Geraldton Coastal Hazard Risk Management and Adaptation Planning Project

Part 2: Coastal Adaptation Report

7 January 2019 | 12693.101.R2.Rev0

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Part 2: Coastal Adaptation Report

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12693.101.R2.Rev0

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Revision	Date	Status	Comments	Prepared	Reviewed	Approved
Rev A	30/5/18	Draft	Issued for Client Review – Not for Public Release	JC	DT	JC
Rev B	2/7/18	Draft	Issued for Public Release	JC	DT	JC
Rev C	15/11/18	Draft	Updated following Public Advertising / Stakeholder review	JC	RW	JC
Rev 0	7/1/2019	Final	Issued Final following Adoption by Council	JC	RW	JC

This project is funded by the Western Australian Planning Commission through the Coastal Management Plan Assistance Program. This report acknowledges the funding contribution made by the Grantor, but recognises that it does not purport to represent the views, statements, opinions or advice of the Grantor

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Executive Summary

The City of Greater Geraldton (CGG) is facing the increasing impacts from coastal erosion and inundation along its coastlines, with those effects forecast to increase in the future under climate change and projected sea level rise. The Geraldton Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) project analyses the coastal infrastructure and property at risk from erosion and inundation, and provides recommendations to guide strategic and operational decision making by the City in terms of the location and maintenance of its coastal infrastructure, development of statutory planning controls and the key focus areas for coastal monitoring, management and adaptation in the short term (to 2032) and longer timeframes out to 2110.

The City recently completed coastal inundation and coastal processes studies (MRA 2015, 2016, 2017) to understand the risk posed by coastal erosion and storm surge inundation processes, under climate change and sea level rise projections for the next 100 years, which confirmed:

- The City's northern beaches are *currently* experiencing severe coastal erosion pressures, as shorelines are eroded and move landward (e.g. Drummond Cove, Sunset Beach, Bluff Point). Under projected climate change scenarios and sea level rise, erosion is forecast to increase for these coastlines;
- The coastal areas south of Point Moore (Mahomet Flats, Tarcoola Beach to Cape Burney) experienced long term accretion, with the Southgate dunes providing a sediment source for the region, which is transported north to Point Moore under the dominant longshore transport process. The Southgate dunes is expected to continue to provide sediment to the system for approximately the next 50 years after which time erosion of shorelines is forecast to occur (MRA 2017);
- Coupled with the erosion threat, the sea level is forecast to rise by 0.4m by 2070 and 0.9m by 2110, which will increase the likelihood of flooding for low lying sections of the City during extreme weather events. This inundation risk is most significant for the Geraldton Town Centre, Beachlands and Point Moore.

The findings of the studies are important to consider in the context of planning needs and siting of infrastructure by the City in the future. In accordance with Western Australia's State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6), coastal areas identified as being at risk of coastal hazard require CHRMAP, to ensure that the identified coastal hazard is factored into decision-making by the City in its land use planning in the future.

The initial stages of the Geraldton CHRMAP project involved community and stakeholder engagement and a risk-based assessment, which examined coastal assets under threat from erosion and inundation in future planning timeframes. The outcomes of this initial CHRMAP phase were reported in the Coastal Hazard and Risk Assessment report (Baird 2019).

This report works through the outcomes from the risk assessment to develop coastal management and adaptation recommendations to mitigate risk to coastal assets. The City's coastline from Drummond Cove to Cape Burney is divided into 12 Coastal Management Units (CMU) shown in Figure E.1. Coastal management and adaptation recommendations have been completed based on the adaptation hierarchy (WAPC 2014) shown in Figure E.2 with the requirements for each CMU outlined, and implementation actions (costs, timing, responsibilities) summarised.

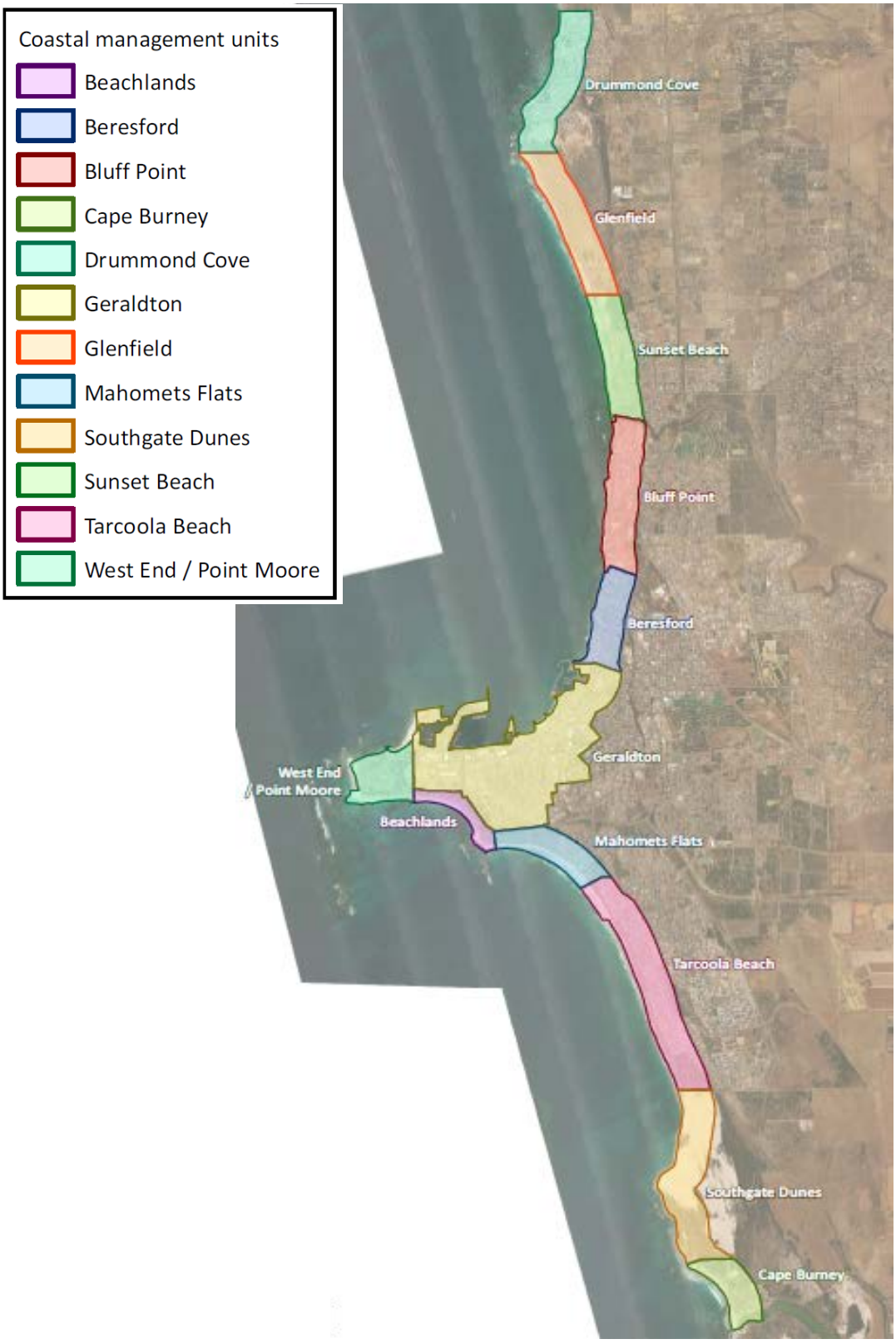

Figure E.1: Coastal Management Units (CMU)

Figure E.2: Coastal Adaptation Hierarchy (WAPC 2014)

Responding to the threat from coastal erosion and inundation is already a major focus for the City and is a process that is likely to increase in the future under projected climate change and sea level rise scenarios. There are many examples of management and adaptation actions throughout the CGG coastal areas, that have been put in place to respond to coastal hazard. The goal of the CHRMAP process is to identify coastal assets in the community and examine the risk posed by erosion and inundation in the immediate term (next 15 years to 2032) and over the longer planning period to 2110 and make recommendations to the City to manage the risk.

The CHRMAP risk assessment process (Baird 2019) is based on the WAPC guidelines (WAPC 2014) and Australian Standards (AS 5334:2013). In the risk framework, risk is defined as a product of likelihood and consequence, with the final risk rating of a coastal asset additionally recognising the ability of an asset to accommodate the coastal hazard impact and recover (adaptive capacity). The risk framework generally follows the CGG standard risk framework (CGG 2015), though it is noted the adaptive capacity is an additional consideration beyond the CGG framework, which increases the overall risk rating for assets with low adaptive capacity such as houses.

The key mapping data applied in the CHRMAP and presented in this report is as follows:

- Coastal erosion hazard lines are shown in **Appendix A.1** for the CMU's, with coastal processes setback calculated for the present day, 2030, 2070 and 2110 planning timeframe;
- Coastal inundation hazard mapping is shown in **Appendix A.2** for the CMU's based on the 500yr ARI storm surge event in the 2110 planning period (includes 0.9m sea level rise) and for the 100yr ARI storm surge event in the 2110 planning period (includes 0.9m sea level rise); and
- Coastal assets and land use categories are shown for each of the CMU's in **Appendix A.3**.

Coastal Assets

There are a large number of coastal assets that are located within the erosion setback lines and coastal inundation areas and this was the focus of the risk assessment process (Baird 2019). This report provides adaptation and management strategies to address the identified risk categories rated at medium, high and extreme in the City's coastal areas. The short-term timeline (to 2032) is the key timeframe over which the adaptation recommendations are made, though the full range of planning timeframes in the datasets (i.e. 2070, 2110) are used to inform future planning requirements.

The coastal assets at highest risk, requiring adaptation and management responses generally fall into two categories:

1. Coastal Infrastructure: It is inevitable that the City's coastal infrastructure (such as access paths, roads, beach shelters, coastal foreshore parks and amenities) will be located adjacent coastal hazard in the direct path of erosion and inundation threat. In practice, as coastal hazard impacts occur the retreat or re-siting of these minor structures is undertaken by the City on an as needs basis (e.g. Drummond Cove, Sunset Beach).

2. Residential and Commercial Development: Coastal erosion is forecast to impact houses / businesses which are currently set back from the coast, but could be directly in the path of coastal erosion as it is realised in future planning periods. Similarly, properties located in low lying areas of the coast will be at increasing risk of inundation under projected sea level rise scenarios (0.4m by 2070 and 0.9m by 2110).

In general, the council infrastructure in coastal areas will continue to be used under a managed retreat scenario. This allows continued use of the infrastructure until such time as it is unsafe or un-useable at which time asset removal is required, or where maintenance costs consistent with the design life of the structure may be required.

Updates to Current Planning Scheme

An update to the City's current planning scheme is recommended to manage the coastal hazard risk for existing and future residential and commercial development along Geraldton's coast. The recommended approach is as follows:

- It is recommended the CGG introduce a Special Control Area (SCA) with a boundary based on the most landward position of either the 2110 coastal erosion setback line or inundation extent for the 500yr ARI event in the year 2110.
- A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. The LCPP will provide recommendations in alignment with the adopted CHRMAP.
- All properties within the SCA will require a Section 70A notification to be placed on title to inform prospective purchasers to the risk of coastal erosion and /or coastal inundation. It is noted that the mechanism for a decision maker to impose a requirement to place a Section 70a notification is typically by way of condition of subdivision or development approval.

This CHRMAP is recommending a cascading suite of measures to address immediate, medium and long-term risks that would be directed through the LCPP. A range of future studies that will be required to improve understanding of the study area and inform the development of the planning recommendations in the LCPP have been identified.

Managing Coastal Erosion Risk for Properties in the SCA

Coastal erosion is the dominant coastal hazard impacting the northern CMU's currently. The Geraldton Town Centre and Beresford CMU's have coastal protection structures in place to prevent erosion, but all sections of the coast further north (Bluff Point, Sunset Beach and Drummond Cove) are at significant risk of erosion. Currently Point Moore south (Grey's beach) is at risk of coastal erosion, and over a longer timeframe (2070 to 2110), coastal erosion hazard is forecast to impact all beaches south of the City, once the Southgate Dunes sediment supply is depleted (MRA 2017).

The CHRMAP has identified the number of properties within the coastal erosion allowance (erosion setback) extent in future planning periods as summarised in Table E.1. This assessment provides a summary of the residential property, commercial property and Council land types based on cadastral information supplied by the City (2017). In Table E.1 there are a total of 15 residential properties in the present to 2030 timeframe, a further 220 properties identified through the 2030 to 2070 timeframe and a further 535 properties in the 2070 to 2110 period. In total there are 770 located properties within the erosion setback at planning year 2110 (commercial and residential combined. Of this total 761 of the identified properties are classified as residential (refer base of Table E.1).

Table E.1: Coastal Erosion Hazard by CMU and Property Type – Current to 2110 Time Frame

CMU	Number of Properties in Current to 2030 Coastal Erosion Setback Area	Number of Properties in 2030 – 2070 Coastal Erosion Setback Area	Number of Properties in 2070 – 2110 Coastal Erosion Setback Area	TOTAL properties at 2110
1.Drummond Cove	0	98	187	**285**
2.Glenfield	1	1	0	**2**
3.Sunset Beach	0	57	82	**139**
4.Bluff Point	13	61	71	**145**
5.Beresford	0	0	0	**0**
6.Geraldton	0	0	0	**0**
7.Point Moore[3]	0	1	61	**62**
8.Beachlands	0	1	4	**5**
9.Mahomets Flats	0	0	3	**3**
10.Tarcoola Beach	0	0	127	**127**
11.Southgate Dunes	1	1	0	**2**
12.Cape Burney	0	0	0	**0**
TOTAL	**15**	**220**	**535**	**770**
Residential Properties[1]	***15***	*218*	*528*	***761***
Commercial[1]	***0***	*2*	*7*	***9***
Council / Public Purpose	***43***	*12*	*15*	***70***

1. Total includes developed and undeveloped vacant lots
2. Council / Public Purpose Land includes Crown Land, Foreshore Reserve and Foreshore Areas.
3. Point Moore properties are included on this table however risk has already been treated for these properties under new lease agreements and risk management is not required under this CHRMAP.

To manage the erosion risk for properties identified within the SCA over the next 100 years, a range of planning-based approaches are recommended to be implemented in the LCPP. The planning approaches are proposed to provide a basis under which development can occur, in a way that recognises the coastal erosion risk to property in the SCA over time.

- For development approval of undeveloped residential or commercial land that *is not* considered to be infill development under SPP2.6, the planning approach recommended is **Avoid** within the SCA. Development will only be permitted on the portion of a lot landward of the 2110 coastal erosion setback line and any additional allowance required for provision of a foreshore reserve as per SPP2.6 (Clause 5.9). It is noted this 'non-infill' category is not expected to apply to many of the vacant lots in the CMU's.
- For development approval of land that *is* considered infill development under SPP2.6, development approval will be supported under an **Accommodate** and **Managed Retreat** approach with mechanisms to address the identified risk specified within the LCPP. It is proposed that three levels of adaptation planning response are outlined within the LCPP, recognising that the current risk for properties at the seaward edge is much higher than for those properties at the 2110 setback extent. Applying a sliding scale of adaptation response in the LCPP, recognises there is uncertainty in the estimate of the long-term shoreline position (e.g. at 2070, 2110), and that making decisions based on this uncertainty today, may impose needless constraint on development of coastal areas.

It is proposed that three categories be defined in the LCPP to make planning recommendations based on a risk category defined by the location of the property in relation to the coastal erosion setback extent:

- **Extreme Risk. Property located within the Current to 2030 Coastal Erosion Setback Extent**

  There are a total of 15 properties identified within the current to 2030 coastal erosion setback extent (Table E.1). In the CHRMAP risk assessment (Baird 2019) these properties are classified at extreme risk. Section 70a notifications would be placed on all properties as the opportunity arises. Additionally:

  - 2 of the 15 properties would not be classified as infill, and would have to **Avoid** development seaward of the 2110 coastal erosion setback line (the 2 sites are undeveloped residential located in Glenfield and Southgate Dunes CMU);
  - 13 of the 15 properties are considered infill and located in the Bluff Point CMU. Managed retreat conditions will be imposed on these properties as a condition of development or redevelopment, with details specified consistent with the Managed Retreat guidelines (DPLH 2017); and
  - The specific managed retreat triggers will be determined by the City and it is recommended that the triggers be incorporated into the Local Coastal Planning Policy which determines the specific guidance for properties in the SCA. The triggers are likely to be based on the Point Moore lease conditions (2017) that would trigger vacating the property if:
    - the most landward limit of the horizontal shoreline datum (HSD) is within the S1 distance of any structures on the lot;
    - no public road is available, or such road is unable to provide safe and/or legal access, to the lot due to coastal hazards;
    - the lot (and any buildings on the lot) has sustained damage to the extent that it is deemed irreparable or a total loss or is rendered uninhabitable for an extended period of time; and
    - water or electricity to the lot is no longer available because the relevant authority has removed or decommissioned access to water or electricity to the lot.

- **High Risk. Property located within the 2030 to 2070 Coastal Erosion Setback Extent**

  There are 218 residential and 2 commercial properties which are located within the 2030 to 2070 coastal erosion setback area. These are predominantly located in Drummond Cove, Sunset Beach and Bluff Point. In the CHRMAP risk assessment (Baird 2019) these properties are classified as being at high risk. For these properties the LCPP will address the erosion risk through a range of **Accommodate** measures. This will be subject to review in future revisions of the CHRMAP, where properties may be moved to the Extreme level of risk if the shoreline erosion progresses (and managed retreat conditions would then be imposed through the LCPP).

  On this basis, it is recommended:

  - that a Section 70a notification be placed on title to inform prospective purchases to the risk;
  - it is important to consider the uncertainty in relation to future sea level rise projections and also shoreline response in each coastal compartment. Given the number of properties that are potentially at risk in the 2030 to 2110 time within the Drummond Cove, Sunset Beach and Bluff Point CMU's, a site-specific assessment of shoreline changes into the future which incorporates geotechnical and geophysical data is warranted. This is a high priority recommendation from this study; and
  - in addition, targeted annual monitoring of the shoreline position will be undertaken, to track the local rate of shoreline erosion. The coastal erosion setback lines will be recalculated at five yearly intervals to re-assess which properties (if any) will move up to the higher category of 'Managed Retreat'.

- **Moderate Risk. Property located within the 2070 to 2110 Coastal Erosion Setback Extent**

  There are 528 residential and 7 commercial properties which are located within the 2070 to 2110 coastal erosion setback area. These properties are classified as being at moderate risk under the CHRMAP risk assessment and include properties from Drummond Cove, Sunset Beach, Bluff Point, Point Moore, Mahomet Flats and Tarcoola Beach. For these properties it is recommended the erosion risk is **Accommodated** through:

the provision that a Section 70a notification be placed on title to inform prospective purchases to the risk;

desktop review of the shoreline position undertaken in future revisions of the CHRMAP, which will determine if the risk rating moves up to the 'High' category if shoreline erosion progresses. No specific monitoring is required, and the recalculation of the shoreline position can be done based on analysis of aerial imagery at approximately five yearly intervals.

Managed Retreat Pathways

For properties that are designated in the 'Extreme Risk' category of Managed Retreat, there are three pathways the CGG must evaluate. As part of the LCPP the CGG will identify the preferred adaptation pathway and then be prepared to act as follows:

1. Under a 'Do Nothing' approach, the CGG will allow natural processes to occur through coastal areas at risk of erosion. At the time that coastal erosion of the shoreline results in impacts to existing properties, the City will seek to resume properties under the *Health Act 2011* (condemn property on the grounds of safety). The structures would be removed and the land transferred to public foreshore reserve, providing a buffer for the coastal areas immediately landward protecting the values of the coast in the area;

2. Under a 'Planned Retreat', the CGG would acquire the properties at risk over time, as the coastal erosion trigger is reached (i.e. HSD moves landward to within the S1 distance of structures). Under this scenario, the City would be required to reserve funds to acquire the properties before or at the time of the erosion trigger. Under the Western Australian framework, voluntary or compulsory acquisition is based on the value of the land and its improvements, exercised through the *Land Administration Act 1997.* The resumed properties would have structures removed and the land would be returned to public foreshore reserve, providing a buffer for the coastal areas immediately landward, and protecting the values of the coast in the area; or

3. Under a 'Protect' strategy, the CGG shall investigate coastal protection options to protect properties that are under direct erosion threat. The opportunity to recover the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme should be investigated by the CGG, to apportion the costs against the properties that are protected.

The *Draft Planned or Managed Retreat Guidelines* (DPLH 2017) outline in detail the process for transferring land from the private to the public realm. The City will need to determine whether it follows a 'Do Nothing' or 'Planned Retreat' pathway for existing properties at risk of erosion as part of the LCPP that will be developed. Whilst the 'Do Nothing' approach does not impose an acquisition cost on the City for the resumption of properties, the City would incur reputational damage and legal costs. The legal precedent is uncertain for the 'Do Nothing' approach and the City would require specialist legal advice prior to adopting this as a formal planning approach. Conversely, the 'Planned Retreat' option comes at significant cost to the City through the acquisition of properties affected (Table E.2 indicates potential number of properties over 100-year planning timeframe), whilst limiting the associated reputational and legal costs. The CGG will be required to make a decision on its preferred way forward and to update its planning framework in the LCPP to clearly outline how managed retreat will be controlled.

The City will need to consider the costs and benefits for taking land through a managed retreat process vs the cost of protecting the vulnerable properties on a case by case basis. The CHRMAP has examined the economic case for coastal protection at two locations to examine the viability of protecting the properties and shoreline areas, compared with a 'do nothing' managed retreat:

- At St Georges Beach in the Bluff Point CMU, a variety of coastal protection structures which would offer protection to both Rundle Park and the properties landward recommended to be classified in Managed Retreat were examined. Cost benefit analysis of a range of alternatives indicated a series of geotextile groynes similar to the one currently installed at the northern end of St Georges Beach could deliver a net return on investment when taking into account the value of the property and public land that is protected (refer Appendix A.5).

- For Drummond Cove, a number of options were considered for protection of the shoreline along the closed section of Whitehill Rd. The analysis of alternatives showed a combination of geotextile groynes backed by a seawall could deliver a net return on investment when taking into account the value of the property and public land that is protected (refer Appendix A.5).

The value of properties being protected is the key driver for the positive economic outcomes in both cases. For the CGG, the ability to protect the coast and preserve the coastal values needs to be balanced against a mechanism where recovery of the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme can be agreed. It is recommended that a geophysical investigation that can deliver a site-specific shoreline response to sea level rise be completed for Bluff Point and Drummond Cove before further prioritisation of potential medium or long-term shoreline protection projects in those CMU's.

The proposed framework for managing coastal erosion in the Local Coastal Planning Policy is summarised in Table E.2.

