well onto the foreshore and rarely even further offshore
Littoral Drift	The movement of beach material in the littoral zone by waves and currents. Includes movement parallel (longshore drift) and sometimes also perpendicular (cross-shore transport) to the shore.
Nourishment	The process of replenishing a beach. It may occur naturally by longshore transport, or be brought about artificially by the deposition of dredged materials or of materials trucked in from upland sites.
Overtopping	Passing of water over the top of a structure as a result of wave runup or surge action.
Recession	A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time.
Runup	The upper level reached by a wave on a beach or coastal structure, relative to still-water level.
Salient	A bulge in the coastline projecting towards an offshore island or breakwater, but not connected to it as in the case of a TOMBOLO - see also Ness and Cusp. Developed by WAVE REFRACTION and diffraction and longshore drift.
Sand	Sediment particles, often largely composed of quartz, with a diameter of between 0.062 mm and 2 mm, generally classified as fine, medium, coarse or very coarse. Beach sand may sometimes be composed of organic sediments such as calcareous reef debris or shell fragments.
Scarp, Beach	An almost vertical slope along the beach caused by erosion by wave action. It may vary in height from a few cm to a meter or so, depending on wave action and the nature and composition of the beach. (See Figure A-1) See also ESCARPMENT.
Scour	Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.
Scour Protection	Protection against erosion of the seabed in front of the toe.

Seawall	A structure, often concrete or stone, built along a portion of a coast to prevent erosion and other damage by wave action. Often it retains earth against its shoreward face. (2) A structure separating land and water areas to alleviate the risk of flooding by the sea. Generally shore-parallel, although some reclamation SEAWALLS may include lengths that are normal or oblique to the (original) shoreline.
Shore	The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a BEACH. Also used in a general sense to mean the coastal area (e.g., to live at the shore).
Shoreline	The line that forms the boundary between the coast and the shore. Commonly, the line that forms the boundary between the land and the water, esp. the water of a sea or ocean.
Still Water level	The surface of the water if all wave and wind action were to cease. In deep water this level approximates the midpoint of the wave height. In shallow water it is nearer to the trough than the crest. Also called the UNDISTURBED WATER LEVEL.
Storm Surge	A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.
Stratigraphy	The study of rock layers (strata) or sediment layering deposited in the earth.
Updrift	The direction opposite that of the predominant movement of littoral materials.

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Attachment A – Coastal Monitoring Plans

Attachment B – Community Consultation