Table E.2: Proposed Planning Requirements in the Local Coastal Planning Policy for Properties at risk of Erosion within the Special Control Area

Conditions	Current to 2030 Coastal Erosion Setback Area EXTREME RISK	2030 – 2070 Coastal Erosion Setback Area HIGH RISK	2070 – 2110 Coastal Erosion Setback Area MODERATE RISK
Number of Properties[1] within category (Residential + Commercial)	15	219	474
Planning Requirement 1	CGG introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.		
Planning Requirement 2	Require Section 70A notification to be placed on all titles within the CMU to inform prospective purchasers to the risk of coastal erosion.		
Planning Approach New Development Not Classified as 'Infill' under SPP2.6	AVOID	AVOID	AVOID
Planning Approach Redevelopment or New Development Classified as 'Infill' under SPP2.6	MANAGED RETREAT	ACCOMODATE	ACCOMODATE
Monitoring Requirement	Targeted monitoring annually to track change in local shoreline position.	Targeted monitoring annually to track change in local shoreline position.	No Specific Monitoring Requirement. Five yearly review of shoreline position based on desktop approaches
Trigger for Changing Category	If CGG elects to protect the shoreline, all properties landward of protection	As part of CHRMAP review within 5 years after re-assessment of	As part of CHRMAP undertake initial review within 5 years after re-

Conditions	Current to 2030 Coastal Erosion Setback Area EXTREME RISK	2030 – 2070 Coastal Erosion Setback Area HIGH RISK	2070 – 2110 Coastal Erosion Setback Area MODERATE RISK
	structure would have Managed Retreat requirements removed.	the erosion setback lines based on monitoring results and site-specific sea level rise response study (selected CMU's).	assessment of the erosion setback lines based on monitoring results and site-specific sea level rise response study (selected CMU's). Following first review, part of CHRMAP review every 10 years, re-calculate the erosion setback lines based on aerial photo analysis (or monitoring where available) and determine if additional properties move into the High-risk category.
CGG Commitment	Decision on strategy, either: 1. 'Do Nothing' approach, the City will allow natural processes to occur, and resume properties as and when they are impacted through the Health Act (acquisition of properties is not required); 2. 'Planned Retreat', voluntary or compulsory acquisition of properties. City to reserve funds to undertake voluntary or compulsory acquisition of properties before or at the time of erosion trigger; or 3. Develop coastal protection options and seek to recover the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme.	Focussed annual monitoring of shoreline position required to reassess the erosion risk for properties at highest risk every 5 years (as part of CHRMAP review). Support projects to increase the natural resilience of the shoreline (revegetation, dune management etc).	Reassess erosion risk every 5-10 years as part of CHRMAP review.

1.Note the properties identified in Point Moore CMU are not included in this total as they are covered by a separate lease agreement with managed retreat conditions imposed

Managing Coastal Inundation Risk for Properties in the SCA

Coastal inundation hazard plots are presented in Appendix A.2 for the 500yr ARI and 100yr ARI storm surge event in the planning year 2110. Storm surge risk for Geraldton is driven by extreme cyclone events,

with inundation impacts increased by projected sea level rise of 0.4m by 2070 and 0.9m by 2110. It is noted that the general tides do not pose an inundation threat to Geraldton's coastal areas, even under projected sea level rise.

The low lying coastal areas where storm surge impacts are most pronounced are the Geraldton Town Centre, Beachlands, Point Moore and Beresford CMU's. In future planning periods under projected sea level rise of 0.9m, large sections of the City centre area and Beachlands are inundated in an extreme storm surge event at the 500yr ARI level (refer Appendix A.2). In future planning periods, inundation also affects areas in Drummond Cove, Bluff Point and Beresford CMU's at low-lying sections of the coastline.

An estimate of the number of properties that are located within the 500yr-ARI inundation extent over the planning timeframe is summarised in Table E.3.

Table E.3 : Properties located within the 500-yr ARI inundation extent over the planning timeframe

CMU	Number of Properties[1] at planning year 2030	Number of Properties[1] at planning year 2070	Number of Properties[1] at planning year 2110
Drummond Cove	18	27	56
Bluff Point	4	9	17
Beresford	30	35	63
Geraldton Town Centre	328	350	390
Point Moore	272	280	284
Beachlands	162	235	420
Tarcoola Beach	3	6	18
Cape Burney	0	3	4
TOTAL	**817**	**945**	**1252**

1.Total for Residential and Commercial and industrial land uses includes developed and undeveloped vacant lots

It is noted that to develop the property analysis presented in Table E.3

- the process to identify properties does not take account of the depth or extent of flooding on the property and captures all properties where the inundation extent goes across a property boundary. The number of properties would reduce if minor flooding cases were removed (i.e. 'nuisance' flooding of less than 200mm).
- the assessment does not account for finished floor levels and is based on the land surface (i.e. the LiDAR).
- the assessment of flood inundation is based on the mapping presented in Appendix A.2 which is likely to be conservative (i.e. show greater depth) with increasing distance inland from the coastline. The mapping has been completed based on a 'bathtub' approach which does not account for reduction in the flood level as it propagates landward through the built foreshore area.

The Geraldton Town Centre is particularly impacted by inundation in future planning periods and a key recommendation from the CHRMAP is that a detailed overland flood study be completed for the design inundation events, to more appropriately define current and future flood levels throughout Geraldton Town Centre CMU to set finished floor level requirements for planning purposes in the LCPP.

A preliminary calculation of the cost of potential impacts associated with coastal inundation of the residential and commercial premises in the Geraldton town centre over the 50-year period to 2068 is

presented in Appendix A.5. The assessment is based on examination of the depth of flooding that would impact properties from a range of return period events most likely to occur (20yr ARI and 100yr ARI scenarios) which include assumed sea level rise. Damages were assessed based on typical residential, commercial and industrial damage curves, with the present value of damages estimated at $3.5 million.

Whilst there are a number of limitations on this assessment, it provides a reasonable basis for understanding the cost of inundation risk to the City centre and provides input to the decision making of where and when an adaptation option against flooding would become economically viable. Targeted outcomes for low lying sections of the CMU, where civil design could additionally provide flood protection (e.g. raising roads as part of general replacement works) should be investigated further.

It is recommended that specific guidelines be provided in the LCPP to address the risk of inundation in future planning periods for properties in the SCA. The recommended adaptation approach to mitigate the risk of storm surge inundation for properties in the SCA is **Accommodate** to be realised through planning controls, building design and emergency planning which would be detailed in the LCPP. The proposed approaches for managing coastal inundation in the LCPP are summarised on Table E.4.

Table E.4: Proposed Planning Requirements in the Local Coastal Planning Policy for Properties at risk of Inundation within the Special Control Area

Option	Adaptation Approach
Planning Controls	• CGG introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • Specific guidance for properties within the SCA would be provided by the Local Coastal Planning Policy (LCPP). • For any new development seeking planning approval on land prone to storm surge, an opportunity exists for the local government to place a condition on any subsequent approval, requiring the landowner/developer to place a Section 70A notification on the certificate of title pursuant to Section 70A of the Transfer of Land Act 1893 to notify prospective purchasers that the lot(s) is located in an area that may be subject to coastal inundation over the next 100 years.
Building Design Recommendations – to be included in LCPP	• Set minimum Finished Floor Levels (FFL) that must be achieved in the design above the design flood condition. • Ensure that all important services, including electricity, permanent fixtures and plumbing are elevated and / or protected from the impact of flooding; • Ensure buildings are designed and materials are employed to withstand structural loads associated with a storm surge flood event; • Ensure foundations and footings are adequate to withstand potential erosive action during coastal inundation; • Where practical, design lower levels of buildings prone to flooding to be permeable to allow water to flow through, without damaging the structure of the building; • Ensure floorspace that is designed to accommodate stock inventory is located above the modelled storm surge flood level; • Where possible, consider the use of false floors in relation to fitout of existing buildings which raise the floor level above the storm surge flood level (where practical); • Employ the use of materials that are resistant to water damage; • Consider floorplate and internal tenancy wall arrangements which would allow for water to flow through rather than build up in dead-end spaces; and • Consider building evacuation requirements.

Option	Adaptation Approach
Emergency Planning – to be included in LCPP	• The local government should ensure that an Emergency Evacuation Plan is prepared, maintained and implemented to ensure the safe evacuation of occupants within the City Centre during a storm surge event.

Summary of Recommended Coastal Adaptation Approaches

A summary of the planning-based recommendations and approaches for managing the CGG coastal infrastructure in each of the 12 CMU's is presented in Table E.5. The two general categories cover:

- Property – private dwellings and business premises including vacant lots; and
- CGG Coastal Infrastructure – coastal structures and coastal areas managed by the CGG (e.g. playground areas, toilets, carparks, roads, foreshore reserve)

Table E.5: Summary Coastal Adaptation Approaches to Manage Risk by CMU

CMU	Erosion	Inundation

Drummond Cove	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 98 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines.
	  • Moderate: 187 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Initial 5-year review of shoreline and updated site-specific assessment of future shoreline hazard lines.
	CGG coastal infrastructure:
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will
		Property – Planning Recommendations
		• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation (56 properties identified within the 2110 inundation extent).
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.
		CGG coastal infrastructure:
		• Consider future raising of Whitehill Rd to provide flood protection for houses in the section south of Hester Street (timeframe is post 2070 based on assumed rate of sea level rise).

CMU	Erosion	Inundation
	allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • The coastal protection structure in front of the Community Hall should be maintained consistent with the design life of the structure. Note the coastal protection feature is not recognised as a long-term commitment for this section of the CMU. • A coastal protection structure for Drummond Cove, north of the Community Hall in front of the closed section of Whitehill Rd warrants further assessment based on high level economic assessment of a protect structure. • Geophysical study of the shoreline areas to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term.	• Full flood study recommended to confirm flooding impacts to properties in future planning periods and set finished floor level requirements of LCPP.

Glenfield	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided
	• Summary of risk level in CMU:
	  • Extreme: 1 properties.
	  • High: 1 properties.
	  • Moderate: 0 properties.
	CGG coastal infrastructure:
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• The Water Treatment Plant is a private asset managed by Water Corp. Assessment of the coastal erosion risk for the site should be undertaken by Water Corp., with a recommendation that a Managed Retreat erosion trigger of 30m distance from the site boundary to the HSD or similar be imposed.
		Property – Planning Recommendations
		• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation.
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.

CMU	Erosion	Inundation

Sunset Beach	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 57 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD). and updated site-specific assessment of future shoreline hazard lines.
	  • Moderate: 82 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Initial 5-year review of shoreline and updated site-specific assessment of future shoreline hazard lines.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• Critical at-risk assets to 2030 are Triton Place Carpark, Caravan Park, Foreshore Reserve areas, Swan Drive Park Toilets and Grassed Areas.
		No Risk of Inundation

Bluff Point	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive

CMU	Erosion	Inundation

	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6.
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 13 properties in addition to Section 70a notification on Title, **Managed Retreat** condition would be imposed at time of development application / redevelopment, with trigger set when erosion of shoreline reduces horizontal distance from HSD to structure to less than (S1).
	  • High: 61 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines.
	  • Moderate: 71 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Initial 5-year review of shoreline and updated site-specific assessment of future shoreline hazard lines.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• Critical at-risk assets to 2030 are St Georges Beach / Rundle Park and amenities and the Heritage Site identified at Kempton St.
	• A coastal protection approach for Rundle Park at St Georges Beach warrants further assessment, based on MCA and CBA analysis of options which recommended a protection through a series of geotextile groynes could deliver a net return on investment on the value of assets it protects on the landside.
		recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation (17 properties identified within the 2110 inundation extent).
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.

Beresford	Property – Planning Recommendations • The CMU is **Protected** from erosion through the revetment structures constructed for the Beresford Foreshore Protection Project. The CGG has elected to continue protection of the CMU in future planning periods. • A Local Coastal Planning Policy (LCPP) will be developed and confirm this CMU as being protected	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and

CMU	Erosion	Inundation
	from erosion in future planning periods to inform development of properties within the CMU. CGG coastal infrastructure • The sand nourishment program currently delivered by the Geraldton Port Authority will be required to continue to support the ongoing requirements for sediment supply to the CMU.	provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation (63 properties identified within the 2110 inundation extent). • **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.
Geraldton Town Centre	Property – Planning Recommendations • The CMU is **Protected** from erosion through a series of groynes, seawalls and revetment structures. • A Local Coastal Planning Policy (LCPP) will be developed and confirm this CMU as being protected from erosion in future planning periods to inform development of properties within the CMU. CGG coastal infrastructure • The sand nourishment program currently delivered by the Geraldton Port Authority will be required to continue to support the ongoing requirements for sediment supply to the CMU.	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation (390 properties identified within the 2110 inundation extent). • Undertake overland flood study to more appropriately define current and future flood levels throughout the CMU and set finished floor level requirements in the LCPP. • **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.

CMU	Erosion	Inundation
		• **Accommodate** inundation risk to people through emergency evacuation and emergency response planning outlined in the LCPP.

Point Moore / West End	Property – Planning Recommendations
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU
	• Lease agreements for Point Moore residents have specified **managed retreat** conditions (CGG2017c). based on erosion and inundation triggers (McCleods 2017). This will be outlined in the LCPP.
	• Summary of risk level in CMU:
	  • Extreme: 0 properties.
	  • High: 1 property.
	  • Moderate: 61 properties.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• Critical at-risk assets to 2030 are Marine Terrace South Side.
	• The coastal protection structure on the south side of Point Moore should be maintained, consistent with the design life of the structure. Note the coastal protection feature has not been recognised as a long-term commitment for this section of coast.
		Property – Planning Recommendations
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU
		• Lease agreements for Point Moore residents have specified **managed retreat** conditions based on erosion and inundation triggers. This will be outlined in the LCPP

Beachlands	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the

CMU	Erosion	Inundation

	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 1 property. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD).
	  • Moderate: 4 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. 5 yearly Review of shoreline.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• Critical at-risk assets to 2030 are Separation Point Carpark / Rd.
		risk of coastal inundation (420 properties identified within the 2110 inundation extent).
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.
		• Include in overland flood study planned for Geraldton Town Centre to more appropriately define current and future flood levels throughout the CMU and set finished floor level requirements in the LCPP
		• Future **Protect** option recommended for further assessment which would raise the land level at the Rail Line Corridor to act as a levy / dike to prevent flooding of inland areas in extreme events.

Mahomet Flats	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 0 properties.
	  • Moderate: 3 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. 5 yearly Review of shoreline.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will
		No Risk of Inundation.

CMU	Erosion	Inundation
	allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • No Critical at-risk assets to 2030.	

Tarcoola Beach	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 0 properties.
	  • Moderate: 127 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. 5 yearly Review of shoreline.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• No Critical at-risk assets to 2030.
		Property – Planning Recommendations
		• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation (18 properties identified within the 2110 inundation extent).
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.

Southgate Dunes	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.	Risk of inundation in dune system in extreme events is an Acceptable risk.

CMU	Erosion	Inundation
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area. For greenfield sites, planning should ensure an appropriate coastal foreshore CGG coastal infrastructure: • The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • No Critical at-risk assets to 2030.	
Cape Burney	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • **Avoid** development of vacant residential land within the identified 2110 coastal hazard area. For greenfield sites, planning should ensure an appropriate coastal foreshore CGG coastal infrastructure • The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • Critical at-risk assets to 2030 - beach lookout and pathway.	Risk of inundation in dune system in extreme events is an Acceptable risk.

Recommendations

The CGG and the local community have led coastal adaptation and management for its coastal areas over a long period of time, and in the future the continued active involvement to respond to coastal risk from erosion and inundation will be critical under forecast climate change and sea level rise. The following recommendations for future studies and monitoring should be undertaken by CGG to support the CHRMAP process and implementation of planning controls:

- A geophysical study of the critical shoreline areas in the northern coastal management units at Drummond Cove, Sunset Beach and Bluff Point should be undertaken to examine for the presence of rock strata beneath the foreshore. Based on the findings, specific analysis and potentially modelling of shoreline response to sea level rise and storm erosion could then be completed, to redefine coastal

erosion setback extents shoreward. The current coastal erosion setback allowances in these sections of coast have been calculated based on SPP2.6 recommendations assuming the shoreline is composed of sand, with no underlying rock. Confirmation of the presence of underlying rock in foreshore areas would improve the understanding of how shorelines in these areas may respond to erosion threat and on this basis setback lines calculated under SPP2.6 (components S1, S2, S3) could be re-examined. These types of geophysical studies have been completed in many similar foreshore areas in Western Australia (e.g. Seabird, Two Rocks, Binningup, Quinns Beach, Trigg Beach) to define rock profiles in coastal areas for input into coastal erosion assessments and CHRMAP studies;

- It is recommended the City undertake a detailed overland flood study to more appropriately define current and future flood levels throughout the SCA (in particular Geraldton Town Centre) before setting finished floor level for new structures in the planning requirements of the LCPP. The process adopted in mapping of the inundation areas in Appendix A.2 applied in the CHRMAP assessment is considered appropriate for the initial study of impacts, however a more detailed assessment of flooding impacts is required to define the specific guidance in the LCPP.
    - The Appendix A.2 inundation mapping shows flood depth determined by applying the design flooding levels to the land surface, as defined by LiDAR data flown in March 2013 (NACC 2013). Baird developed the flood maps based on an initial 'bathtub' type approach, improved by applying a 'hydro-connectivity' algorithm. Hydro-connectivity ensures that the flooded areas inland connect to the offshore ocean region. The hydro-connected surface overcomes the limitation of the standard bathtub method where isolated inland pockets of inundation will occur noting there are still limitations in this approach. The key limitations of the Appendix A.2 mapping that would be overcome by a detailed flood study are cited as:
        - The LiDAR dataset is based on land levels in 2013. Additional ground survey to capture changes in landform in foreshore areas since the 2013 survey data capture could be incorporated in the assessment;
        - the finished floor levels of properties in the coastal areas is not considered in the inundation mapping. Defining the floor height at property level will provide a more robust definition of flood risk; and
        - The calculated depth of inundation for inland areas is based on the offshore ocean level and does not consider the loss of vertical height inland associated with propagation of the flood level across the foreshore area (i.e. surface roughness, drainage infrastructure, wave setup effects reducing inland).

      The flood study would provide improved understanding of flooding impacts for planning purposes in the LCPP and refine the inundation extents reported in Appendix A.2. Adaptation options for flood control could also be further assessed through this process. The overland flood study should adopt a modelling methodology that incorporates all key processes including coastal water levels and wave forcing, vegetation and surface roughness, high resolution ground and building elevation data, rainfall on grid and drainage infrastructure; and
- A targeted monitoring program to support the CHRMAP recommendations and build understanding of coastal erosion and inundation impacts in key coastal areas has been developed (Section 15); and
- CGG should fund, implement and support community projects to increase the natural resilience of the shoreline through revegetation and dune management. A focus of the CGG should be to encourage community organisation and involvement in those activities.

This CHRMAP has identified a budget of approximately $515,000 will be required over the 14-year period 2019 to 2032 to address the cost of annual monitoring, complete the recommended additional studies to inform the LCPP and undertake review of the CHRMAP twice in the 14-year timeframe.

A proposed implementation timeline and cost for the execution of the recommended studies and monitoring over the next five years is presented in Figure E.3 based on the full suite of studies outlined in **Table 15.8**. The total cost for the five-year period 2019 – 2023 is $273,500. The full-size project timeline is attached in **Appendix A.6**.

Task	Description (Frequency/Location)	Start	Cost
Year 1	**2019 (Baseline)**		**$102,500**
1.1	Analysis of Shoreline Movements (5 Yearly)	07-Jan-19	$1,500
1.2	Beach Transect Survey (Summer)	04-Mar-19	$3,500
1.3	Beach Transect Survey (Winter)	02-Sep-19	$3,500
1.4	UAV Survey (2 Yearly)	25-Mar-19	$4,000
1.5	Storm Bite Analysis (post storm)	01-Jan-19	$1,500
1.6	Photo Monitoring (Summer and post storm)	01-Apr-19	$2,500
1.7	Photo Monitoring (Winter and post storm)	02-Sep-19	$2,500
1.8	Minor Structure Inspection (Summer and post storm)	01-Apr-19	$2,500
1.9	Minor Structure Inspection (Winter and post storm)	30-Sep-19	$2,500
1.10	Coastal Protection Structure Inspection (Yearly and post storm)	04-Nov-19	$3,500
1.11	Geophysical Assessment (D, BP, SB)	11-Feb-19	$75,000
Year 2	**2020**		**$82,000**
2.1	Beach Transect Survey (Summer)	02-Mar-20	$3,500
2.2	Beach Transect Survey (Winter)	31-Aug-20	$3,500
2.3	Storm Bite Analysis (post storm)	01-Jan-20	$1,500
2.4	Photo Monitoring (Summer and post storm)	02-Mar-20	$2,500
2.5	Photo Monitoring (Winter and post storm)	31-Aug-20	$2,500
2.6	Minor Structure Inspection (Summer and post storm)	06-Apr-20	$2,500
2.7	Minor Structure Inspection (Winter and post storm)	31-Aug-20	$2,500
2.8	Coastal Protection Structure Inspection (Yearly and post storm)	02-Nov-20	$3,500
2.9	Detailed Flood Study (GTC)	10-Feb-20	$60,000
Year 3	**2021**		**$26,000**
3.1	Beach Transect Survey (Summer)	01-Mar-21	$3,500
3.2	Beach Transect Survey (Winter)	30-Aug-21	$3,500
3.3	UAV Survey (2 Yearly)	29-Mar-21	$4,000
3.4	Storm Bite Analysis (post storm)	01-Jan-21	$1,500
3.5	Photo Monitoring (Summer and post storm)	01-Mar-21	$2,500
3.6	Photo Monitoring (Winter and post storm)	30-Aug-21	$2,500
3.7	Minor Structure Inspection (Summer and post storm)	05-Apr-21	$2,500
3.8	Minor Structure Inspection (Winter and post storm)	30-Aug-21	$2,500
3.9	Coastal Protection Structure Inspection (Yearly and post storm)	01-Nov-21	$3,500
Year 4	**2022**		**$22,000**
4.1	Beach Transect Survey (Summer)	28-Feb-22	$3,500
4.2	Beach Transect Survey (Winter)	01-Aug-22	$3,500
4.3	Storm Bite Analysis (post storm)	03-Jan-22	$1,500
4.4	Photo Monitoring (Summer and post storm)	28-Feb-22	$2,500
4.5	Photo Monitoring (Winter and post storm)	05-Sep-22	$2,500
4.6	Minor Structure Inspection (Summer and post storm)	04-Apr-22	$2,500
4.7	Minor Structure Inspection (Winter and post storm)	05-Sep-22	$2,500
4.8	Coastal Protection Structure Inspection (Yearly and post storm)	31-Oct-22	$3,500
Year 5	**2023**		**$41,000**
5.1	Beach Transect Survey (Summer)	06-Mar-23	$3,500
5.2	Beach Transect Survey (Winter)	31-Jul-23	$3,500
5.3	UAV Survey (2 Yearly)	27-Mar-23	$4,000
5.4	Storm Bite Analysis (post storm)	02-Jan-23	$1,500
5.5	Photo Monitoring (Summer and post storm)	06-Mar-23	$2,500
5.6	Photo Monitoring (Winter and post storm)	31-Jul-23	$2,500
5.7	Minor Structure Inspection (Summer and post storm)	03-Apr-23	$2,500
5.8	Minor Structure Inspection (Winter and post storm)	04-Sep-23	$2,500
5.9	Coastal Protection Structure Inspection (Yearly and post storm)	30-Oct-23	$3,500
5.10	CHRMAP Review	07-Aug-23	$15,000
TOTAL	**Cost for All Activities over 5 Years (2019-2023)**		**$273,500**

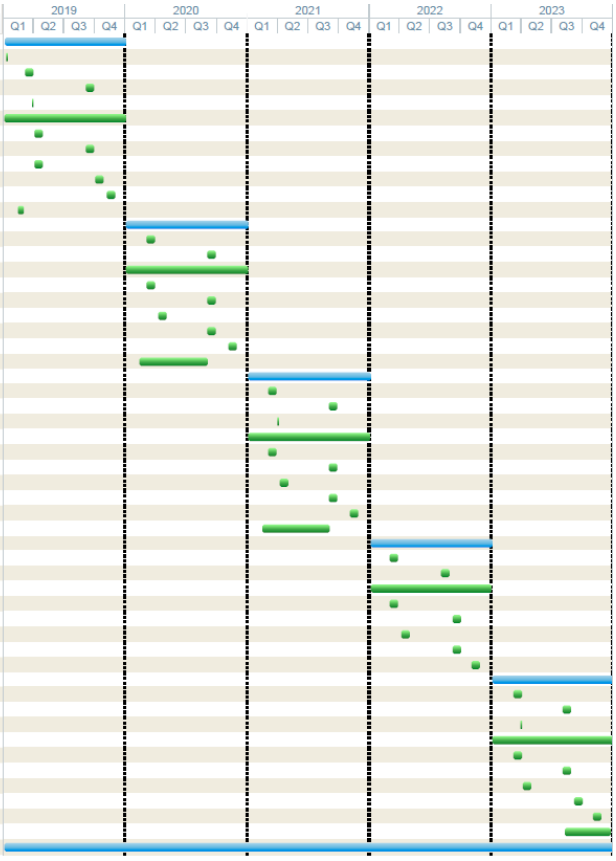

Figure E.3: Proposed Implementation Plan for Monitoring and Additional Studies

There are a number of funding streams that could be used to support the cost of the planned monitoring process and detailed studies recommended as outlined in Section 15. Opportunities to involve local community groups or schools in the monitoring process should be sought, to foster opportunities for local based groups to be involved and take ownership of developing the understanding of both coastal hazard and coastal adaptation.

The CHRMAP process is a continual process that will be revised regularly in the future to ensure its recommendations are meeting the goal of addressing the identified coastal hazard risks. As the understanding of coastal processes through Geraldton improves over time and dynamic coastal areas change under general conditions and extreme events, there will be a need to update the CHRMAP document to maintain its relevance. The first review of the CHRMAP is scheduled within 5 years and all the priority studies and monitoring summarised in Figure E.3 should be completed prior to that review. Ongoing review after that time should every be 5 or 10 years depending on risk and changes in shoreline and sea level rise projections.

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Abbreviations Table

BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CGG	City of Greater Geraldton
DPLH	Department of Planning Lands and Heritage
LCPP	Local Coastal Planning Policy
MCA	Multi-Criteria Assessment
SPP2.6	State Coastal Planning Policy 2.6

1. Introduction

1.1 Overview

The City of Greater Geraldton (CGG) is approximately 420km north of Perth, with a population of approximately 40,000 people. The town area extends along the coast, north and south of the town centre over approximately 30km of coast. The Town Centre incorporates the Port of Geraldton, recreational and commercial marina precincts, and a developed foreshore area around the town beaches.

The shoreline areas in the city centre are highly modified, with coastal structures in place to protect the port and town beaches, which inhibit the natural flow of sediment to the north. The natural shorelines outside the city are highly dynamic with many of the areas north of the City (the northern beaches) experiencing erosion, while coastal areas on the south are generally accreting, fed by the Southgate dunes system.

The City recently completed coastal inundation and coastal processes studies (MRA 2015, 2016, 2017) to understand the risk posed by coastal erosion and storm surge inundation processes, under climate change and sea level rise projections for the next 100 years, which confirmed:

- Coastal areas north of the City are *currently* experiencing severe coastal erosion pressures, as shorelines are eroded and move landward (e.g. Drummond Cove, Sunset Beach, Bluff Point). Under projected climate change scenarios and sea level rise, erosion is forecast to increase for these coastlines;
- Coastal areas south of Point Moore (Mahomet Flats, Tarcoola Beach to Cape Burney) historically show long term accretion, with the Southgate dunes providing a sediment source for the region, which is transported north to Point Moore under the dominant longshore transport process. The Southgate dunes is expected to continue to provide sediment to the system for approximately the next 50 years after which time erosion of shorelines is forecast to occur; and
- Coupled with the erosion threat, the sea level is forecast to rise by 0.4m by 2070 and 0.9m by 2110, which will increase the likelihood of flooding for low lying sections of the City during extreme weather events. This inundation risk is most significant for the Geraldton Town Centre and Point Moore.

The findings of the studies are important to consider in the context of planning needs and siting of infrastructure by the City in the future. In accordance with Western Australia's State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6), coastal areas identified as being at risk of coastal hazard require CHRMAP, to ensure that the identified coastal hazard is factored into decision-making by the City in its land use planning in the future.

The CHRMAP project for Geraldton was developed in consultation with CGG, the local community and a range of stakeholders, to provide a range of recommendations to guide decision making by the City in terms of the location and maintenance of its coastal infrastructure and provide guidance for the development of statutory planning controls. The stages of the CHRMAP project have involved:

- The initial stages of the Geraldton CHRMAP project involved community and stakeholder engagement and a risk based assessment was completed, which examined the City's coastline from Drummond Cove to Cape Burney in 12 Coastal Management units (CMU) to analyse coastal assets under threat from erosion and inundation in future planning timeframes (refer Figure 2.1). The outcomes of this initial CHRMAP phase were reported in the Coastal Hazard and Risk Assessment report (Baird, 2018).
- In this current report, Coastal Adaptation Planning recommendations are presented for the CMU's, using the coastal hazard information and risk rating results from Baird (2018). Coastal adaptation strategies are recommended that can deliver appropriate levels of response to immediate threats, and that can be adjusted to respond to changes in the future as risk of coastal erosion and inundation increase. Coastal adaptation responses to mitigate coastal hazard have been identified in each of the CMU's, underpinned by economic analysis of the alternatives at key locations.

Currently, the City is in Stage 2 of a 4-stage process to develop a policy which will guide actions to be taken when and if coastal assets become at risk of erosion or inundation. At the completion of Stage 2, the CHRMAP will make a series of recommendations on adaptation approaches and planning based strategies that can address the identified risk in the City's coastal areas. In Stages 3 and 4, the City will be required to formally develop its Local Coastal Planning Policy (LCPP) which will determine the planning approaches and adaptation strategies it will adopt to manage risk in its coastal areas.

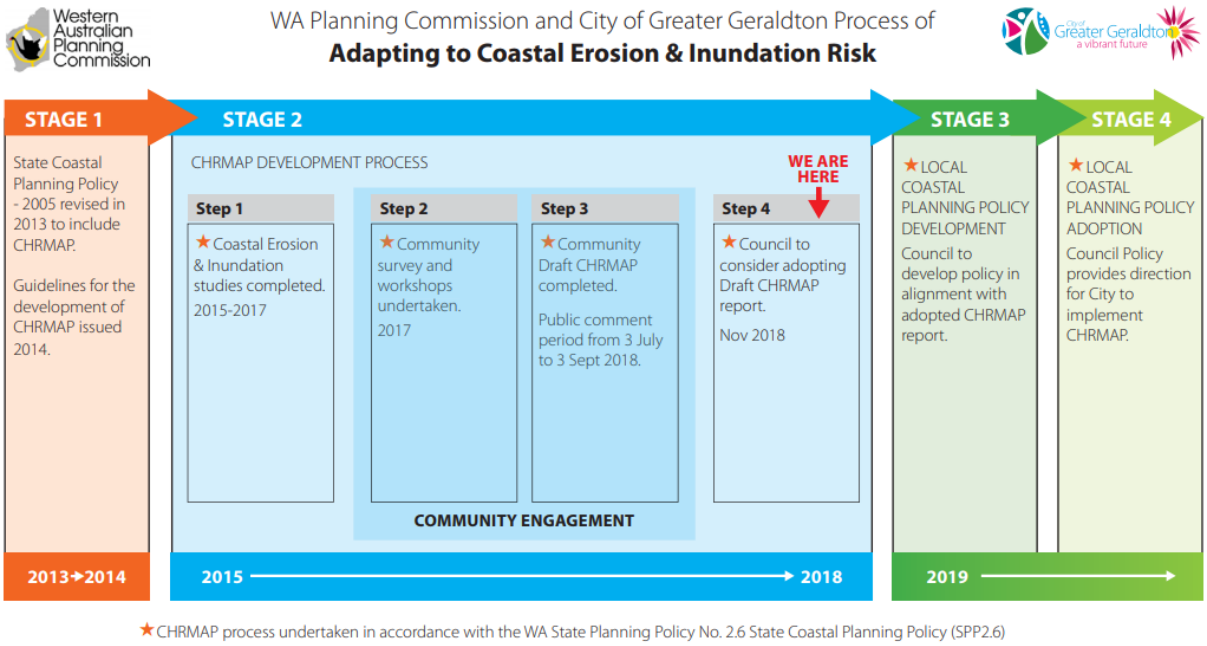

Figure 1.1: Flowchart showing project timeline in November 2018 (CGG2018)

1.2 Document Format

The format of document sections is as follows:

- Section 2: Coastal Hazard Risk Management and Adaptation Overview
- Section 3 to Section 14: Coastal Adaptation by Coastal Management Unit
  - Drummond Cove
  - Glenfield
  - Sunset Beach
  - Bluff Point
  - Geraldton Centre
  - West End / Point Moore
  - Beachlands
  - Mahomet Flats
  - Tarcoola Beach
  - Southgate Dunes
  - Cape Burney
- Section 15: Implementation Summary
- Section 16: Summary and Recommendations

2. Coastal Hazard and Risk Assessment Overview

2.1 Coastal Hazard

The coastal erosion mapping and coastal inundation mapping for future planning periods is presented in **Appendix A.1** and **Appendix A.2** respectively. These form the basis of the risk assessment which was completed for the 12 coastal management units (CMU) delineated along the Geraldton Coast (Figure 2.1).

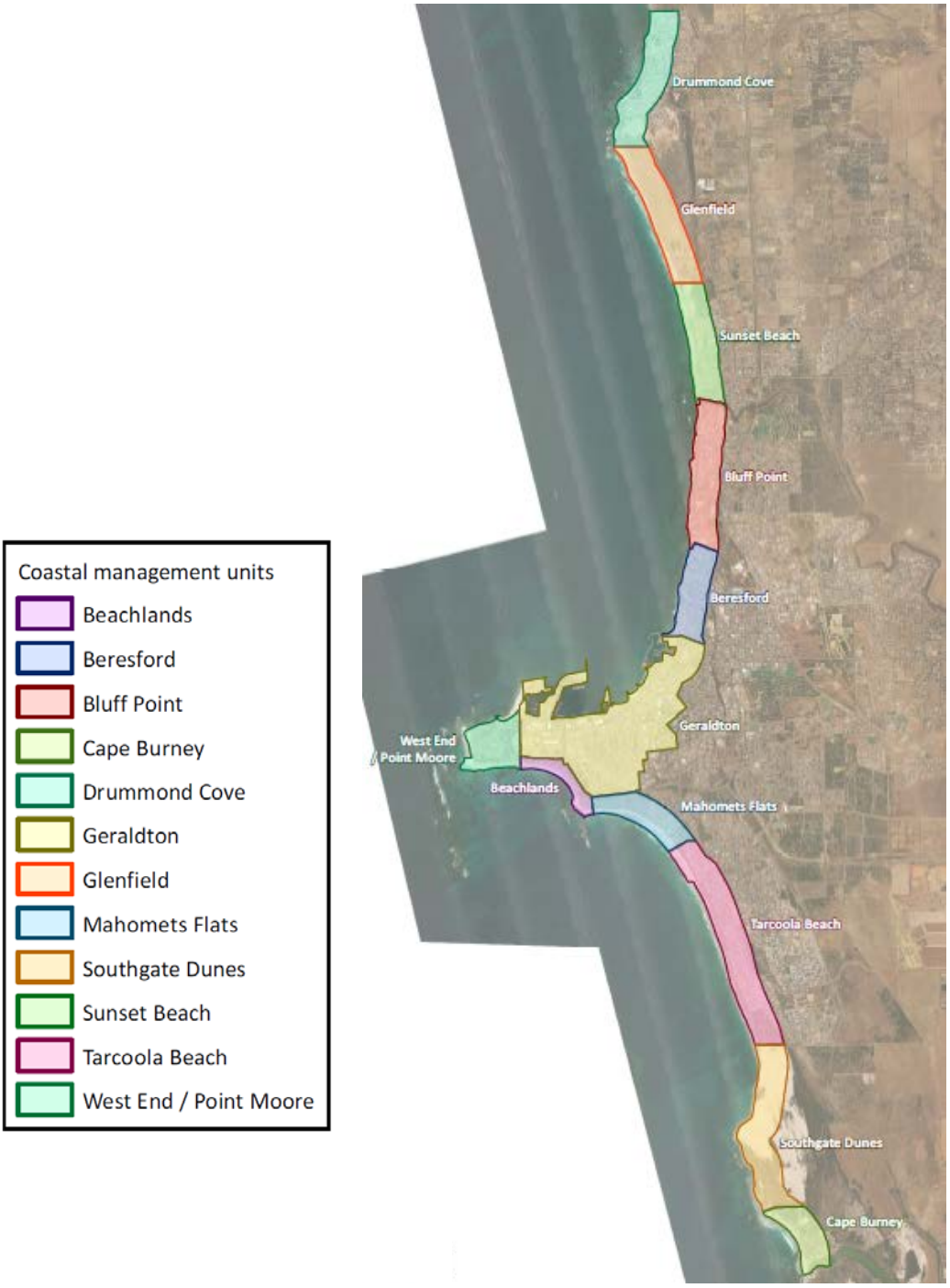

Figure 2.1: Coastal Management Units

2.2 Risk Assessment Process Summary

The Geraldton CHRMAP risk assessment was delivered in accordance with local and national guidelines and standards (WAPC2014, AS5334-2013). Coastal assets and land use categories in Geraldton's coastal areas are shown in **Appendix A.3**. The risk assessment process and outcomes reported in Baird 2019, provide a summary of the key coastal assets in Geraldton's coastal areas at risk of erosion and inundation in the immediate short term (to 2030) and long term (2070, 2110).

In summary, the risk assessment completed for Geraldton's coastal areas in Baird 2019 examined:

1. Coastal hazard from erosion and inundation in future planning periods;
1. Key coastal infrastructure and assets at risk from coastal hazard in Geraldton's coastal areas;
2. Community and cultural values of the coastal zone;
3. Likelihood and consequence of coastal hazard impact;
4. Adaptive capacity of coastal assets affected by inundation and erosion; and
5. Priority coastal assets identified in the community engagement process.

From the risk assessment in Baird 2019, the rating for each of the coastal assets was determined (Low, Medium, High or Extreme). For CHRMAP, coastal assets rated in the High and Extreme risk categories, require adaptation approaches to address the risk and move the risk rating down to an acceptable level. The risk framework generally follows the CGG standard risk framework (CGG 2015), though it is noted the adaptive capacity is an additional consideration beyond the CGG framework, which increases the overall risk rating for assets with low adaptive capacity such as houses.

2.3 Risk Management and Adaptation

2.3.1 Community Values

The community and stakeholder engagement for the Geraldton CHRMAP was designed to gain an understanding of the community values in the coastal areas and guide development of adaptation options that can meet the objective of mitigating coastal hazard risk and that are supported by the general community (Baird 2019).

2.3.2 Adaptation Hierarchy

The risk management and adaptation hierarchy (WAPC2014) provides a platform for decision making that aims to build coastal resilience and maintain flexibility for future decision makers in coastal areas. The hierarchy is built on a tiered approach of adaptation response as presented in Figure 2.2.

Figure 2.2: Risk Management and Adaptation Hierarchy (WAPC 2014)

There are four broad categories of potential adaptation options in Figure 2.2 (WAPC 2014):

1. **Avoid**: avoid new development in areas at risk of coastal hazard;
2. **Planned or Managed Retreat**: allow existing development until coastal impacts arise. Relocate or remove assets within an area identified as likely to be subject to intolerable risk of damage from coastal hazards over the planning time frame;
3. **Accommodate**: If sufficient justification can be provided for not avoiding development of land that is at risk from coastal hazards then Accommodation adaptation measures should be provided that suitably address the identified risks. Can involve design and/or management strategies that render the risks from the identified coastal hazards acceptable for example design of assets to withstand the impact of coastal hazard; and
4. **Protect**: where sufficient justification can be provided for not avoiding the use or development of land that is at risk from coastal hazards and accommodation measures alone cannot adequately address the risks from coastal hazards then coastal protection works may be proposed where there is a need to preserve the foreshore reserve, public access and public safety, property and infrastructure that is not expendable.

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

2.4 Adaptation Options Toolbox

A range of adaptation tools available to mitigate coastal risk applied in the CHRMAP under the Avoid-Managed Retreat -Accommodate-Protect categories is summarised in Table 2.1. A full description of the options is provided in **Appendix A.4**.

Adaptation options in Table 2.1 have been developed from a range of sources including WAPC 2014 and the National Climate Change Adaptation Research Facility (NCCARF) Coast Adapt tools, as well as incorporating options provided through the community involvement in the CHRMAP workshops.

2.4.1 Nature Based Adaptation Options – Building Resilience

It is noted that there are a range of ‘soft protect’ or nature-based solutions that can be applied to increase the resilience of shorelines under threat from coastal erosion. Examples include dune management, sand fences and coastal revegetation. The use of geotextiles and beach nourishment are also considered in these terms in this report as these are not traditional ‘hard’ engineering solutions. These approaches have been categorised as ‘Temporary Protect / Improve Resilience’ measures in the Toolbox of options listed in Table 2.1.

It is noted that the City has been active in developing site specific Temporary Protect / Improve Resilience measures to increase the resilience of its shorelines with many examples of approaches including sand fences and revegetation programs through its coastal areas, coupled with dedicated measures applied at Bluff Point (geotextile groynes) and Drummond Cove (sand nourishment). It is assumed that measures aimed at building resilience in the foreshore areas at risk of erosion will continue to be undertaken by the City and community in future.

Table 2.1: Adaptation Options Toolbox Summary for Risk Mitigation of Coastal Assets

	Code	Adaptation Type	Applicable
Avoid	Av.1	Setback Controls	Erosion and Inundation
Managed Retreat	MR.1	Leaving Assets Unprotected	Erosion and Inundation
	MR.2	Removal of Assets	Erosion and Inundation
	MR.3	Prevent Further Development	Erosion and Inundation
	MR.4	Land Swap	Erosion and Inundation
Accommodate	Ac.1	Notification on Title	Erosion and Inundation
	Ac.2	Building Design	Inundation
	Ac.3	Emergency Evacuation	Inundation
	Ac.4	Appropriate Finished Floor Levels	Inundation
	Ac.5	Filling Land	Inundation
Temporary Protect / Improve Resilience	TPIR.1	Coastal Re-Vegetation	Erosion
	TPIR.2	Dune Management	Erosion and Inundation
	TPIR.3	Beach Nourishment	Erosion
	TPIR.4	Geotextile Sand Bags – Groynes and Seawalls	Erosion
Protect	Pr.1	Groynes	Erosion
	Pr.2	Seawalls	Erosion
	Pr.3	Flood Mitigation Structure	Erosion and Inundation
	Pr.4	Artificial Reefs	Erosion

2.5 Current and Historical Examples of Adaptation Approaches in the City's Coastlines

Responding to the threat from coastal erosion is already a significant focus for the City and one that will increase in magnitude in the future as the community is faced with responding to increased loss of coastal infrastructure, houses and businesses.

There are many current and historical examples of coastal management and adaptation approaches throughout the CGG coastal areas, as summarised in Table 2.2. The CGG and the local community have led coastal adaptation and management for its coastal areas over a long period of time, and in the future the continued active involvement to respond to coastal risk from erosion and inundation will be required under forecast climate change and sea level rise.

Table 2.2: Existing Coastal Adaptation Measures - Summary by Coastal Management Unit

CMU	Examples of Adaptation Response to Erosion Pressure
Drummond Cove	Managed Retreat of houses west of Whitehill Rd. the last house was removed in 2017 and the land has been returned to foreshore reserve. Rock Wall built in front of Community Hall (2014) Closure of Whitehill Rd due to erosion (2015) Sand nourishment of closed section of Whitehill Rd to provide temporary protection against coastal erosion (2015-2018)
Glenfield	Undeveloped
Sunset Beach	Managed Retreat of Triton Ave Toilet Block (2017) Managed Retreat of Fencing, signage, pathways, road from upper foreshore Caravan Park Lease has a Managed Retreat Trigger, once erosion reaches an agreed distance from the boundary Sand Fencing and Revegetation
Bluff Point	St Georges Beach Geotextile Groyne Structure (2016) St Georges Beach Sand Fencing and Revegetation Bluff Point Revegetation Projects
Beresford	Revetment Structures completed 2018 (800m total) Tombola Structure Midalia's Beach renourishment and reprofiling (2018) Ongoing Sand Nourishment (from Pages Beach) as part of Northern Beaches Program (GPA)
Geraldton Town Centre	Protection structures in place around the port and Batavia Coast Marina Buried Seawalls, groynes along all town beaches Ongoing Sand Nourishment (from Pages Beach) as part of Northern Beaches Program (GPA)
Point Moore / West End	Leasehold agreements finalised in 2017 have Managed Retreat Conditions in place Seawall constructed in 2013 south side of Point Moore (Greys Beach) Sand Fence placed in the shoreline in front of Seawall south side of Point Moore
Beachlands	Sand Fencing and Revegetation
Mahomet Flats	Sand Fencing and Revegetation
Tarcoola Beach	Sand Fencing and Revegetation
Southgate Dunes	Undeveloped
Cape Burney	Sand Fencing and Revegetation

2.6 Adaptation Strategy

Within each of the Coastal Management Units (CMU), the adaptation approach to manage risk is reported in detail in the Sections to follow. The format is that each CMU is reported separately, with a summary of the adaptation outcomes and recommendations, followed by the adaptation management detail.

For CHRMAP there are two key asset groupings:

1. Coastal Infrastructure: It is inevitable that the City's coastal infrastructure (such as access paths, roads, beach shelters, coastal foreshore parks and amenities) will be located in the direct path of the identified erosion threat. In practice, as coastal erosion occurs the retreat or re-siting of these minor structures is undertaken by the City on an as needs basis (this is already undertaken by CGG in places such as Sunset Beach).
2. Residential / Commercial Development: Coastal erosion is forecast to impact vacant property, existing houses and businesses which are currently set back from the coast but could be directly in the path of coastal erosion as it is realised in future planning periods. Similarly, properties located in low lying areas of the coast will be at increasing risk of inundation under projected sea level rise scenarios (0.4m by 2070 and 0.9m by 2110).

In general, the council infrastructure in coastal areas will continue to be used under a managed retreat scenario. This allows continued use of the infrastructure until such time as it is unsafe or un-useable at which time asset removal is required, or where maintenance costs consistent with the design life of the structure may be required.

For residential and commercial development, the general adaptation strategy developed in the CHRMAP is summarised for each of the CMU in Table 2.3 based on the adaptation hierarchy.

Table 2.3: General Coastal Adaptation Strategy by Coastal Management Unit

CMU	Erosion	Inundation
Drummond Cove	Managed Retreat / Accommodate	Accommodate
Glenfield[1]	Avoid	Accommodate
Sunset Beach	Managed Retreat / Accommodate	No Risk
Bluff Point	Managed Retreat / Accommodate	Accommodate
Beresford	Protect -Structures in Place	Accommodate
Geraldton Town Centre	Protect -Structures in Place	Accommodate
Point Moore / West End	Managed Retreat / Accommodate	Accommodate / Managed Retreat
Beachlands	Managed Retreat / Accommodate	Accommodate
Mahomet Flats	Managed Retreat / Accommodate	Accept Risk (minimal)
Tarcoola Beach	Managed Retreat / Accommodate	Accommodate (minimal)
Southgate Dunes	Avoid	Accept Risk (minimal)
Cape Burney	Avoid	Accept Risk (minimal)

Notes: 1. Water Treatment Plant is a Water Corp. asset that is located within the 2110 coastal erosion setback allowance. It is recommended that this will continue operation under a managed retreat scenario.

2.7 Economic Framework

The economic framework for the CHRMAP is detailed in **Appendix A.5**. A detailed economic evaluation of adaptation options was completed at key locations in Drummond Cove, Bluff Point and Geraldton Town Centre to support the CHRMAP process and involved:

- Determining economic value of assets at risk to coastal hazards;
- Determining the current and future annual cost of hazards to susceptible assets in the CGG Coastal Zone;
- Determining the cost of options to mitigate coastal hazards; and
- Economic evaluation of reduction in costs of hazards to susceptible assets as a result of mitigation options.

The evaluation of the adaptation options task had two key components:

- Multi-Criteria Analysis (MCA); and
- Cost Benefits Analysis (CBA).

From the toolbox of adaptation options available (Table 2.1), a suite of preferred adaptation options has been determined within each of the CMU. The multi-criteria analysis and cost benefit analysis was used to evaluate the adaptation recommendations at specific locations, with full detail provided in the Economic **Appendix A.5**.

3. Drummond Cove (CMU1)

3.1 Adaptation Summary and Recommendations

The Drummond Cove CMU extends across 2.5km shoreline at the northern end of the Geraldton study area. The projected coastal erosion is shown in Appendix A.1, and inundation hazard mapping in Appendix A.2 with a summary of the coastal hazard for the CMU provided as follows:

- The section of coast is presently eroding at a rate of between 0.4m (in the south) and 2.0m (north) annually (MRA 2016). The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates there are a significant number of coastal assets at risk of erosion under the projected coastal erosion scenarios including:
  - Residential property;
  - Undeveloped residential or commercial land;
  - Community Hall and associated infrastructure (skate ramp, playground, tennis court)
  - Roads (Whitehill Rd, Surfside Terrace) and Carparks (Community Hall and Smugglers);
  - Foreshore infrastructure (toilets, shelters, benches, fencing);
  - Utilities (Water Corp. etc); and
  - Dunes and beaches.
- Coastal inundation risk from large storm events and sea level rise is shown in Appendix A.2 for the 500yr ARI event in 2110. The inundation risk is generally contained within the foreshore areas and foreshore reserve with some properties identified as being at risk of inundation in future planning periods:
  - The number of residential and commercial properties which are within the 500yr ARI inundation extent for respective planning periods in the CMU is forecast as 18 properties at year 2030, 27 properties at year 2070 and 56 properties at year 2110.

Coastal hazard risk management and adaptation planning (CHRMAP) has been completed for the assets identified as being at risk in the CMU (Baird 2019). Risk mitigation strategies have been determined from options in the coastal adaptation hierarchy of Avoid, Managed Retreat, Accommodate or Protect.

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

Residential and Commercial Development

- Planning policies will need to be updated as follows:
  - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
  - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or inundation;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP;
- The coastal erosion hazard in the CMU is forecast to impact 0 properties by 2030 (Extreme Risk), 98 properties in the 2030 to 2070 period (High Risk) and 187 properties in the 2070 to 2110 period (moderate Risk). To manage erosion risk for these properties the LCPP will provide recommendation to:

- Avoid development of vacant residential land within the identified 2110 coastal erosion hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve is provided (refer SPP2.6)
- Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level. Summary of risk for properties in the CMU
  - Extreme: 0 properties
  - High: 98 properties. **Accommodate** erosion risk with Section 70a notification on Title, Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines required.
  - Moderate: 187 properties. **Accommodate** erosion risk with Section 70a notification on Title, 5 yearly Review of shoreline and updated site-specific assessment of future shoreline hazard lines.

Note: 'properties' includes all built and vacant residential and commercial blocks.

CGG coastal infrastructure:

- The general approach for minor infrastructure within the CMU is **Managed Retreat**. Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;
- The coastal protection structure in front of the Community Hall should be maintained consistent with the design life of the structure. Note the coastal protection feature is not recognised as a long-term commitment for this section of the CMU;
- A number of adaptation options were considered in the CHRMAP economic assessment (Appendix A.5) for protection of the shoreline along the closed section of Whitehill Rd. The analysis of alternatives showed a combination of geotextile groynes backed by a seawall could deliver a net return on investment when taking into account the value of the property and public land that is protected over the immediate timeframe (next 30 years). These coastal assets are rated at High risk in the present to short term (to 2030) timeframe and increase to Extreme risk thereafter. The high value of property at risk of erosion in future planning periods and the values of the coast noted in the Community Engagement process underline the importance of this issue. On this basis, it is recommended that a coastal protection option for Drummond Cove, north of the Community Hall in front of the closed section of Whitehill Rd warrants further assessment.

Monitoring and Management

- Recommend a geophysical study of the shoreline areas is undertaken to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term;
- The foreshore reserve area offers a crucial natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Active monitoring and nature-based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are strongly recommended. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 3.1, based on the risk assessment process completed (Baird 2019). The assets presented in Table 3.1 are those identified at High or Extreme risk over the 100-year planning period, with the full list of assets assessed described in Baird 2019. The adaptation timelines in Table 3.1 are based on projected erosion setback lines (Appendix A.1) and timeframes indicated for moving from one adaptation approach to the next in the hierarchy (i.e. from Managed Retreat to Avoid) is based on the future rate of erosion. The erosion trigger point will be the focus of future monitoring actions recommended (Section 15).

Table 3.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Drummond Cove CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Non-Infill Developable land within 2110 Erosion Extent	AVOID								
Property in 2030 to 2070 Erosion Setback extent (e.g. Whitehill Rd, Surfside Tce)	ACC./ MONITOR	ACCOMMODATE / MAN.RETREAT							
Property in 2070 to 2110 Coastal Erosion Setback	ACC / MONITOR				ACC / MAN.RETREAT				
Community Hall and Associated Infrastructure	MON.	MANAGED RETREAT							
Roads (Whitehill Rd)	MON	MAN.RET	AVOID						
Roads (Surfside Terrace)	MON	MAN.RET	AVOID						
Carpark Smugglers Rest	MON	MAN.RET	AVOID						
Dunes	MONITOR and BUILD RESILIENCE (Nature Based Options)								
Foreshore Reserve	MONITOR and BUILD RESILIENCE (Nature Based Options)								

Note: low value CGG assets (e.g. bollards, fencing) were included in the risk assessment in Baird 2019 but the overall risk rating is low or moderate due to their value, and these have not been included in the table above.

The assets at highest risk in the CMU are summarised in Table 3.2, with the adaptation approaches that are recommended to manage the risk.

Table 3.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner[1]	Measure to Address Risk
Property in 2030 to 2070 Erosion Setback extent (e.g. Whitehill Rd, Boat Cove, Estuary Way, Waterfront Circuit, Stillwater Ave)	M	H	E	E	Private	City to establish Special Control Area (SCA) and a Local Coastal Planning Policy (LCPP) will provide guidance on development standards which must be met to respond to the risk of coastal erosion and / or inundation.
Property located in 2070 to 2110 Coastal Erosion Setback extent (e.g. Stillwater Ave, Tailer Street)	M	M	H	E	Private	
Community Hall	H	E	E	E	CGG	Managed retreat trigger - Allow

Beach Shelters	M	M	H	H	CGG	continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Skate Park, Tennis Court	H	H	E	E	CGG	
Community Hall Carpark	H	E	E	E	CGG	
Carpark Smugglers Pass	M	H	H	E	CGG	
Informal Boat Launch	M	H	H	H	CGG	
Roads – Whitehill Rd	M	H	E	E	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Roads –Surfside Terrace	M	H	E	E	CGG	
Beaches	M	M	H	H	Community	Monitor erosion, build resilience through temporary protection and nature-based approaches (revegetation programs, sand trapping etc)
Dunes	H	E	E	E	Community	
Foreshore Reserve	M	H	H	E	Community / CGG	

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

There are a range of utilities infrastructure that are affected by coastal erosion risk through the CMU. Based on the mapping presented in Appendix A.3:

- There is one Water Corp. pump station located in the present - 2030 erosion hazard, and one located in the 2030-2070 coastal erosion hazard extent;
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling and Telstra infrastructure (including conduits, cables, pillars, pits) located in the 2030-2070 and 2070-2110 coastal erosion hazard extent.

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk.

There are a range of utilities infrastructure that are affected by coastal inundation risk through the CMU. Based on the mapping presented in Appendix A.3:

- There are two Water Corp. pump stations located in the design flood extent (500yr ARI inundation in year 2110).
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling and Telstra infrastructure (including conduits, cables, pillars, pits) located in the design flood extent (500yr ARI inundation in year 2110).

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their inundation risk.

3.2 Drummond Cove Coastal Hazard

3.2.1 Coastal Erosion Hazard

The Drummond Cove CMU is experiencing significant erosion pressures, most notably along its northern extent. Increased erosion of the foreshore in the section of coast immediately north of the Community Hall in the past 5 years has resulted in the closure of Whitehill Rd (Figure 3.1). This section of coast has continued to face erosion pressure and the CGG has undertaken periodic sand nourishment to prevent further shoreline loss.

Figure 3.1: Drummond Cove Whitehill Road Looking North. Upper Left Image - April 2014, Upper Right Image - May 2016 (NACC Photomon), Lower Image - May 2018 Beach nourishment following TC Marcus.

Through the central section of the CMU the Community Hall and associated infrastructure (car parks, playground, tennis court, shelters, BBQs etc) are protected by a rock seawall constructed in approximately 2014 by the CGG, following a significant erosion event (Figure 3.2). It is noted that the rock structure was not formally designed, and whilst it has been effective in preventing further landward erosion of the

shoreline in front of the Community Hall, the severe erosion problems of the beach to the north (Figure 3.1) have potentially been exacerbated.

The section of coast to the south of the Community Hall, has now been returned to foreshore reserve (Figure 3.3). Previously this area was occupied by residential dwellings, which dated back to the original settlement of Drummond Cove. Over recent years, the residents have been removing habitable structures and vacating the land under a managed retreat scenario (due to erosion risk), a process led by the CGG which provided incentives (e.g. land swap / discounts) in the newer development areas of Drummond Cove. Additional detail on this process is provided in Section 15.

It is noted that the erosion hazard for the CMU assumes that the coastal areas are sandy shorelines, where underlying rock will not offer protection against coastal erosion processes. A geophysical study of the critical shoreline areas to examine presence of rock strata is recommended to improve the confidence in the coastal erosion setback extents in future planning periods.

Figure 3.2: Drummond Cove seawall in front of Community Hall (looking south)

Figure 3.3: Foreshore Reserve created south of Community Hall. Photo taken in June 2017 prior to the final habitable structure being removed.

3.2.2 Coastal Inundation Hazard

The inundation hazard for the Drummond Cove CMU is shown as depth associated with the 500yr ARI inundation event in the planning year 2110, in Appendix A.2. The inundation mapping shows the risk of inundation in extreme events impacts the foreshore reserve and public open space areas. The Community Hall and associated infrastructure is at risk of inundation with depth of flooding to 0.5m. For the lower lying section of Whitehill Road south of Hester Street, there is inundation risk to properties for 0.5m to 1m depth of flooding.

3.3 Drummond Cove Coastal Adaptation

3.3.1 General Adaptation Strategy

Coastal adaptation approaches have been considered in the Drummond Cove CMU through four sections, based on consideration of the key assets at risk, coastal features and timing of coastal hazard impact. The sections are shown in Figure 3.4, and ordered north to south in the CMU as follows.

- Section 1. Whitehill Rd – between Drummond Cove Rd and Community Hall
- Section 2. Community Hall to Seacrest Way
- Section 3. Seacrest Way to Surfside Terrace
- Section 4. Surfside Terrace

Figure 3.4: Drummond Cove CMU – Coastal Adaptation Sections (image Google Earth)

A summary of the erosion risk for the Drummond Cove CMU is presented in Table 3.3, with general adaptation strategies recommended through the CHRMAP process.

Table 3.3: Coastal Adaptation Summary – Drummond Cove CMU, Erosion Risk

Location	Length	Key Considerations	Adaptation Strategy
Section 1. Drummond Cove Road to Community Hall	Length 450 m	Historically observed rate of erosion calculated 2.0 m annually from recent aerial imagery (MRA 2016) Whitehill Rd Closed from north of Community Hall. Periodic sand nourishment and reshaping of shoreline undertaken by CGG to slow rate of erosion. Houses in Boat Cove, Estuary Way, Waterfront Circuit, Stillwater Ave (west side) forecast erosion impact 2030-2070. Public open space and environmental conservation areas at the foreshore, forecast erosion impact current - 2030	**Managed retreat** recommended for CGG infrastructure. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion • **Avoid** development of vacant residential land within the SCA not classified as Infill under SPP2.6. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level A geophysical study of the critical shoreline areas to examine presence of rock strata is recommended. Increase resilience of shoreline through temporary protect and resilience building measures designed to maintain the buffer to coastal processes for areas landward. Annual Shoreline monitoring to track rate of erosion. Short term – continued beach nourishment, moving to longer term solution (Either Managed Retreat or Protect)
Section 2. Community Hall to Seacrest Way	Length 550 m	Historical rate of erosion is 2.0 m annually for Community Hall section of coast (MRA2016) and 0.95m annually (MRA2016) for southern foreshore reserve (south of Hester Street). Community hall and associated assets (carpark, playground, BBQs etc) cited as highly valued by community. Shoreline protection in front of the Community Hall is not assumed to be maintained in future periods - all infrastructure considered at erosion risk in current to 2030 period. Whitehill Road forecast erosion impact 2030. Houses Whitehill Rd and Hester Street, forecast erosion impact 2030-2070.	**Managed retreat** recommended for CGG infrastructure. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion • **Avoid** development of vacant residential land within the SCA not classified as Infill under SPP2.6. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level A geophysical study of the critical shoreline areas to examine presence of rock strata is recommended. Maintain rock protection of shoreline currently in place in front of Community Hall through minor repair and maintenance. Longer term once seawall structure fails, **Managed Retreat.**

Location	Length	Key Considerations	Adaptation Strategy
		Foreshore reserve area south of Community Hall provides coastal buffer ranging in width from 50-70 m (to Seacrest Way).	Increase resilience of foreshore reserve area through targeted revegetation programs, designed to maintain the buffer to coastal processes for areas landward. Shoreline monitoring to track rate of erosion and identify critical locations (erosion hotspots)
Section 3. Seacrest Way to Surfside Terrace	Length 800 m	Historically observed rate of erosion is 0.95m annually. Houses in Whitehill Rd and Surfside Terrace forecast erosion impact in 2030 – 2070 timeframe Erosion forecast to impact Smugglers Car Park, Whitehill Rd and Surfside Terrace 2030-2070. Dune system and coastal buffer ranging in width from 60-200 m.	**Managed retreat** recommended for CGG infrastructure. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion • **Avoid** development of vacant residential land within the SCA not classified as Infill under SPP2.6. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level A geophysical study of the critical shoreline areas to examine presence of rock strata is recommended. Increase resilience of foreshore reserve through targeted revegetation programs Shoreline monitoring to track rate of erosion and identify critical locations (erosion hotspots)
Section 4. Surfside Terrace South	Length 700 m	Historically observed rate of erosion is 0.4m annually (i.e. lower than the shorelines to the north). Alignment of Coast varies, with NW and SW facing shorelines. Erosion forecast to impact southern end of Surfside Terrace and houses by 2070. Glenfield Beach Drive and SW edge of Glenfield Estate forecast erosion impact 2070-2110. Dune system and coastal buffer minimum 100m width.	**Managed retreat** recommended for CGG infrastructure. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion • **Avoid** development of vacant residential land within the SCA not classified as Infill under SPP2.6. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level Increase resilience of foreshore and dune areas, through targeted revegetation programs, designed to extend the timeline of natural buffer to coastal processes. Shoreline monitoring to track rate of erosion and identify critical locations (erosion hotspots)

A summary of the inundation risk for the Drummond Cove CMU is presented in Table 3.4 with general adaptation strategies recommended through the CHRMAP process.

Table 3.4: Coastal Adaptation Summary – Drummond Cove CMU, Inundation Risk

Location	Key Considerations	Adaptation Strategy
Section 1. Drummond Cove Road to Community Hall	Properties in Estuary Way • Flood immunity to 500yr ARI flood level in present day, 2030, 2070. • With projected sea level rise, will experience approximately 1m depth inundation in 2110 under the 500yr ARI event. Noted this is likely to be accounted for by freeboard height of property. Foreshore Reserve areas susceptible to inundation in future planning periods.	Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures (Section 15). Short term inundation of the foreshore reserve in large events is acceptable. Monitor for safety following impacts. Short term inundation of the dunes / beach and foreshore reserve in large events is acceptable. Monitor for safety following impacts. Minor flooding of road is an acceptable risk. Monitor for safety following impacts. Consider future raising of Whitehill Rd to provide flood protection for houses (timeframe is post 2070 based on assumed sea level rise)
Section 2. Community Hall to Seacrest Way	Inundation across the Community Hall section of coast and foreshore reserve south is 1m or less in the 500yr ARI event to 2070. For the 2110 500yr ARI event, flood depth of 1.3m through the section of coast. Flooding contained on west side of Whitehill Road to 2070, with flooding (1.1m) in section of the road south of Hester St in 2110 for the 500yrARI event. Inundation risk to houses in section of Whitehill south of Hester St in 2110 for the 500yrARI event. Flood depth of 1.2m to >1.7m for properties. Whitehill Rd acts as a flood control until approximately 2070 for these properties under assumed sea level rise.	
Section 3. Seacrest Way to Surfside Terrace	Inundation is contained within the Foreshore and dune areas and does not impact houses or roads over the planning period to 2110. Inundation risk for Smugglers car park (land level is approximately 2.0mAHD). In 500yr ARI event in present day would flood to approx. 1.7m depth, increasing to 2.1m depth in the 2070 period.	
Section 4. Surfside Terrace South	Inundation is mostly contained within foreshore and dunes. Minor flooding of Surfside Terrace in the 2110 planning period under assumed sea level rise. Potential for inundation on south side of Glenfield Estate in 2110 planning period. Noted the inundation mapping is based on land levels defined by NACC LiDAR March 2013, and additional fill may have been placed to raise land level since.	

3.3.2 Adaptation Approaches by Asset

A suite of adaptation approaches and recommendations to mitigate the erosion and inundation risk to assets in the Drummond Cove coastal compartment is summarised in Table 3.5. These have been

developed from the adaptation tools listed in the Avoid-Managed Retreat -Accommodate-Protect categories in Section 2.3.2.

Table 3.5: Adaptation Options – Drummond Cove CMU

Asset / Location	Erosion	Inundation
Existing Houses	**Accommodate / Managed Retreat** • Place notification on title (Ac.1) at redevelopment or time of sale • Subject to LCPP conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (Moderate, High or Extreme)	**Accommodate** inundation consistent with planning timeframes to 2110 through LCPP • Notification on title (Ac.1) • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.4) • Filling Land (Ac.5)
Infill Development (based on SPP2.6 Definition)	Allow infill development on vacant properties in the identified coastal hazard area of the SCA. Subject to LCPP conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme)	**Accommodate** inundation, dependant on inundation level of lot and based on planning horizon (Ac.1 Ac.2 Ac.4 Ac.5)
Undeveloped residential Land, South of Glenfield Estate (non-infill)	**Avoid** development in identified coastal hazard area (Av1).	Where practical **Avoid** development in identified coastal hazard area (Av1). **Accommodate** inundation, dependant on inundation level of lot and based on planning horizon (Ac.1 Ac.2 Ac.4 Ac.5)
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts Under long term sea level rise (2070 to 2110|) emergency planning for evacuation routes may be required (Ac.3)
Carparks	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Community Hall	Maintain rock protection of shoreline currently in place through minor repair and maintenance. Noted this protection structure is not considered a long-term commitment. Longer term once seawall structure fails, **Managed Retreat.** Assess **Protect** option in further detail (Pr.1, Pr.2) based on further analysis of the cost and benefit.	Negligible Risk – current risk of inundation is low (MR.1). In future planning periods, short term inundation in large events is acceptable. Monitor for safety following impacts
CGG / Community Structures – Toilets, Skate park, Tennis Courts, Beach	**Managed Retreat** - Assess **Protect** option in further detail (Pr.1, Pr.2) based on further analysis of the cost and benefit.	Negligible Risk – current risk of inundation is low (MR.1). In future planning periods, short term inundation in large events is acceptable. Monitor for safety following impacts

Asset / Location	Erosion	Inundation
Shelters, Playground		
Informal Boat Launch	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Acceptable Risk – short term inundation in large events is acceptable. Monitor for safety following impacts
Beach /Dunes	Apply Temporary Protect and Resilience Building measures (TPIR1, TPIR2, TPIR3, TPIR4) to prevent erosion of landside areas. Monitor erosion to identify local areas that are rapidly eroding or dune blowouts.	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts.

3.4 Economic Analysis – Adaptation options for Erosion Protection for Whitehill Rd and Community Hall

An economic assessment of adaptation options to protect the Whitehill Rd section of the coast from coastal erosion was undertaken due to the extreme risk level for this section of shoreline cited in the risk assessment and high value of this section of coast to the community identified in the stakeholder engagement process.

The economic assessment applied multi-criteria analysis and cost benefit analysis to support decision-making for the preferred adaptation option in this section of coast. The full economic assessment is detailed in **Appendix A.5**. Summary outcomes are presented in this section.

The evaluation of the adaptation options task has two key components:

- Multi-Criteria Analysis (MCA); and
- Cost Benefits Analysis (CBA).

The economic framework evaluates the adaptation options through the following broad steps:

1. Determining economic value of assets at risk to coastal hazards;
2. Determining the current and future annual cost of hazards to susceptible assets in the Coastal Zone;
3. Determining the cost of options to mitigate coastal hazards; and
4. Economic evaluation of reduction in costs of hazards to susceptible assets as a result of mitigation options.

Appendix A.5 provides a detailed overview of the MCA and CBA processes and also provides information on sensitivity cases run for the analyses in the CHRMAP. Further information on the application of MCA and CBA for assessment of coastal adaptation including case studies can be found at the CoastAdapt site (https://coastadapt.com.au/sites/default/files/information-manual/IM04_Costs_and_benefits.pdf).

3.4.1 Multi-Criteria Assessment

A multi-criteria assessment of adaptation options that could be applied in the Drummond Cove CMU to protect the coastal assets landward was undertaken on seven options. The list of options examined in MCA to provide protection against erosion in the CMU were:

1. Beach Nourishment;
2. Buried Seawall;
3. Groyne Structures (geotextile);
4. Artificial Reef;
5. Breakwater enclosing a Boat Launch (MRA Concept);
6. Revegetation; and
7. Do Nothing (a managed retreat approach)

The MCA process is detailed in Appendix A.5. Each of the seven options was rated based on a scored assessment in the following general categories:

- Foreshore Reserve and Beach
- Road Infrastructure
- Utilities
- Ecological Areas (onshore and offshore)
- Residential Properties
- Commercial Properties
- Parks and public space

From the seven options assessed, the highest ranked options that were carried through to cost benefit analysis (CBA) were the buried seawall, groyne structures, artificial reef and Breakwater enclosing a boat launch.

3.4.2 Cost Benefit Analysis

The four highest ranked MCA options were assessed in further detail using CBA. To undertake this process, the structures were considered at an initial concept level of detail, to develop indicative costs of each to apply in the CBA. The costs developed for each concept were calculated based on market costs provided by the City for similar projects completed in their coastal areas. It is noted that the CBA is based on an *initial concept level* of detail and if the structural options are progressed in future, additional economic analysis would be recommended to refine cost assumptions in the CBA. Additionally, should the concepts advance to planning and detailed design, the assessment of coastal structures would need to consider their impact to coastal processes in adjacent sections of the coast.

The full list of assumptions and underlying analysis of the CBA is detailed in **Appendix A.5** and include the following:

- Estimation of economic values
  - A discount rate of seven per cent per annum has been applied
  - Construction of the options has been assumed to be undertaken in 2021
  - Year 2022 has been applied as the year of opening for each scenario
  - A benefit evaluation period of 30 years from opening was adopted.
  - All values given are in 2017 dollars.
- Coastal erosion scenarios
  - 2018 – no erosion occurs
  - 2030 – the erosion of the shoreline is based on the historical rate (S2) and sea level rise (S3) components including an allowance for uncertainty (0.2m/year). The erosion from the 100-year

ARI storm event (S1) is not included. This is on the basis that the probability of this event having occurred within a 12-year period is relatively low

- 2070 - the erosion rate is based on the historical rate (S2) and sea level rise (S3) components including an allowance for uncertainty (0.2m/year). The erosion from the 100-year ARI storm event (S1) is included. This is on the basis that the probability of this event having occurred within a 50-year period is higher

- Base Case
  - In the absence of the adaptation approach, it is assumed that a 'do-minimum' approach would be adopted. The Council would be assumed to take no action to mitigate against the erosion and a planned retreat approach would be adopted instead. Once a property becomes uninhabitable due to coastal erosion, it is assumed that the property would be vacated, and the property owners/ occupiers would be relocated to a safer location within the same LGA. The analysis assumes that, with erosion, the beach would progress backwards and hence the beach area would largely remain the same. The indirect costs associated with the base case include the loss of park(s), reserve area(s) together with the roads and the properties.

There are three key categories in the Cost Benefit Analysis calculation:

- Present Value Cost (PV Cost). The total cost of each respective adaptation option based on capital cost and on-going maintenance.
- Present Value Benefit (PV Benefit). The value of coastal assets that are impacted by coastal erosion. The assessment includes Beach/Parkland/Foreshore Values, Residential Property Values, Asset values (e.g. CGG infrastructure).
  - It is noted that intangible benefits (Usage values for the beach and parkland, environmental values and damage to utilities infrastructure) are not included in the cost for this level of analysis. These could be included in more detailed assessment of options in future stages.
  - It is noted the 'base case' assumes that nothing is done to protect the coast and erosion will impact foreshore areas based on the coastal erosion setback calculations (MRA2016). Under this assumption the seawall in front of the community hall is not maintained and does not offer coastal protection to the coastal assets landward.
- Benefit Cost Ratio (BCR): A ratio calculated from PV Cost and PV Benefit indicating the net return on investment. A score greater than a value of 1 (BCR>1) indicates there is a net return on investment for the option based on the value of assets it protects on the landside. In simple terms a BCR value of 1.1 indicates that for every $1 spent on an adaptation option there is a $1.10 return on the investment based on the value of the coastal assets that are protected.

The results from the CBA for Drummond Cove are shown in Table 3.6 for the shortlisted options and show:

- protection of the coast through either the Geotextile groynes + buried seawall option or the boat launch option (Stage 1) are the best outcomes. As shown in Table 3.6 the analysis for both adaptation options results in a high BCR value of 1 or greater; and
- for the Stage 2 boat launch option, this has the lowest BCR (0.6) however there are likely to be other benefits associated with this option that are not currently incorporated within this analysis. If more information on the likely usage of the ramp in terms of visitor numbers etc was available, this may improve this estimate.

Table 3.6: Drummond Cove, Closed Section of Whitehill Rd. Results of Cost Benefit Analysis

	Boat Launch - Stages 1 and 2	Boat Launch Stage 1 Only	Sea Wall	Artificial Reef	Geotextile Groynes and Buried Seawall
PV COST	$7,126,700	$3,614,000	$4,471,800	$4,492,800	$3,330,000
PV BENEFIT	$3,970,900	$3,670,600	$3,670,600	$3,670,600	$3,670,600
NPV	-$3,155,800	$56,600	-$801,100	-$822,200	$340,500
BCR	0.6	1.0	0.8	0.8	1.1

Appendix A.5 provides additional results on a range of sensitivity cases run for the CBA, which test the assumptions with regard to the valuation of property and coastal assets that go into the Present Value Benefit calculations (PV Benefit). It is noted that the value of property makes up 24% of the PV Benefit in the CBA calculation, and the BCR outcomes are not highly dependent on the assumed property value through the CMU (detailed in Appendix A.5).

The CBA outcomes provide a basis to justify protection along the closed section of Whitehill Rd in the 30-year timeframe assessed, providing the cost of the protection is approximately $3 million or less. It is noted there are a significant number of properties at risk of erosion in future planning periods, but the CBA has only considered a 30-year timeframe due to the significant uncertainties associated with the coastal changes beyond this timeframe.

A more detailed assessment of the format of the preferred protect option (i.e. community consultation, preliminary engineering) and means by which the CGG could recover the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme should be investigated.

3.5 Implementation

3.5.1 Short Term Implementation Plan

The recommendations for the short-term implementation plan for Drummond Cove CMU over the 15-year period to 2032 is provided in Table 3.7.

Table 3.7: Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • For non-infill development, Avoid development of areas at risk of erosion in the SCA. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided • For infill development, allow development in coastal erosion setback under LCPP that recognises coastal hazard risk level (Moderate, High or Extreme) and which allows for adaptation response to vary from Accommodate to Managed Retreat. Classification review scheduled at five yearly intervals as part of the CHRMAP review.

Item	Comments
	• For properties with identified inundation risk, accommodate inundation through planning and design measures specified in LCPP. A coastal protection approach for Drummond Cove north of the Community Hall in front of the closed section of Whitehill Rd warrants further assessment. MCA and CBA analysis of options considered show a net return on investment on the value of assets protected on the landside is possible. The high value of property at risk of erosion in future planning periods and the values of the coast noted in the Community Engagement process underline the importance of this issue.
Aim and strategic direction for coastal management	Build understanding of the process of coastal erosion affecting shoreline areas. Requirement for annual monitoring of shorelines to track shoreline erosion in front of Whitehill Rd. Recommended to undertake geophysical study of shoreline areas to identify presence of hard rock. The coastal protection structure in front of the Community Hall should be maintained consistent with the design life of the structure. Note the coastal protection feature is not recognised as a long-term commitment for this section of the CMU. Increase resilience of foreshore reserve areas through revegetation of coastal areas, supported by shoreline monitoring to track rate of erosion and to target efforts. Temporary Protection and Nature-based approaches to improve to build resilience (e.g. coastal revegetation, sand trapping fences, refer Section 2.4.1) of the foreshore reserve from erosion are currently in place by CGG and strongly recommended for future. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.
Timing of adaptation response and trigger point at which adaptation commences	1.Properties. Accommodate: There are 98 properties identified in the High-risk category for erosion (located in the 2030 to 2070 erosion setback). Properties will systematically move into the Extreme category and be placed under Managed Retreat conditions as further erosion of the shoreline is monitored in the CMU as part of the five yearly CHRMAP review process. 2.Council infrastructure in foreshore (roads, carparks, pathways, BBQs, toilets, shelters). Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe.
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15) Geophysical study of the shoreline areas to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term (estimate $25,000) Nature based approaches to increase resilience of shorelines and foreshore areas (e.g. sand trapping fences, revegetation). Recommended for section north of the Community Hall. CGG led programs supported through grant funding (estimated $10,000 annually). Further assessment of protection option for Whitehill Rd section of coast north of Community Hall. o Economic study and beach use study to further define CBA uncertainties (estimated $10,000).

Item	Comments
	o Preliminary Engineering study for design of protect option ($40,000).
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer section 15.1 detail, in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. CGG -Additional studies for a coastal protection option at Whitehill Rd section of coast north of Community Hall to confirm assumptions in economic analysis and community acceptance of option. CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP. CGG / Community – Lead and support projects that build coastal resilience for foreshore areas and dunes in foreshore reserve areas north of the Community Hall.
Performance Measures by which the plan can be evaluated	Updated planning policy (LCPP) that can effectively address managed retreat implementation for existing and future development within coastal erosion hazard extent. Effective monitoring campaign and geophysical study that leads to improved understanding of coastal erosion processes, developed knowledge of the rate and format of coastal changes through the CMU. Implementation of targeted programs to build resilience in foreshore areas that are successful in maintaining the existing coastal buffer. Mitigation of coastal erosion risk for section of beach fronting the closed section of Whitehill Rd with Community support for the approach.

3.5.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for the CMU is recommended to include the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach and potential erosion of the shoreline. Key locations to include:
   - Closed section of Whitehill Rd;
   - Foreshore reserve south of Community Hall (Hester Street to Seacrest Way); and
   - Shoreline in front of Surfside Terrace at narrowest point to shoreline.
2. Beach transect analysis should be supplemented by UAV capture of shoreline elevation at lower capture frequency (e.g. bi-annually). This will be used to assess volumetric changes for specific shoreline areas of focus.
3. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.
4. Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events.
5. Photo monitoring of the beach (continuation of NACC photomon program).
6. Inspection of minor structures (e.g. access, shelters etc) in the foreshore area directly exposed to coastal erosion and inundation for condition / safety twice yearly and after large storm events

7. Inspection of rock protection structure in front of Community Hall for condition at minimum twice yearly and after large storm events.

It is proposed that the cost of annual monitoring could be eligible for 50% funding via the DoT CAP grants (outlined in Section 15.4).

4. Glenfield (CMU 2)

4.1 Adaptation Summary and Recommendations

Glenfield CMU is an undeveloped section of the coast, with the water treatment plant (WTP) the only built structure of note.

- The shorelines in the area are experiencing erosion at varying degrees. In MRA 2016, the annual erosion rate is recommended as 1.5m/yr in the very south of the CMU, 0m /yr (i.e. stable / accreting) through the central section and 0.4 m/yr in the very northern section of the CMU.
- The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates the coastal assets at risk of erosion under the projected coastal erosion scenarios include:
    - Water Treatment Plant;
    - Vacant undeveloped land in the north of the CMU (southern section of Drummond Cove);
    - Dunes and beaches.
- Coastal inundation risk from large storm events and sea level rise in future planning periods does not present a risk in the CMU (refer Appendix A.2). The natural land level is generally elevated above the design flood level, however a low-lying section of coast in the north of the CMU is noted.

Coastal hazard risk management and adaptation planning (CHRMAP) has been completed for the CMU. The key CHRMAP recommendations for the management of the Glenfield CMU are summarised as follows:

- The general approach to manage erosion risk is **Avoid** all development within the identified coastal hazard area. This will apply for all City infrastructure, private property and foreshore areas.
- Planning policies and strategies will need to be updated to reflect the recommended adaptation approaches. This will require
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
- The foreshore reserve area offers a crucial natural buffer against coastal erosion and inundation for inland areas as well as providing highly valued public amenity. Active monitoring and nature-based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are strongly recommended. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 4.1 , based on the risk assessment process completed (Baird 2019). The adaptation timelines in Table 4.1 are based on projected erosion setback lines (Appendix A.1).

Table 4.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Sunset Beach CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Developable Land in Erosion Setback Extent to 2110	AVOID								
Water Treatment Plant	MON.	MAN.RET	AVOID						
Dunes	MONITOR and BUILD RESILIENCE (Nature Based Options)								
Beaches and Flora	MONITOR and BUILD RESILIENCE (Nature Based Options)								

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

The assets at highest risk in the CMU are summarised in Table 4.2 along with the adaptation approaches that are recommended to manage the risk.

Table 4.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Water Treatment Plant	H	E	E	E	Water Corp.	Utilities infrastructure is privately owned, and it is the responsibility of Water Corp. to determine future adaptation approaches to manage their erosion risk. Recommend a managed retreat trigger which is activated when erosion of shoreline is within 30m of structure.
Dunes	M	M	H	H	Community	Monitor erosion, build resilience through nature-based approaches (revegetation programs, sand trapping etc.)
Beaches, Flora and Fauna	M	M	H	H	Community	

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

There is minimal utilities infrastructure that is affected by coastal erosion risk through the CMU. Based on the mapping presented in Appendix A.3:

- One Water Corp. pump station is located in the 2070 - 2110 coastal erosion hazard extent.
- A Water Corp. pressure main and a Water Corp. Wastewater Treatment Plant are located within the 2070 - 2110 coastal erosion hazard extent.

Utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk.

4.2 Glenfield Coastal Hazard

4.2.1 Coastal Erosion Hazard

Glenfield CMU consists of natural shoreline areas, which are experiencing erosion at varying degrees. In MRA 2016, the annual erosion rate is assigned as 1.5m/yr in the very south of the CMU, 0m /yr (i.e. stable / accreting) through the central section and 0.4 m/yr in the very northern section of the CMU. The coastal setback lines are shown in Appendix A.1 indicating:

- The foreshore area of the Glenfield coastal compartment is a natural section of coast which is undeveloped.
- The water treatment plant (WTP) is located in the shoreline area with coastal erosion forecast to impact in the 2070 to 2110 timeframe.

4.2.2 Coastal Inundation Hazard

The inundation hazard is shown as depth associated with the 500yr ARI inundation event in the planning year 2110, shown for the Glenfield CMU in Appendix A.2. The inundation mapping shows there is no risk of inundation for the upper foreshore area due to the natural topographic relief, however some low-lying dune areas in the north of the CMU are at risk of inundation in extreme events.

4.3 Glenfield Coastal Adaptation

4.3.1 General Adaptation Strategy

Coastal adaptation approaches for erosion have been considered in the Glenfield CMU in Table 4.3.

Table 4.3: Coastal Adaptation Summary – Glenfield CMU, Erosion Risk

Location	Length	Key Considerations	Adaptation Approach
Glenfield CMU	Length 2.8km	There exists a large area of land north of the compartment (south of the Glenfield Estate development) which is zoned for urban development. The western extent of this is impacted by both erosion setback and inundation hazard.	**Avoid** new development in identified coastal hazard area.
		A key consideration in the compartment is the water treatment plant (WTP). At its closest point, the boundary of the WTP is approximately 120m from the HSD currently. The coastal setback is forecast to impact the WTP by approximately 2070. It is noted the WTP is at an elevation of approximately 8m AHD and is not susceptible to inundation hazard. There are significant dune features between the shoreline (HSD) and the WTP noted as a natural control.	Utilities infrastructure is privately owned, and it is the responsibility of Water Corp. to determine future adaptation approaches to manage their erosion risk. It is recommended **Managed retreat** for the WTP to be setup with erosion trigger larger than the S1 distance, recognising the importance of preventing catastrophic failure of the infrastructure as a result of erosion. A 30m managed retreat trigger is recommended.

The WTP is shown in Figure 4.1 with the distance to the HSD indicated as approximately 100m currently.

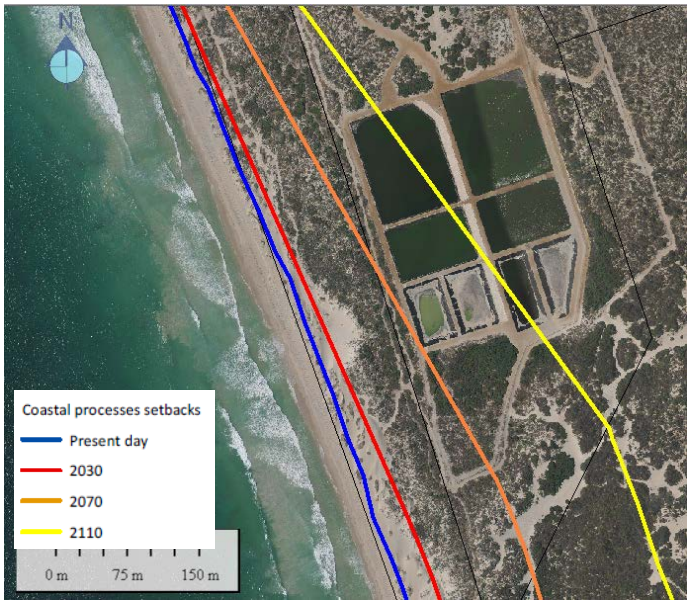

Figure 4.1: Glenfield Water Treatment Plant – Distance to HSD

4.3.2 Adaptation Approaches by Asset

In Table 4.4, a summary of recommended adaptation approaches and recommendations to mitigate the erosion risk to assets in the Glenfield coastal compartment are presented, based on the key assets at risk identified in the hazard assessment (Baird 2019).

Table 4.4: Adaptation Options by Asset – Glenfield CMU

Asset / Location	Erosion	Inundation
Developable Land	**Avoid** development in identified coastal hazard area (Av1).	Avoid development in identified coastal hazard area where possible. Inundation hazard can be accommodated in development of the land level or the design of structures through options AC2, AC4, AC5.
Beach /Dunes	**Managed Retreat** Allow the coast to erode naturally (MR.1). Monitor erosion to identify local areas that are rapidly eroding or dune blowouts.	Short term inundation in large events is acceptable. Monitor for safety following impacts.
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes.	Short term inundation in large events is acceptable. Monitor for safety following impacts.
Water Treatment Plant (under control of Water Corp.)	**Managed Retreat** - Monitor erosion at least 2 yearly intervals (vegetation lines, ground survey) to track progress of erosion against forecast potential.	No Risk. WTP is set at approximately +8m AHD. Not impacted by inundation in the 100 years planning period.

Asset / Location	Erosion	Inundation
	Set retreat trigger point when most landward limit of the Horizontal Shoreline Datum (HSD) is within 30m of the site boundary (MR.1 MR.2).	

4.4 Implementation

4.4.1 Short Term Implementation Plan

The proposed short-term implementation plan for Bluff Point CMU over the 15-year period to 2032 is provided in Table 4.5.

Table 4.5: Glenfield CMU Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	The WTP is owned by Water Corp. Recommendation for a Managed Retreat erosion trigger set at a distance of 30m from the HSD. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • For non-infill development, Avoid development of areas at risk of erosion in the SCA. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided • For infill development, allow development in coastal erosion setback under LCPP that recognises coastal hazard risk level (Moderate, High or Extreme) and which allows for adaptation response to vary from Accommodate to Managed Retreat. Classification review scheduled at five yearly intervals as part of the CHRMAP review. • For properties with identified inundation risk, accommodate inundation through planning and design measures specified in LCPP.
Aim and strategic direction for coastal management	Avoid development within identified coastal hazard setback. Build understanding of the process of coastal erosion affecting shoreline areas.
Timing of adaptation response and trigger point at which adaptation commences	The WTP is owned by Water Corp. Recommended for a Managed Retreat erosion trigger set at a distance of 30m from the HSD. S1 for this section of coast is 13m.
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15).

Item	Comments
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP.
Performance Measures by which the plan can be evaluated	Improved understanding of coastal erosion processes through the CMU.

4.4.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for Glenfield CMU should target the following:

1. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.
2. Analysis of extent of acute erosion (storm bite) at the foreshore in front of WTP following large storm events.

5. Sunset Beach (CMU 3)

5.1 Adaptation Summary and Recommendations

The Sunset Beach Coastal management unit (CMU) covers the 2km shoreline north of the Chapman River mouth. The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1, with a summary of the coastal hazard for the CMU provided as follows:

- The section of coast is presently eroding at a rate of 1.5m annually (MRA 2016). The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates there are a significant number of coastal assets at risk of erosion under the projected coastal erosion scenarios including:
  - Residential property;
  - Undeveloped residental or commercial block of land;
  - Swan Foreshore Reserve;
  - Caravan Park;
  - Roads (Volute St, Outrigger Esplanade) and Carparks (Triton Ave, Bosely St);
  - Foreshore infrastructure (toilets, shelters, benches, fencing);
  - Cycle and walking paths;
  - Utilities (Water Corp. etc); and
  - Dunes and beaches.
- Coastal inundation risk from large storm events and sea level rise in future planning periods does not present a risk in the CMU – the natural land level is elevated well above the design flood level in this section of coast.

Coastal hazard risk management and adaptation planning (CHRMAP) has been completed for the assets identified as being at risk in the Sunset Beach Coastal Management Unit. Risk mitigation strategies have been determined from options presented in the coastal adaptation hierarchy of Avoid, Managed Retreat, Accommodate or Protect. The key CHRMAP recommendations for the management of the Sunset Beach CMU are summarised as follows:

Residential and Commercial Development

- Planning policies will need to be updated as follows:
  - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
  - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion;
- The coastal erosion hazard in the CMU is forecast to impact 0 properties by 2030 (Extreme Risk), 57 properties in the 2030 to 2070 period (High Risk) and 82 properties in the 2070 to 2110 period (moderate Risk). To manage erosion risk for these properties:
  - Place Section 70A notification on titles to inform prospective purchasers to the risk of coastal erosion
  - Avoid development of vacant residential land within the identified 2110 coastal erosion hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve is provided (refer SPP2.6)
  - Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:

- Extreme: 0 properties.
- High: 57 properties. **Accommodate** erosion risk with Section 70a notification on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines required.
- Moderate: 82 properties. **Accommodate** erosion risk with Section 70a notification on Title. 5 yearly Review of shoreline and updated site-specific assessment of future shoreline hazard lines.

CGG coastal infrastructure:

- The general approach within the CMU for coastal infrastructure is **Managed Retreat**. Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;

Monitoring and Management

- Recommend a geophysical study of the shoreline areas is undertaken to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term;
- The foreshore reserve area offers a crucial natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Active monitoring and nature-based approaches (refer Section 2.4.1) to build resilience (e.g. coastal revegetation, sand trapping fences) of this foreshore reserve from erosion are currently in place by CGG and strongly recommended for future. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 5.1, based on the risk assessment process completed (Baird 2019). The adaptation timelines in Table 5.1 are based on projected erosion setback lines (Appendix A.1).

Table 5.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Sunset Beach CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Vacant land classified as 'Non-Infill' (e.g. north of Sail Blvd)	AVOID								
Property in 2030 to 2070 Erosion Setback extent (Property West of Volute St, Outrigger Drive)	MON. /ACCOM.	ACCOMODATE / MAN.RET							
Property in 2070 to 2110 Coastal Erosion Setback extent (e.g. East Volute St)	MON. / ACCOM		ACCOM. / MAN.RETREAT						
Swan Park Toilets	MON/ MAN RET.		AVOID						
Walking and Cycling Paths	MON.	MANAGED RETREAT							
Roads (Triton, Outrigger)	MON	MAN.RET	AVOID						
Carpark Boseley St, Triton Place	MON	MAN.RET	AVOID						
Caravan Park	MON.	MANAGED RETREAT							
Dunes	MONITOR and BUILD RESILIENCE (Nature Based Options)								
Foreshore Reserve	MONITOR and BUILD RESILIENCE (Nature Based Options)								
Trees	MON	MANAGED RETREAT							

The coastal setback lines are shown in Appendix A.1.3 showing:

- There are a significant number of properties at risk over the planning timeframe to 2110, with erosion risk highest for properties on Volute Street and Outrigger Drive (forecast to be impacted in the timeframe 2030 to 2070).
- Council assets including Triton Avenue carpark, Bosely Street carpark and Swan Foreshore reserve are all at current erosion risk.
- The caravan park is at current risk of erosion on its western boundary, and in the 2030 to 2070 planning period is forecast to lose significant land area as the erosion setback line is located 146m landward of the current shoreline position (HSD). The current lease agreement for the western section of the park, has a managed retreat trigger set for when the coast erodes to the point when the Mean High High Water (MHHW) line is within 10m of the property boundary.

5.2.2 Inundation Hazard

The inundation hazard associated with the 500yr ARI inundation event in the planning year 2110, is shown for the Sunset Beach CMU in Appendix A.2. The inundation mapping shows there is no risk of inundation for the upper foreshore area due to the natural topographic relief through this section of coast.

5.3 Sunset Beach Coastal Adaptation

5.3.1 General Adaptation Strategy

Coastal adaptation approaches for erosion have been considered in the Sunset Beach CMU through three sections, based on consideration of the key assets at risk, coastal features and timing of coastal hazard impact. The sections are shown in Figure 5.3, and ordered north to south in the CMU as follows.

- Section 1. Northern extent of CMU to Sail Boulevard
- Section 2. Sail Boulevard to Bosley Street
- Section 3. Bosley Street to Chapman River

Figure 5.3: Sunset Beach CMU – Coastal Adaptation Sections (image Google Earth)

Table 5.3: Coastal Adaptation Summary – Sunset Beach CMU, Erosion Risk

Location	Length	Key Considerations	Adaptation Approach
Section 1. Northern CMU to Sail Boulevard	Length 750m	There exist substantial tracts of vacant residential land along the northern compartment of Sunset Beach which are located on the seaward side of the coastal erosion hazard line that could not be classified as 'infill' development pursuant to SPP 2.6. Historically observed rate of erosion is 1.5m annually. Outrigger Esplanade, Sail Boulevard forecast erosion impact 2030 - 2070.	**Managed retreat** recommended for CGG infrastructure. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require

Location	Length	Key Considerations	Adaptation Approach
Section 2. Sail Boulevard to Bosley Street	Length 700m	Houses Volute Street forecast erosion impact 2030 – 2070 The Triton Avenue car park is located on a section of beach experiencing significant erosion with forecast erosion impact current to 2030. The toilet block at Triton Avenue was removed by CGG in 2017 after its managed retreat trigger was reached (coastal edge was within 10m). Bosley Street car park at the entrance to the Caravan Park is located on a section of beach experiencing significant erosion in recent years with forecast erosion in current to 2030 timeframe.	planning approval. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. Develop LCPP with conditions on development stated: • **Avoid** development of vacant residential land within the SCA not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve as required by SPP2.6 is provided. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level. A geophysical study of the critical shoreline areas to examine presence of rock strata is recommended. Annual Shoreline monitoring to track rate of erosion.
Section 3. Bosley Street to Chapman River	Length 450m	The Sunset Beach Holiday Park lease is split in two sections (east and west areas). The westernmost section has a managed retreat trigger point set, for when the boundary is within 10m of the Mean High, High Water mark (MHHW, 0.4m AHD). The trigger point is forecast to be realised in the current to 2030 timeframe. The Swan foreshore park and community area is bound by the Chapman River on its southern side, and the Caravan park on the north side. Facilities include car parking, community use foreshore areas and ablution block forecast at risk in the current to 2030 timeframe. Chapman River Mouth is a key feature for coastal processes (dynamic response to flooding / extreme events and source of sediment. A registered aboriginal heritage site (AHIS site 5561) is located on the northern bank of Chapman River mouth.	

5.3.2 Adaptation Approaches by Asset

In Table 5.4, a summary of adaptation approaches and recommendations to mitigate the erosion risk to assets in the Sunset Beach coastal compartment are presented in Table 5.4, based on the key assets at risk identified in the hazard assessment (Baird 2019).

Table 5.4: Adaptation Options by Asset – Sunset Beach CMU

Asset / Location	Erosion	Inundation
Existing Houses	**Accommodate / Managed Retreat** • Place notification on title (Ac.1) at redevelopment or time of sale. Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme).	No risk
Infill Development (based on SPP2.6 Definition)	Allow infill development on vacant properties in the identified coastal hazard area of the SCA. Subject to LCPP conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (Moderate, High or Extreme).	No risk
Undeveloped residential Land, North of Sail Boulevard	**Avoid** development in identified coastal hazard area (Av1).	No risk
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2).	No risk
Carparks, Triton St and Bosely St	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2).	No risk
Caravan Park	**Managed Retreat** - Allow the coast to erode naturally (MR.1), monitor erosion of shoreline against agreed trigger point for retreat.	No risk
Swan foreshore park	**Managed Retreat** - Allow the coast to erode naturally, maintain function of assets under defined trigger points for removal (MR.1 > MR.2).	No risk
Beach /Dunes	**Managed Retreat / Protect** Allow the coast to erode naturally (MR.1) Monitor erosion to identify local areas that are rapidly eroding or dune blowouts. Apply Temporary Protect and Resilience Building measures (TPIR1, TPIR2, TPIR3, TPIR4) to prevent erosion of landside areas.	No risk
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes.	No risk
Cycle / Walking Paths	**Managed Retreat** - Allow the coast to erode naturally, and monitor paths to ensure safety. Rebuild over time as required, adopting setback level consistent with design life (MR.1 MR.2).	No risk

5.4 Implementation

5.4.1 Short Term Implementation Plan

The short-term implementation plan for Sunset Beach CMU over the 15-year period to 2032 is provided in Table 5.5.

Table 5.5: Sunset Beach CMU Short Term Implementation Plan to year 2032

Item	Comments
Preferred Adaptation Approach	The general approach for all CGG coastal infrastructure is managed retreat. The approach will allow use of asset to continue until defined trigger points are reached, at which point asset removal is required. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • For non-infill development, Avoid development of areas at risk of erosion in the SCA. • For infill development, allow development in coastal erosion setback that recognises coastal hazard risk level (Moderate, High or Extreme) and which allows for adaptation response to vary from Accommodate to Managed Retreat. Classification review scheduled at five yearly intervals as part of the CHRMAP review.
Aim and strategic direction for coastal management	Adopt a managed retreat approach to allow continued function of CGG assets in the coastal areas until risk is intolerable. Build understanding of the process of coastal erosion affecting shoreline areas. Requirement for annual monitoring of shorelines to track shoreline erosion. Recommended to undertake geophysical study of shoreline areas to identify presence of hard rock.
Timing of adaptation response and trigger point at which adaptation commences	1.Properties. Accommodate: There are 57 properties identified in the High-risk category for erosion (located in the 2030 to 2070 erosion setback). Properties will systematically move into the Extreme category and be placed under Managed Retreat conditions as further erosion of the shoreline is measured in the CMU, under the five yearly CHRMAP review process. 2.Council infrastructure in foreshore (roads, carparks, pathways, BBQs, toilets, shelters). Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe.
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15). Geophysical study of the shoreline areas to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term (estimate $25,000).

Item	Comments
	Allowance for forecast modification / removal in the next 15 years based on projected erosion: • Bosley Street Carpark and Triton Avenue carpark. • Sections of Swan drive foreshore park (re-siting fences, pathways etc). • Caravan Park managed retreat trigger may be activated – set for when erosion results in the MHHW mark on the shore is surveyed at a distance of 10m from the property boundary.
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer section 15.1 detail, in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP.
Performance Measures by which the plan can be evaluated	Updated LCPP that can effectively address managed retreat implementation for existing development and infrastructure. Improved understanding of coastal erosion processes through the CMU.

5.4.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for the CMU is recommended to include the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach. Key locations to include:
   - In front of Swan foreshore reserve
   - In front of caravan park
   - In front of Volute Drive
   - In front of Outrigger Drive
2. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.
3. Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events.
4. Photo monitoring of the beach (continuation of NACC photomon program).
5. Inspection of minor structures (e.g. access, shelters etc) in the foreshore area directly exposed to coastal erosion and inundation for condition / safety twice yearly and after large storm events.

6. Bluff Point (CMU 4)

6.1 Adaptation Summary and Recommendations

The Bluff Point Coastal management unit (CMU) extends from the Chapman River mouth to Mabel Street in the south. The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1, with a summary of the coastal hazard for the CMU provided as follows:

- The section of coast is presently eroding at a rate of between 0.3m to 0.9m annually. The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates there are a significant number of coastal assets at risk of erosion under the projected coastal erosion scenarios including:
    - Residential property
    - Undeveloped residential or commercial block of land
    - Rundle Park and St Georges Beach
    - Roads (Kempton St) and Carparks
    - Foreshore infrastructure (toilets, shelters, benches, fencing)
    - Cycle and walking paths
    - Utilities (Telstra, Western Power etc)
    - Dunes and beaches
- Coastal inundation risk from large storm events and sea level rise in future planning periods is generally contained in the existing foreshore reserve. The majority of residential property within the CMU is not at risk of inundation. However, low-lying properties and roads in the coastal areas between Fuller Street and the Chapman River mouth are at risk in extreme events and under future sea level rise scenarios. Sea level rise of 0.9m by 2110 is adopted in future coastal planning scenarios based on recommendations in the State Coastal Planning Policy (SPP2.6).
    - The number of residential properties which are within the 500yr ARI inundation extent for respective planning periods in the CMU is forecast as 4 properties at year 2030, 9 properties at year 2070 and 17 properties at year 2110.

The key CHRMAP recommendations for the management of the Bluff Point CMU are summarised as follows:

Residential and Commercial Development

- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
    - Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion / inundation;
- The coastal erosion hazard in the CMU is forecast to impact 12 properties by 2030 (Extreme Risk), an additional 61 properties in the 2030 to 2070 period (High Risk) and further 69 properties in the 2070 to 2110 period (moderate Risk). To manage erosion risk for these properties:
    - **Avoid** development of vacant residential land within the identified 2110 coastal erosion hazard area not classified as Infill under SPP2.6; and

- Allow infill development within the identified 2110 coastal erosion hazard area subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
  - Extreme: 12 properties. Section 70a notification on Title, **Managed Retreat** condition would be imposed at time of development application / redevelopment, with trigger set when erosion of shoreline reduces horizontal distance from HSD to structure to less than 26m (S1).
  - High: 61 properties. **Accommodate** erosion risk with Section 70a notification on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines required.
  - Moderate: 69 properties. **Accommodate** erosion risk with Section 70a notification on Title. 5 yearly Review of shoreline and updated site-specific assessment of future shoreline hazard lines.
- **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures specified in the LCPP;

CGG coastal infrastructure:

- The general approach within the CMU for coastal infrastructure is Managed Retreat. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required;
- Critical at-risk assets to 2030 are St Georges Beach / Rundle Park and amenities (toilets, carpark, foreshore reserve, BBQ's, pathways etc), Midden Site, Kempton St; and
- A coastal protection approach for Rundle Park at St Georges Beach warrants further assessment, based on MCA and CBA analysis of options which recommended a protection through a series of geotextile groynes could deliver a net return on investment on the value of assets it protects on the landside (BCR=2.4). Further studies are required to confirm the underlying economic assumptions, engineering costs, coastal processes and community values in this section of coast;

Monitoring and Management

- Recommend a geophysical study of the shoreline areas is undertaken to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term;
- The foreshore reserve area between Rundle Park and Fuller Street offers a crucial natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Active monitoring and nature-based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are strongly recommended. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 6.1, based on the risk assessment process completed for the project (Baird 2019). The adaptation timelines in Table 6.1 are based on projected erosion setback lines (Appendix A.1).

The assets at highest risk in the CMU are summarised in Table 6.2,along with the adaptation approaches that are recommended to manage the risk.

Table 6.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Bluff Point CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Non-Infill Developable land within 2110 Erosion Extent	AVOID								
Property in the Current to 2030 Coastal erosion Setback Area	MANAGED RETREAT								
Property classified as Infill in 2030 to 2070 Erosion Setback extent	MONITOR	MAN. RETREAT							
Property classified as Infill in 2070 to 2110 Coastal Erosion Setback extent	MON.				MANAGED RETREAT				
Carparks (Rundle Park)	MON	MAN.RET	AVOID						
Nazareth House	MONITOR						PROTECT (TBC)		
Rundle Park foreshore areas and	MON.	MANAGED RETREAT							
Beach /Dunes: Rundle Park to Fuller	MONITOR and PROTECT (Nature Based Options)								
Beach Access Paths	MON	MANAGED RETREAT							
Cycle / Walking Paths [1]	MONITOR	MANAGED RETREAT							
Midden Site, Bluff Point	MONITOR and PROTECT (Nature Based Options)								

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

Table 6.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Property West of Kempton St	E	E	E	E	Private	City to establish Special Control Area (SCA) and a Local Coastal Planning Policy (LCPP) will provide guidance on development standards which must be met to respond to the risk of coastal erosion and / or inundation.
Property North Kempton / Crowtherton St	H	E	E	E	Private	
Property East of Kempton St	M	H	E	E	Private	
Property Kempton St, South of Cecily St	H	E	E	E	Private	
Nazareth House	M	M	H	E	Roman Catholic Church	
School of the Air	M	H	E	E	Dept Education	
Lighthouse Estate Retirement Village	M	H	E	E	Private	

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Roads - Kempton street	H	H	E	E	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Roads - Cecily, Morris, Elphick, Crowtherton	M	H	H	E	CGG	
Beaches	M	M	H	H	Community	Monitor erosion
Foreshore Reserve	H	H	E	E	Community	Build resilience through revegetation programs
Beach St Georges	H	H	E	E	Community	Monitor Erosion. Nourishment may be considered following extreme events
Toilets St Georges	H	E	E	E	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Car Park St Georges	H	H	E	E	CGG	
Rundle Park St Georges	H	H	E	E	Community	High value asset to community. Further investigation of protect option
Carpark Bluff Point 'Leading Lights'	M	M	H	H	DoT	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Carpark Opposite Crowtherton St	M	H	H	H	CGG	
Cycling / Walking Tracks	M	H	H	E	CGG	
Dunes	H	H	E	E	Community	Build resilience through revegetation programs
Trees	M	H	H	H	Community	Plan for removal and replanting as future requires
Registered Aboriginal Site 4762, Bluff Point Kempton St.	E	E	E	E	Community	Require specialist heritage advice regarding management of registered aboriginal site (AHIS site 4762).
Water Corp. Pumping Station end Fuller Street	H	E	E	E	Water Corp.	Asset privately held by Water Corp..

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

There are a range of utilities infrastructure that are affected by coastal erosion risk through the CMU. Based on the mapping presented in Appendix A.3:

- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the present – 2030, 2030-2070 and 2070-2110 coastal erosion hazard extents;
- ATCO gas lines are concentrated in the 2030-2070 and 2070-2110 coastal erosion hazard extent;
- A Water Corp. pump station is located within the present - 2030 coastal erosion hazard extent, and another is located in the 2030-2070 coastal erosion hazard extent.

There are a range of utilities infrastructure that are affected by coastal inundation risk through the CMU. Based on the mapping presented in Appendix A.3:

- A Water Corp. pump station is located in the design flood extent (500yr ARI inundation in year 2110);
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, ATCO gas lines and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the design flood extent (500yr ARI inundation in year 2110).

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their inundation risk.

6.2 Bluff Point Coastal Hazard

6.2.1 Coastal Erosion Hazard

The shoreline north of Rundle Park to the Chapman River mouth is presently eroding at a rate of 0.3m annually, whist the section of coast from St Georges Beach and south to Beresford is eroding at a rate of 0.9m annually (MRA 2016). The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates there are a significant number of coastal assets at risk of erosion.

St Georges beach is a key community asset used for a range of water based activities. The beach fronts Rundle Park with facilities including playgrounds, open space, toilets, carparking, shelters, seating and BBQs. To increase the resilience of the St Georges beach shoreline, CGG has undertaken the following:

- In 2016 CGG constructed a geotextile groyne structure at the northern end of the beach. Sediment is moving northward under general longshore drift and as a result there is build-up of sediment on the southern side of the groyne, whilst on the northern side, down drift erosion is noted (Figure 6.1). The structure has been in place since 2016, supported by sand nourishment across St Georges beach in 2016 and 2017 (each program, approximately 1,000m^3).
- In early 2018 CGG has trialled a series of soft structures on the beach, made of rope hessian material. These act to stabilise the foreshore area, trapping wind-blown sand and allowing vegetation to establish. These also formalise beach access along St Georges beach (Figure 6.2: ‘Soft’ structures for building resilience on the St Georges shoreline (May 2018)).

Figure 6.1: Geotextile Groyne north end of St Georges Beach (photo June 2017 looking North)

Figure 6.2: 'Soft' structures for building resilience on the St Georges shoreline (May 2018)

6.2.2 Coastal Inundation Hazard

Storm surge inundation hazard for the 2110 planning year, 500yr ARI event is presented in Appendix A.2. Coastal inundation risk is generally contained in the existing foreshore reserve and the majority of residential property within the CMU is not at risk of inundation. However, low-lying properties and roads in the coastal areas between Fuller Street and the Chapman River mouth are at risk in extreme events and under future sea level rise scenarios.

6.3 Bluff Point Coastal Adaptation

6.3.1 General Recommendations

Coastal adaptation approaches have been considered in the Bluff Point CMU through four sections, based on a consideration of the key assets at risk, coastal features and timing of coastal hazard impact. The four sections are shown in Figure 6.3, and ordered north to south in the CMU as follows:

- Section 1: Chapman River Mouth to Fuller Street.
- Section 2: Fuller Street to Champion Bay Rise.
- Section 3: Champion Bay Rise to Elphick Avenue / North of Rundle Park.
- Section 4: St Georges Beach / Rundle Park to Mabel Street.

Figure 6.3: Bluff Point CMU – Coastal Adaptation Sections (image Google Earth)

A summary of the erosion risk for the Bluff Point CMU is presented in Table 6.3, with general adaptation strategies recommended through the CHRMAP process.

Table 6.3: Coastal Adaptation Summary – Bluff Point CMU, Erosion Risk

Location	Length	Key Considerations	Adaptation Strategy
Section 1. Chapman River Mouth to Fuller Street	Length 320 m	Houses west of Kempton Street and on Frederick Street forecast erosion 2030 Houses east of Kempton Street forecast erosion impact 2030-2070 timeframe Chapman River Mouth is a key feature for coastal processes (dynamic response to flooding / extreme events and source of sediment)	**Managed retreat** recommended for CGG infrastructure. Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion • **Avoid** development of vacant residential land within the SCA not classified as Infill under SPP2.6. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level (Moderate, High, Extreme) Consider viability of Protect option against erosion for Rundle Park. Requires further analysis of structural options, study of beach use / community input and further valuation of assets that could be protected. Increase resilience of foredune areas, through targeted revegetation programs, designed to extend the timeline of natural buffer to coastal processes. Shoreline monitoring to track rate of erosion and identify critical locations (erosion hotspots) A geophysical study of the critical shoreline areas to examine presence of rock strata is recommended. Examine requirement for sand nourishment to be delivered as part of the northern beaches program (by the Port Authority)
Section 2. Fuller Street to Champion Bay Rise	Length 550 m	Houses and Roads forecast erosion impact 2070 - 2110 Dune system and coastal buffer ranging in width from 70-90 m (to Kempton St) Historically observed rate of erosion is 0.3 m annually Value of CGG assets at risk is low (roads, pathways)	
Section 3. Champion Bay Rise to Elphick Avenue / North of Rundle Park	Length 550 m	Erosion setback line forecast to impact Kempton Street by 2030 Erosion setback line forecast to impact houses on Kempton St in 2030 – 2070 timeframe Dune system and coastal buffer ranging in width from 40-60 m (to Kempton St) Historical rate of erosion 0.3 m/yr	
Section 4. St Georges Beach and Rundle Park	Rundle Park Section 450 m South of Rundle Park to Mabel Street 130 m	Alignment of Coast varies WNW (Rundle Park) and WSW (south of Rundle Park). Historical rate of erosion of 0.9 m/yr. Rundle Park identified as a key community use asset, currently at risk of erosion (S1). Erosion setback line forecast to impact Kempton Street by 2030 Erosion setback line forecast to impact houses on Kempton St in 2030 – 2070 timeframe Geotextile groyne structure at northern end of St Georges beach since 2017 provides a bank of sand on updrift (southern) side, and loss of sand on down drift (north) side.	

A summary of the inundation risk for the Bluff Point CMU is presented in Table 6.4 with general adaptation strategies recommended through the CHRMAP process.

Table 6.4: Coastal Adaptation Summary – Bluff Point CMU, Inundation Risk

Location	Key Considerations	Adaptation Strategy
Section 1. Chapman River Mouth to Fuller Street	Properties on Western side of Kempton Street – land levels at approximately 2.8 m - 3.0 m AHD. • Flood immunity to 100 yr ARI flood level in present day, 2030. • With projected sea level rise will experience approximately 1 m depth inundation in 2110 Properties in Frederick Street and east of Kempton Street – land levels at approximately 3.3 m AHD. • Flood immunity to 100 yr ARI flood level in present day, 2030, 2070. • With projected sea level rise will experience approximately 0.5 m depth inundation in 2110 Inundation risk to minor City infrastructure in the foreshore reserve	Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures specified in a LCPP (Section 15). Options include: • Notification on Title • Building Design • Appropriate Finished Floor Levels • Filling Land Short term inundation of the foreshore reserve in large events is acceptable. Monitor for safety following impacts.
Section 2. Fuller Street to Champion Bay Rise	Inundation is contained within the Foreshore reserve and does not impact Kempton Street or Houses Inundation risk to minor City infrastructure in the foreshore reserve	Short term inundation of the dunes / beach and foreshore reserve in large events is acceptable. Monitor for safety following impacts
Section 3. Champion Bay Rise to Elphick Avenue / North of Rundle Park	Inundation is contained within the Foreshore reserve and does not impact Kempton Street or Houses. Inundation risk to minor City infrastructure in the foreshore reserve	Short term inundation of the dunes / beach and foreshore reserve in large events is acceptable. Monitor for safety following impacts
Section 4. St Georges Beach and Rundle Park	Inundation is contained within Rundle Park Foreshore area. Inundation risk to City infrastructure in the foreshore area of Rundle Park. No inundation risk for Kempton Street or Houses	Short term inundation in large events is acceptable. Monitor for safety following impacts

6.3.2 Adaptation Approaches by Asset

A suite of adaptation approaches and recommendations to mitigate the erosion and inundation risk to assets in the Bluff Point coastal compartment is summarised in Table 6.5. These have been developed from the adaptation tools listed in the Avoid-Managed Retreat -Accommodate-Protect categories in Section 2.

Table 6.5: Adaptation Options – Bluff Point CMU

Asset / Location	Erosion	Inundation
Existing Houses	**Accommodate / Managed Retreat** • Place notification on title (Ac.1) at redevelopment or time of sale Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme) For 13 properties in the CMU, Managed Retreat classification will be imposed Monitor erosion of coast against projected rate of future erosion	No risk for properties south of Fuller St. For the properties north of Fuller Street, **Accommodate** inundation consistent with planning timeframes to 2110 through • Notification on title (Ac.1) • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.4) • Filling Land (Ac.5)
Infill Development (based on SPP2.6 Definition)	Allow infill development on vacant properties in the identified coastal hazard area of the SCA. Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (Moderate, High or Extreme)	No risk for properties south of Fuller St. For the properties north of Fuller Street, **Accommodate** inundation, dependant on inundation level of lot and based on planning horizon (Ac.1 Ac.2 Ac.4 Ac.5)
Undeveloped residential land, North of Fuller St (Non-Infill)	**Avoid** development in identified coastal hazard area (Av1).	**Avoid** development in identified coastal hazard area (Av1).
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts Under long term sea level rise (2070 to 2110|) emergency planning for evacuation routes may be required (Ac.3)
Carparks	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Nazareth House	**Managed Retreat** - Allow the coast to erode naturally (MR.1), monitor erosion of shoreline against projected rates and consider future protection to protect the asset (forecast timeframe 2070 to 2110).	No Risk - Not impacted by inundation in the 100 years planning period (note flooding from Chapman River catchment processes not considered)
Rundle Park foreshore areas and facilities	**Managed Retreat** - Assess **Protect** option in further detail (TPIR.4, Pr.1, Pr.2) based on further detailed analysis of the cost and benefit.	Negligible Risk – current risk of inundation is low (MR.1). In future planning periods, short term inundation in large events is acceptable. Monitor for safety following impacts
Beach /Dunes	**Managed Retreat** Monitor erosion to identify local areas that are rapidly eroding or dune blowouts. Increase resilience through planting programs (PR.5). Apply	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

Asset / Location	Erosion	Inundation
	Temporary Protect and Resilience Building measures (e.g. TPIR1, TPIR2, TPIR3, TPIR4) to prevent erosion of landside areas.	
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts.
Cycle / Walking Paths	**Managed Retreat** - Allow the coast to erode naturally, and monitor paths to ensure safety. Rebuild over time as required, adopting setback level consistent with design life (MR.1 MR.2)	Short term inundation in large events is acceptable (MR.1). Design for inundation (Ac.2) Monitor for safety following impacts.
Midden Site, Bluff Point	**Managed Retreat** - Require specialist heritage advice regarding management of registered aboriginal site (AHIS site 4762) in a managed retreat approach. Monitor coastal erosion to identify erosion rate as a priority. Increase resilience through Temporary Protect and Resilience Building measures (TPIR1, TPIR2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

6.4 Economic Analysis – Adaptation options for Rundle Park and St Georges Beach

An economic assessment of adaptation options to protect the Rundle Park and St Georges Beach section of the coast from coastal erosion was undertaken due to the high value of this section of coast to the community identified in the stakeholder engagement process.

The economic assessment applied multi-criteria analysis and cost benefit analysis to support decision

Item	Comments
	o Preliminary Engineering study for design of protect option ($40,000).
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG -Additional studies for a coastal protection option at St Georges Beach to confirm assumptions in economic analysis and community acceptance of option. CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP CGG – Lead and support projects that build coastal resilience for foreshore areas and dunes
Performance Measures by which the plan can be evaluated	Updated Local Coastal Planning Policy that can effectively address managed retreat implementation for existing development. Effective monitoring campaign that leads to improved understanding of coastal erosion processes, developed knowledge of the rate and format of coastal changes through the CMU. Implementation of targeted programs to build resilience in foreshore areas that are successful in maintaining the existing coastal buffer. Mitigation of coastal erosion risk for St Georges beach and Rundle Park with Community support for the approach.

6.5.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for the CMU is recommended to include the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach and potential erosion of the shoreline. Key locations to include:
    - North of the Beresford coastal protection structures;
    - St Georges Beach in front of Rundle Park;
    - North of Rundle Park – Elphick Avenue to Champion Bay Rise; and
    - Shoreline north of Fuller Street to Chapman River mouth.
2. Beach transect analysis should be supplemented by UAV capture of shoreline elevation at lower capture frequency (e.g. bi-annually). This will be used to assess volumetric changes for specific shoreline areas of focus (e.g. St Georges Beach)
3. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.
4. Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events.
5. Photo monitoring of the beach (continuation of NACC photomon program)

6. Inspection of minor structures (e.g. access, shelters etc) in the foreshore area directly exposed to coastal erosion and inundation for condition / safety twice yearly and after large storm events
7. Inspection of Geotextile breakwater at St Georges Beach for condition and performance at minimum twice yearly and after large storm events

It is proposed that the cost of annual monitoring could be eligible for 50% funding via the DoT CAP grants (outlined in Section 15.4).

The City should also examine ways in which community groups and schools can be involved in future monitoring and management of coastal areas (e.g. replanting programs).

7. Beresford (CMU5)

7.1 Adaptation Summary and Recommendations

The Beresford Coastal management unit (CMU) covers the 2km section of shoreline north of the Batavia Coast Marina. The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- After several years of investigations and analysis, the City committed to foreshore protection works under the *Beresford Foreshore Coastal Protection Project*, to address coastal erosion and protect this section of coast for the long term.
    - The coastal erosion hazard in the CMU will impact 0 properties in the 2018 (current) to 2110 period because of the coastal protection measures in place and the City's decision to Protect this section of coast.
- The natural land level through the northern section of the CMU is set above the storm surge and sea level rise scenarios. However, low-lying properties and roads in the coastal areas in the south of the CMU from the Chapman Rd / Phelps St roundabout and extending through the properties along Chapman Rd, Flour Key and Urch St. are at risk of inundation in extreme events and under future sea level rise scenarios.
    - The number of residential and commercial properties which are within the 500yr ARI inundation extent for respective planning periods in the CMU is forecast as 30 properties at year 2030, 35 properties at year 2070 and 63 properties at year 2110.

Coastal hazard risk management and adaptation planning (CHRMAP) has been completed for the assets identified as being at risk in the Beresford Coastal Management Unit. Risk mitigation strategies have been determined from options presented in the coastal adaptation hierarchy of Avoid, Managed Retreat, Accommodate or Protect. The key CHRMAP recommendations for the management of the CMU are summarised as follows:

Residential and Commercial Development

- The general approach to manage erosion risk is **Protect** achieved through the revetment structures constructed through the Beresford Foreshore Protection Project. This will apply for all City infrastructure, private property and foreshore areas.
- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
    - Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation;
    - **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures specified in the LCPP;

CGG coastal infrastructure:

- The general approach to manage erosion risk is **Protect** achieved through the revetment structures constructed through the Beresford Foreshore Protection Project. This will apply for all City infrastructure, private property and foreshore areas.

Monitoring and Management

- The revetment structures are discontinuous and for structural integrity and to maintain a continuous protection of areas landward, the CGG will be required to commit to monitoring and active management in the area. Monitoring of the shoreline response and coastal processes post construction of the revetments will be a key requirement;
- The sand nourishment program for the northern beaches delivered by the Geraldton Port Authority will be required to continue to support the ongoing requirements for sediment supply to the CMU

The Long-term adaptation pathway for the assets in the CMU that are at risk of inundation is Accommodate. It is noted that based on the risk assessment presented in Baird 2019, there are no assets in the Beresford CMU that are rated at High or Extreme risk in the planning period to 2110.

7.1.1 Coastal Erosion Hazard

The coastal compartment of Beresford has historically experienced erosion of its foreshore areas. After several years of investigations and analysis, the City committed to foreshore protection works under the *Beresford Foreshore Coastal Protection Project*, to address coastal erosion and protect this section of coast for the long term. The $23.1 million project was jointly funded by Royalties for Regions, Mid-West Ports Authority and the City (CGG 2018) involving:

- three shore based rock revetments constructed to mitigate erosion (~800m total length)
- a protective 100m breakwater extension to the existing detached breakwater and a 45m extension to the existing groyne
- significant sand nourishment and reprofiling of Midalia's Beach (with coarse sand)
- planting of approximately 80,000 native coastal seedlings to stabilise the foreshore

Construction of the revetment structures was completed in early 2018, with the landscaping and amenities due for completion in the latter half of 2018.

The City has worked through a number of previous studies and options assessments to arrive at its decision to adopt a **Protect** position against coastal erosion in the CMU (CGG2017a). Whilst the revetment structures are not continuous along the coast, the integrity of the revetments requires the unprotected shoreline to maintain their position. This will require an ongoing commitment from the city to maintain the structures and to ensure the unprotected sections of the shoreline between the revetments hold their position. Under this assumption, the entire coastal compartment is acknowledged in the CHRMAP as protected against erosion in the future.

In Appendix A.1 mapping of coastal erosion allowances for the CMU shows there are no coastal erosion setback lines assigned, with the shoreline assumed to be maintained in its current position through the protection structures in future. The infrastructure and assets landward of the shoreline areas are considered to be protected from coastal erosion. It is noted that the structures are designed for an approximate 50-year design life (~2070) and as well as the commitment to maintain and monitor the structures now, the CGG should reserve funds for the future to rebuild the protection structures at the end of their design life.

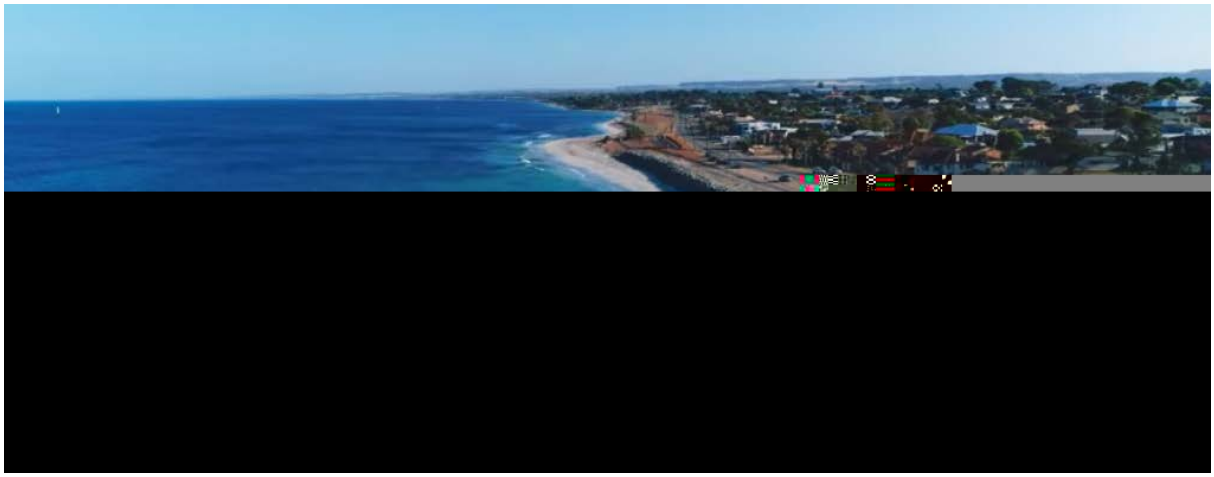

Figure 7.1: Southern revetment structure, looking north along Chapman Road (CGG 2017b)

Under ministerial Act, Mid-West ports will continue to supply sand to the northern beaches from Beresford CMU to Chapman River, to maintain the natural longshore transport processes interrupted by the port. The Beresford Foreshore project design aims to maintain the new shoreline alignment, with no impediment on the natural sediment flow northward.

Monitoring of the Beresford shoreline profile will be important, to confirm the long-term stability of the shoreline post construction of the revetment structures, and to ensure the coastal dynamics for the Bluff Point CMU immediately to the north are unchanged.

7.1.2 Coastal Inundation Hazard

Storm surge inundation hazard for the 2110 planning year, 500yr ARI event is presented in Appendix A.2. The natural land level through the northern section of the CMU is set above the storm surge and sea level rise scenarios. However, low-lying properties and roads in the coastal areas in the south of the CMU from the Chapman Rd / Phelps St roundabout and extending through the properties along Chapman Rd, Flour Key and Urch St. are at risk of inundation in extreme events and under future sea level rise scenarios.

There are a range of utilities infrastructure that is affected by coastal inundation risk at the southern end of the CMU in future planning periods. Based on the mapping presented in Appendix A.3:

- One Water Corp. pump station is located in the design flood extent (500yr ARI inundation in year 2110).
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, ATCO gas lines and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the design flood extent (500yr ARI inundation in year 2110).

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their inundation risk.

7.2 Beresford Coastal Adaptation

7.2.1 General Recommendations

A summary of the inundation risk for the Beresford CMU is presented in Table 7.1 with general adaptation strategies recommended through the CHRMAP process.

Table 7.1: Coastal Adaptation Summary – Beresford CMU, Inundation Risk

Location	Key Considerations	Adaptation Strategy
Low Lying Southern section of CMU	Properties in south of CMU at Chapman Rd, Phelps St, Urch St, Flour Key zoned 'Mixed Use'. Land levels at approximately 2.8 m - 3.0 m AHD. • Flood immunity to 100 yr ARI flood level in 2030. • With projected sea level rise will experience approximately 1m depth inundation in 2110	Accommodate inundation risk to property to ensure risk is mitigated over the planning time frame through design and planning measures (Section 15) outlined in LCPP. Options include: • Notification on Title • Building Design • Appropriate Finished Floor Levels • Filling Land
	Section of Chapman Rd north of the Phelps St Roundabout. • Flood immunity to 100 yr ARI flood level in 2030. • With projected sea level rise will experience approximately 1 m depth inundation in 2110	Short term inundation of road in large events is acceptable. Monitor for safety following impacts. Emergency planning measures to be developed for future planning periods where depth of inundation may pose a risk to vehicles.
	Inundation risk to minor City infrastructure in the foreshore reserve	Short term inundation of infrastructure in the foreshore reserve in large events is acceptable. Monitor for safety following impacts.

7.2.2 Adaptation Approaches by Asset

A suite of adaptation approaches and recommendations to mitigate the inundation risk to assets in the Beresford coastal compartment is summarised in Table 7.2. These have been developed from the adaptation tools listed in the Avoid-Managed Retreat -Accommodate-Protect categories in Section 2.

Table 7.2: Adaptation Options – Bluff Point CMU

Asset / Location	Erosion	Inundation
Industrial / Commercial Premises Chapman Rd / Phelps St / Flour Key	No Risk	**Accommodate** inundation consistent with planning timeframes to 2110 through • Notification on title (Ac.1) • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.4) • Filling Land (Ac.5)
Infill Development (based on SPP2.6 Definition)	No Risk	**Accommodate** inundation, dependant on inundation level of lot and based on planning horizon (Ac.1 Ac.2 Ac.4 Ac.5)
Roads	No Risk	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts For sections of road inundated in future planning periods, emergency plan to be designed to control risk to vehicles in floodwaters.

Asset / Location	Erosion	Inundation
		Emergency evacuation routes to be determined based on access to flooded sections of main transport routes (Marine Terrace, Chapman Street).
Carparks	No Risk	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach /Dunes	Port Authority to Continue to supply sand from Pages Beach	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach Access Paths	No Risk	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts.
Cycle / Walking Paths	No Risk	Short term inundation in large events is acceptable (MR.1). Design for inundation (Ac.2) Monitor for safety following impacts.

7.3 Implementation

7.3.1 Short Term Implementation Plan

The short-term implementation plan for Beresford CMU over the 15-year period to 2032 is provided in Table 7.3.

Table 7.3: Beresford CMU Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	The CMU has adopted a Protect approach for coastal erosion following completion of the Beresford foreshore Coastal protection project (2018). Coastal inundation affecting commercial and industrial properties in the south of the CMU is to be Accommodated.
Aim and strategic direction for coastal management	The revetment structures are discontinuous and for structural integrity and to maintain a continuous protection of areas landward, the CGG will be required to commit to monitoring and active management in the area. Monitoring of the shoreline response and coastal processes post construction of the revetments will be a key requirement. Monitor sea level rise and extreme storm surge flooding events, to compare against projected inundation. Knowledge sharing. The large-scale planting of native seedlings in this section of the coast to stabilise the foreshore offers a valuable insight for other sections of the Geraldton foreshore recommended for natural protection options (e.g. Bluff Point CMU, Drummond Cove CMU). Re-assess further the inundation risk following the foreshore works as land levels may have changed since the NACC LiDAR.

Item	Comments
Timing of adaptation response and trigger point at which adaptation commences	No Triggers set
Indicative cost of preferred adaptation option	Maintenance of revetment structures will be an ongoing cost to the City Assumed GPA will continue to supply sand to the CMU without cost to the City
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach (Accommodate inundation risk). It is recommended to: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. • For properties with identified inundation risk, accommodate inundation through planning and design measures. CGG – Monitoring program to examine shoreline changes at revetments and in sections of coast not covered by revetment
Performance Measures by which the plan can be evaluated	Updated Local Coastal Planning Policy that can effectively address inundation risk for future planning purposes. Effective monitoring campaign that leads to improved understanding of coastal processes, developed knowledge of the rate and format of coastal changes through the CMU.

7.3.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for the CMU is recommended to include the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach and potential erosion of the shoreline. Key locations to include:
   - In front of revetments
   - Compartmentalised beaches (gaps between revetments)
2. Beach transect analysis should be supplemented by UAV capture of shoreline elevation at lower capture frequency (e.g. bi-annually). This will be used to assess volumetric changes for specific shoreline areas
3. Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events.
4. Photo monitoring of the beach (e.g. NACC photomon program)
5. Inspection of Revetments for condition and performance after large storm events

8. Geraldton Town Centre (CMU6)

8.1 Adaptation Summary and Recommendations

The Geraldton Town Centre management unit covers the shoreline from the Fishermans Marina (east of Pages Beach) to the north of Batavia Coast Marina. The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- The town centre shoreline is protected against erosion, with rock structures in place to protect the port and Batavia Marina, as well as a range of protection measures in place along the shorelines of the Town Centre including buried seawalls, rock groynes and sand nourishment;
    - The coastal erosion hazard in the CMU will impact 0 properties in the 2018 (current) to 2110 period because of the coastal protection measures in place and the City's decision to Protect this section of coast.
- The general land levels along the shoreline and in the developed sections of coast adjacent the shore make the CMU susceptible to extreme storm surge inundation. The general tides pose no threat of inundation to the town centre, however there is a risk of inundation under extreme storm surge events, which increases in future planning periods under projected sea level rise.
    - The number of residential and commercial properties which are within the 500yr ARI inundation extent for respective planning periods in the CMU is forecast as 328 properties at year 2030, a further 22 properties at year 2070 (350 total) and a further 40 properties at year 2110 (390 total).

The key CHRMAP recommendations for the management of the Geraldton Town Centre CMU are summarised as follows:

Residential and Commercial Development

- The City has adopted a **Protect** position against coastal erosion in the CMU and it has been assumed for the CHRMAP this continued commitment will protect the infrastructure and assets landward of the shoreline areas from coastal erosion;
- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP;

CGG coastal infrastructure:

- Coastal protection infrastructure is managed by the DOT and the port (Town Beach Groynes, Batavia Marina and Port coastal protection elements) and these will require an ongoing commitment to continue this protection for assets landward of the CMU.
- The town beaches will require on-going sand nourishment, and the program currently undertaken by the Port Authority to provide sand extracted from Pages Beach will need to be continued to ensure sediment supply into the CMU and to maintain beach amenity;
- The general approach to managing coastal inundation risk for all City infrastructure is **Accommodate**. The approach will allow use of asset to continue, with future inundation risk to be managed through

appropriate planning measures and building design and emergency planning in low lying areas during extreme events;

A preliminary calculation of the potential impacts associated with coastal inundation of the residential and commercial premises in the town centre over the 50-year period to 2070, estimates the present value of damages at $3.5 million. Whilst there are a number of limitations on this assessment, it provides a reasonable basis for understanding the cost of inundation risk, and when an adaptation option against flooding (e.g. dike, raised seawall), would become economically viable.

It is recommended the City undertake a detailed overland flood study to more appropriately define current and future flood levels throughout the SCA before setting finished floor level for new structures in the planning requirements. The flood depths from CHRMAP have been developed based on bathtub flooding using the NACC LiDAR from 2013 and flood levels are likely to be overly conservative with distance inland from the coastline. The flood study would provide confidence around planning levels and adaptation options for flood control could be further assessed.

Monitoring and Management

It is essential that maintenance of coastal protection structures and continuation of the sand nourishment program currently delivered by the Geraldton Port Authority and DoT continue to support the ongoing requirements for protection and sediment supply to the CMU.

The Long-term adaptation pathway for the assets in the CMU that are at risk of inundation is Accommodate. The assets at highest risk in the CMU are summarised in Table 8.1 along with the adaptation approaches that are recommended to manage the risk.

Table 8.1: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Geraldton Port Land areas	M	M	H	H	Mid-West Ports	Outside of CHRMAP to determine
Houses - Marine Terrace, Foreshore Drive	M	M	H	H	Private	City to establish Special Control Area (SCA) and a Local Coastal Planning Policy (LCPP) will provide guidance on development standards which must be met to respond to the risk of coastal inundation Emergency response planning measures to be developed for future planning periods
Houses - Low Lying Block of Marine Terrace, Crowther, Duboulay, Burgess, Shenton, Cunningham St	H	H	E	E	Private	
Business and Commercial Premises in CBD at low lying section cnr Foreshore Drive and Marine Terrace	H	H	E	E	Private	
Business and Commercial Premises in CBD General	M	H	H	H	Private	

There is extensive concentration of utilities infrastructure that is affected by coastal inundation risk throughout the CMU in current and future planning periods. Based on the mapping presented in Appendix A.3:

- There are 7 Water Corp. pumping stations that is located through the CMU that will be at risk of inundation in extreme event in futre planning periods.
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling and ATCO gas lines are also located in the inundation hazard throughout the CMU.

It is noted that utilities infrastructure is privately owned and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk.

8.2 Geraldton Town Centre Coastal Hazard

8.2.1 Coastal Erosion Hazard

The town centre shoreline is protected against erosion, with rock structures in place to protect the port and Batavia Marina, as well as a range of protection measures in place along the shorelines of the Town Centre including buried seawalls, rock groynes and sand nourishment.

The City has adopted a **Protect** position against coastal erosion in the CMU and it has been assumed for the CHRMAP this continued commitment will protect the infrastructure and assets landward of the shoreline areas from coastal erosion. The beaches will require on-going sand nourishment, and the program currently undertaken by the Port Authority to provide sand extracted from Pages Beach will need to be continued to ensure sediment supply into the CMU and to maintain beach amenity.

It is noted that the CHRMAP is focussed specifically on the coastal areas and assets that are under the control of the CGG. Within the CMU the Batavia coast Marina in under the control of the Department of Transport and the Geraldton Port is under the control of Mid-West Ports. There are coastal protection features in place in these sections of the coast that are not the responsibility of the CGG.

- The Batavia Coast Marina and associated protection structures provide protection to the landside areas which include both commercial and residential property as well as CGG infrastructure. It has been assumed that the DoT will continue to maintain the current level of erosion protection for all coastal assets landward in future planning periods, with no commitment from the CGG.
- The Geraldton Port maintains coastal protection structures and berth areas that provide hard protection against coastal erosion for all infrastructure landward. This includes the Main Roads corridor and railway lines that service the port as well as industrial areas that are located on the south side of the port around Marine Terrace. It has been assumed that the DoT will continue to maintain the current level of erosion protection for all coastal assets landward in future planning periods, with no commitment from the CGG.

8.2.2 Coastal Inundation Hazard

The Geraldton Town Centre shoreline interface comprises port infrastructure, foreshore parks, the Batavia Coast Marina and its developed areas (residential / commercial). The general land levels vary in the foreshore area, with elevation increasing moving north from the port to the Batavia marina. The general tides pose no threat of inundation to the town centre, however there is a risk of inundation under extreme storm surge events.

The storm tide levels for future planning horizons are shown in Table 8.2 and in Figure 8.1 the approximate level of the land elevation in the foreshore is shown, indicating the level of flood immunity offered to the inland sections of coast.

The existing level of the shoreline areas shown in Figure 8.1, is high enough to provide flood immunity against the 20yr ARI event (2.0m AHD in the present day). For large storm tide events such as the 100yr

ARI (2.9m AHD) or the 500yr ARI (3.6m AHD), these would lead to significant flooding of the foreshore and inland areas.

- The land level in the foreshore area is lowest around the port, at approximately 2.0m AHD and moving north through the foreshore parks the land levels increase to between 2.2m AHD to 2.7m AHD.
- Referring to the levels indicated in Figure 8.1, a 20yr ARI storm tide level in the present day of 2.0m AHD would be held back by the general level of the shoreline interface. In the planning year 2110 with 0.9m sea level rise, the 20yr ARI water level would be at a height of 2.9mAHD and this storm tide level would not be contained by the shoreline at its current level.
- Under assumed sea level rise scenarios, the immunity that the shoreline areas provide today against a small storm tide event (20yr ARI) will be reduced. Similarly, sea level rise assumed in future planning periods will result large storm tide events (100yr and 500yr ARI) impacting progressively larger areas and infrastructure within the CMU as the flooding pushes further inland.

Figure 8.1: Indicative Level of Foreshore Areas (From NACC LiDAR, Datum mAHD)

Table 8.2: Geraldton Town Centre – Extreme Water Level

Year	2015	2030	2070	2110
20yr ARI	2.0m AHD	2.1m AHD	2.4m AHD	2.9m AHD
100yr ARI	2.9m AHD	3.0m AHD	3.3m AHD	3.8m AHD
500yr ARI	3.6m AHD	3.7m AHD	4.0m AHD	4.5m AHD

It is noted that under SPP2.6 requirements, the extent of inundation impact from a 500yr ARI inundation event in the 2110 planning year requires consideration and this event has been assessed in CHRMAP and flood extents are shown in the mapping in Appendix A.2.

For discussion in this section there are two design flooding cases selected to illustrate flooding impacts for the CMU:

- the 100yr ARI event in the planning year 2110 at a level of 3.8mAHD (includes 0.9m sea level rise) as shown in Figure 8.2.
- the 100yr ARI event in the planning year 2030 at a level of 3.0mAHD (includes 0.1m sea level rise) as shown in Figure 8.3.

The selection of these two events is to provide an overview of the flood risk for a case which is at the high range of the return period cases in Table 8.2 (100yr ARI selected over the most extreme 500yr), and to demonstrate the impact of sea level rise.

The mapping in Figure 8.2 shows the depth of inundation associated with the 100yr ARI event in the planning year 2110 at a level of 3.8mAHD (includes 0.9m sea level rise). The key areas that are at risk of inundation in the 100year planning period shown in Figure 8.2 are summarised in Table 8.3.

Figure 8.2: Geraldton Town Centre - showing the depth of inundation at the peak of a 100yr ARI event in 2110 (Storm tide level of 3.8m AHD)

Table 8.3: Inundation impacts for Geraldton Town Centre from 100yr ARI event in 2110

Location	Inundation Impacts for the 100yr ARI storm tide event, 2110
1 Marine Terrace[1]	Marine Terrace >1.5m depth of flooding
2 Low Lying Residential Properties	The largest flooding impact for residential property is to the low-lying section of land in the section bound by Marine Terrace, Crowther Street, Deboulay St, Burgess Terrace, Shenton St, Cunningham Street. Depth of flooding in 2110 is >1m through the area generally and >1.5m depth adjacent Marine Terrace The flood pathway is through the port area and across Marine Terrace which is at its lowest point in this section.
3 Foreshore Areas	Inundation depth of 1m to 1.5m across the foreshore parks and playground areas

Table 8.4: Coastal Adaptation Summary – Geraldton Town Centre CMU, Inundation Risk

Location	Adaptation Strategy
Geraldton Port	Outside of CHRMAP scope to make recommendations. Mid-West Port Authority to undertake their own risk assessment to determine future adaptation approaches to manage coastal hazard risk.
Batavia Coast Marina	Outside of CHRMAP scope to make recommendations. Department of Transport to undertake their own risk assessment to determine future adaptation approaches to manage coastal hazard risk.
Low Lying Residential Properties, Commercial and Industry sites Foreshore Areas Central Geraldton Landward of Batavia Marina (incl Museum, high-rise residential, commercial, development land)	Accommodate inundation risk to property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP (Section 15). Options include: • Notification on Title • Building Design • Appropriate Finished Floor Levels • Filling Land • Emergency evacuation Short term inundation of roads in large events is acceptable. Monitor for safety following impacts. Emergency response planning measures to be developed for future planning periods where depth of inundation may pose a risk to vehicles. Evacuation routes and access for emergency services to be determined based on flood depth.

8.3.2 Adaptation Approaches by Asset

In Table 8.5, a summary of adaptation approaches and recommendations to mitigate the erosion and inundation risk to assets in the Geraldton Town Centre coastal compartment are presented, based on the key assets at risk identified in the hazard assessment (Baird 2019).

Table 8.5: Adaptation Options by Asset – Geraldton Town Centre

Asset / Location	Inundation
Commercial and residential properties	For all residential and commercial properties, **Accommodate** inundation consistent with planning timeframes to 2110 through • Notification on title (Ac.1) • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.4) • Filling Land (Ac.5) • Emergency Evacuation (Ac.3)
Infill Development (based on SPP2.6 Definition)	**Accommodate** inundation, dependant on inundation level of lot and based on planning horizon (Ac.1 Ac.2, Ac.3, Ac.4 Ac.5)

Asset / Location	Inundation
Roads	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts For sections of road inundated in future planning periods, emergency plan to be designed to control risk to vehicles in floodwaters. Emergency evacuation routes to be determined based on access to flooded sections of main transport routes (Marine Terrace, Chapman Street).
Carparks	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Foreshore areas and facilities	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts Building design to factor in inundation risk in future planning periods
Beaches	Short term inundation in large events is acceptable. Monitor for safety following impacts
Cycle / Walking Paths	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts.

8.4 Geraldton Town Centre Economic Assessment of Adaptation Options

A preliminary calculation of the potential impacts associated with coastal inundation of the residential and commercial premises in the town centre over the 50-year period to 2068 is presented in **Appendix A.5**. The assessment is based on examination of the depth of flooding that would impact the properties from the 20yr ARI and 100yr ARI scenarios under assumed sea level rise. Damages are assessed based on typical residential, commercial and industrial damage curves, with the present value of damages estimated at $3.5 million. It is important to note that under assumed climate change (sea level rise) there will be continually increasing damages for inundation. Using a starting year of 2028, the 50 year estimate of damages would increase to $4.5 million in present value.

Whilst there are a number of limitations on this assessment, it provides a reasonable basis for understanding the cost of inundation risk to the City centre and provides input to the decision making of where and when an adaptation option against flooding (e.g. dike, raised seawall), would become economically viable. For the estimated $3.5 million of damages, it is not warranted to pursue large scale adaptation options that will flood proof the City. However, targeted outcomes for low lying sections of the CMU, where civil design could additionally provide flood protection (e.g. raising roads as part of general replacement works) should be investigated further. In addition, a key recommendation of this CHRMAP is a more detailed assessment of the flood impacts on the town centre as the methodology adopted in MRA (2017) does not account for changes in flood levels with distance from the coastline.

For future planning periods, development within the CMU will need to factor the inundation risk into the development process. In the absence of a protection structure for the coastal area, there will likely be a requirement to initiate an emergency evacuation plan for residents in low lying areas, and as part of the emergency procedures, a number of key access routes (Marine Terrace, Chapman Rd) will likely need to be closed.

8.5 Planning Levels – Finished Floor Levels

It is recommended the City undertake a detailed overland flood study to more appropriately define current and future flood levels throughout the SCA before setting finished floor level for new structures in the revised planning requirements that will support the SCA. The flood depths from CHRMAP have been developed based on bathtub flooding using the NACC LiDAR from 2013 and flood levels are likely to be overly conservative with distance inland from the coastline. The flood study would provide confidence around planning levels and adaptation options for flood control could be further assessed.

Following the detailed overland flood study the CGG will be required to adopt a position with regards the level it will require all finished floor levels to be developed for new structures going forward. In accordance with SPP2.6 the inundation from a 500yr ARI inundation event in the planning year 2110 has been considered for the CMU, as well as lower return periods at the 20yr and 100yr level. This is summarised in Table 8.2 with the 500yr ARI level in 2110 at 4.5mAHD, 100yr ARI at 3.8mAHD and 20yr ARI at 2.9mAHD. The City must determine the level of risk they are willing to accept in future extreme events over the 100-year planning period. The City may decide that for high value critical infrastructure (e.g. hospitals, emergency services), the 500yr ARI level be adopted, but that they are willing to accept the 100yr ARI with appropriate allowance for freeboard (e.g. +0.4m) for general planning purposes. This decision will be informed from the outcomes of the detailed overland flood study as well as the need to consider the floor levels in existing development within the CMU.

Prior to a detailed overland flood study being completed. It is recommended that development specific assessments are undertaken, until completion of a comprehensive overland flood study which can specify more appropriate flood levels throughout the SCA.

8.6 Implementation

8.6.1 Short Term Implementation Plan

The short-term implementation plan for Geraldton Town Centre is outlined in Table 8.6.

Table 8.6: Geraldton Town Centre CMU Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	The CMU has adopted a Protect approach for coastal erosion Coastal inundation risk is to be Accommodated through a range of planning, design and emergency management measures to be developed as part of the LCPP. City to undertake a detailed overland flood study to define current and future flood levels throughout the SCA before setting finished floor level for new structures in the revised planning requirements that will support the SCA.
Aim and strategic direction for coastal management	Continue to maintain the coastal protection measures in place to defend the shoreline from erosion. Sediment supplied by the GPA from Pages Beach as part of the northern beaches program needs to be used to nourish the town beaches in the CMU Monitor rate of sea level rise against projected rates adopted in the inundation studies. Analyse extreme storm surge flooding events that impact the town, to examine scale of storm surge and inundation outcomes.
Timing of adaptation response and trigger point at which adaptation commences	No Triggers set

Item	Comments
Indicative cost of preferred adaptation option	Further planning based studies to assess Emergency access and evacuation requirements Detailed overland flood study to define current and future flood levels throughout the SCA to be applied in planning policy finished floor level recommendations (estimated $60,000)
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG – undertake detailed flood study to define the current and future flood levels in the CMU CGG – continued maintenance of coastal protection structures GPA - sand nourishment program currently delivered by the Geraldton Port Authority will be required to continue to support the ongoing requirements for sediment supply to the CMU
Performance Measures by which the plan can be evaluated	Updated planning policy that can effectively address inundation risk for future planning purposes.

8.6.2 Monitoring

Monitoring within the CMU is recommended to include the following:

- Review sea level rise guidance from the IPCC and / or position statements from the DoT will need to be considered in future CHRMAP revisions (nominally every 5 years).
- Undertake site specific survey of key flood control features (e.g. drains / culverts) and define finished floor levels through the CMU in low lying areas to better understand the inundation risk in extreme events.

9. Point Moore (CMU 7)

9.1 Adaptation Summary and Recommendations

The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- The south side of Point Moore is presently eroding at a rate of 0.6m annually, whilst the west and north side of Point Moore is accreting (MRA 2015). The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 shows a far more severe (i.e. wider) setback on the southern side of Point Moore compared to the west and north in recognition of the erosion and accretion processes in these respective shorelines. There are a significant number of coastal assets at risk of erosion in future planning periods including:
    - Residential property;
    - Foreshore Reserve and Park at Point Moore and Pages Beach;
    - Volunteer Rescue;
    - Roads (Marine Terrace) and Carparks (Greys Beach East, Pages Beach, Point Moore);
    - Foreshore infrastructure (toilets, shelters, benches, fencing);
    - Cycle and walking paths; and
    - Dunes and beaches.
- Coastal inundation risk from large storm events and sea level rise in future planning periods is a significant risk in the CMU – the natural land level across Point Moore does not offer topographic relief from extreme storm surge events.

The key CHRMAP recommendations for the management of the Point Moore CMU are summarised as follows:

Residential and Commercial Development

- The Point Moore CMU was the subject of a separate CHMRAP based assessment completed in 2017 by CGG. The process extended lease agreements for Point Moore residents under specified managed retreat conditions based on erosion and inundation. The LCPP will need to include the outline the managed retreat conditions applied to the properties under the lease agreements.
    - The coastal erosion hazard in the CMU is forecast to impact 0 properties by 2030 (Extreme Risk), 1 property in the 2030 to 2070 period (High Risk) and a further 61 properties in the 2070 to 2110 period (moderate Risk).
    - The number of residential and commercial properties which are within the 500yr ARI inundation extent for respective planning periods in the CMU is forecast as 272 properties at year 2030, 280 properties at year 2070 and 284 properties at year 2110.

CGG coastal infrastructure:

Risk mitigation strategies for remaining assets have been determined from options presented in the coastal adaptation hierarchy of Avoid, Managed Retreat, Accommodate or Protect. The key CHRMAP recommendations for the management of the CMU are summarised as follows:

- The general approach to manage erosion risk is **Managed Retreat**. This will apply for all City infrastructure, and foreshore areas. The approach will set erosion triggers that allow the use of coastal assets to continue until coastal erosion of the shoreline reaches a threshold distance from the respective asset:

  - Council maintained roads, pathways, foreshore infrastructure (BBQs, toilets, shelters etc). Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;
- The CGG constructed a coastal protection structure on the south side of Point Moore in 2014 which has stabilised this section of the shoreline, following progressive erosion of the shoreline. The maintenance of this structure in the short term (to 2030) is supported consistent with the design life of the structure. It is noted the coastal protection has not been recognised as a long-term feature in the coastal erosion setback for Point Moore; and
- The foreshore and dune areas surrounding Point Moore offer a critical natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Active monitoring and nature-based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are strongly recommended. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 9.1, based on the risk assessment process completed (Baird 2019). The adaptation timelines in Table 9.1 are based on projected erosion setback lines (Appendix A.1).

Table 9.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Point Moore CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Property South Side Pt Moore	MANAGED RETREAT								
Marine Terrace South Side	MONITOR	MANAGED RETREAT							
Marine Terrace West Side									
Point Moore Lighthouse	MONITOR					MANAGED RETREAT			
Lighthouse Keepers Cottage	MONITOR					MANAGED RETREAT			
Toilets Pages Beach	MONITOR						MAN.RETREAT		
Car Park Pages Beach	MONITOR					MANAGED RETREAT			
Foreshore Park Pages Beach	MON.					MANAGED RETREAT			
Foreshore Park Point Moore	MON				MANAGED RETREAT				
Volunteer Rescue / Toilets	MON				MANAGED RETREAT				
Carpark Point Moore	MONITOR				MANAGED RETREAT				
Toilets Point Moore	MONITOR and BUILD RESILIENCE (Nature Based Options)								
Trees and Coastal Vegetation	MONITOR and BUILD RESILIENCE (Nature Based Options)								
Cycle and Walking Paths (South)	MON	MANAGED RETREAT							

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

The assets at highest risk in the CMU are summarised in Table 9.2,along with the adaptation approaches that are recommended to manage the risk.

Table 9.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Property South Side Pt Moore	M	M	H	E	Private	Addressed in Lease Agreements through Managed Retreat Triggers
Marine Terrace South Side	H	E	E	E	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Marine Terrace West Side	M	M	H	H	CGG	
Point Moore Lighthouse	H	H	E	E	AMSA	Active monitoring of erosion south of Point Moore. Current buffer to erosion of > 130m allows significant lead time to consider protect / re-siting options in future planning periods.
Lighthouse Keepers Cottage	M	M	H	H	Private	
Toilets Pages Beach	M	M	H	H	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe Noted Pages Beach is accreting and has been over a long period of time. Monitor future shoreline changes
Car Park Pages Beach	M	H	H	E	CGG	
Foreshore Park Pages Beach	L	M	H	H	CGG	
Foreshore Park Point Moore	L	M	M	H	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe Noted that beach is assessed as accreting over a long period of time. Monitor future shoreline changes
Volunteer Rescue	M	H	E	E	Private	
Carpark Point Moore	M	H	H	E	CGG	
Toilets Point Moore	M	H	H	E	CGG	
Dunes - NW	H	H	E	E	Community	Monitor erosion, build resilience through nature based approaches (revegetation programs, sand trapping etc)
Dunes - South	M	H	H	E	Community / CGG	
Trees and Coastal Vegetation	M	H	H	H	Community	Plan for removal and replanting as part of foreshore management plan
Cycle and Walking Paths (South Side)	M	H	H	H	Community / CGG	Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

Based on the mapping presented in Appendix A.3, Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, ATCO gas lines and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the design flood extent (500yr ARI inundation in year 2110).

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk.

9.2 Point Moore Coastal Hazard

9.2.1 Coastal Erosion Hazard

Point Moore is at significant risk of erosion, with coastal setback lines shown in Appendix A.1 showing:

- Coastal erosion setback is highest on the southern side of Point Moore, with Marine Terrace at current risk of erosion;
- In the 2030 to 2070 planning timeframe, the erosion setback is forecast to impact Marine Terrace, Astrolabe Lane, Monsoon Lane and Sextant Lane;
- Properties on the south side of Point Moore on Astrolabe Lane are within the erosion setback in the 2070 to 2110 period;
- Erosion of the north and western side of Point Moore is forecast to be contained within the dune and foreshore reserve areas in future planning periods;
- The Lighthouse and Carpark are at risk of erosion forecast in the timeframe 2070 to 2110.

On the south side of Point Moore a coastal protection structure was constructed in 2014 to prevent further erosion of the shoreline, shown in Figure 9.1Figure 9.1: Marine Terrace South Side of Point Moore, sand fence and coastal protection structure along the foreshore.. The rock structure extends approximately 2m above and 2m below the below the surface, and a sand fence has been placed in front.

Figure 9.1: Marine Terrace South Side of Point Moore, sand fence and coastal protection structure along the foreshore.

9.2.2 Coastal Inundation Hazard

The depth associated with the 500yr ARI inundation event in the planning year 2110 is shown for Point Moore CMU in Appendix A.2. Of note:

- The flood extent for the 500yr ARI design case in 2110 shows that the majority of Point Moore is susceptible to inundation due to its low-lying nature. Depth across properties is generally 1m or higher.
- The northern and western side of Point Moore experiences a greater depth of flooding than the southern side, with Marine Terrace experiencing up to 1m of flooding on the northern and western sides. Marine Terrace on the south side is not inundated in this scenario;

9.3 Point Moore Coastal Adaptation

9.3.1 General Recommendations

Point Moore is at significant risk of both coastal erosion and coastal inundation as shown in Figure 9.2. The City completed an assessment of coastal hazard for Point Moore in 2017, to determine the basis for extension to existing lease agreements for the residents. The process resulted in a lease extension granted for a period of 21 years (to 2039) subject to the lease being mandatorily extinguished should trigger points be realised. The trigger points are detailed under Clause 15.4.1 (McCleods 2017) offering termination of the lease if:

(a) the most landward limit of the horizontal shoreline datum (HSD) is within 25 metres of any structures on the Site;

(b) no public road is available, or such road is unable to provide safe and/or legal access, to the Site due to coastal hazards;

(c) within any twelve month period any part thereof the Site is flooded or inundated to a depth of 0.3 metres or greater from two or more separate hazard events;

(d) the Site (and any buildings on the Site) has sustained damage to the extent that it is deemed irreparable or a total loss or is rendered uninhabitable for an extended period of time;

(e) water or electricity to the Site is no longer available because the relevant authority has removed or decommissioned access to water or electricity to the Site.

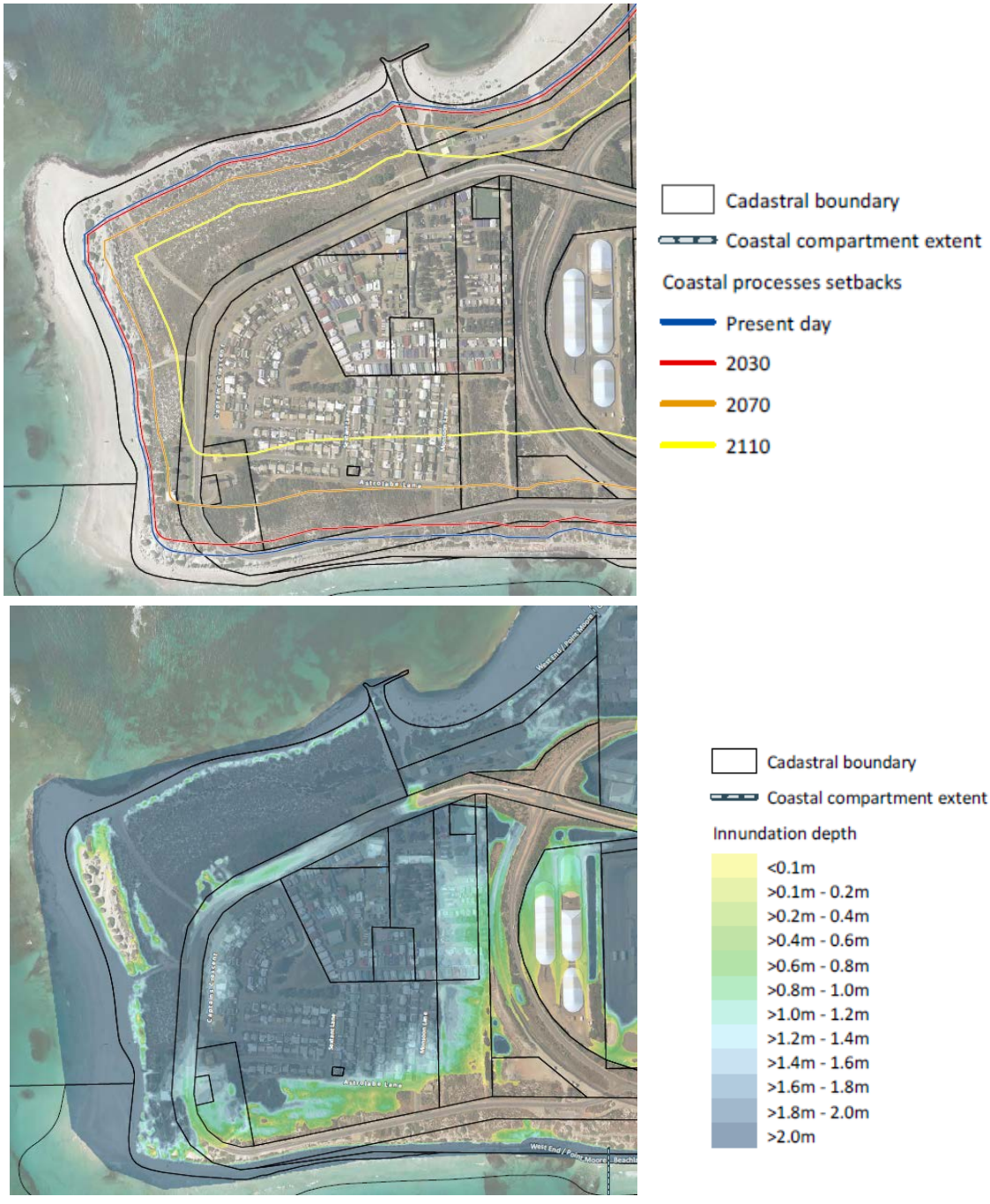

Figure 9.2: Point Moore CMU – Coastal Erosion Setback Lines (above), Inundation Depth for 500yr ARI 2110 scenario (below)

9.3.2 Adaptation Approaches by Asset

In Table 9.3, a summary of adaptation approaches and recommendations to mitigate the erosion and inundation risk to assets in the Point Moore coastal compartment are presented, based on the key assets at risk identified in the hazard assessment (Section 2).

Table 9.3: Adaptation Options by Asset – Point Moore CMU

Asset / Location	Erosion	Inundation
Existing Houses	**Managed retreat.** (Lease Agreements to 2039) • Leave assets unprotected (MR.1) • Removal of assets (MR.2) trigger point set for when distance from built structures to HSD is 25m (i.e. S1). Monitor rate of erosion of coast, and proximity to trigger distance for retreat of structures	**Managed Retreat** **(**Lease Agreements to 2039) Managed retreat inundation trigger set for when 2 flooding events of 0.3m or greater occur in a 12-month period
Point Moore Lighthouse	Monitor erosion rate against projected rate. High value community asset. Consider protection or relocation of lighthouse at trigger point of 25m distance to HSD (forecast timeframe for erosion 2070 – 2110)	**Accommodate** inundation Building design (Ac.2) Emergency Evacuation (Ac.3)
Lighthouse Keepers Cottage	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2). Forecast timeframe for erosion 2070 – 2110) Relocate-able structure can be repositioned as required	**Accommodate** inundation Building design (Ac.2) Emergency Evacuation (Ac.3) Appropriate Finished Floor Levels (Ac.4)
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Carparks	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Volunteer Rescue	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	**Accommodate** inundation Building design (Ac.2) Emergency Evacuation (Ac.3) Appropriate Finished Floor Levels (Ac.4)
Toilets Pages Beach	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	**Accommodate** inundation Building design (Ac.2)
Foreshore Parks and facilities	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

Asset / Location	Erosion	Inundation
Beach /Dunes	**Managed Retreat / Protect** Allow the coast to erode naturally (MR.1) Monitor erosion to identify local areas that are rapidly eroding or dune blowouts. Increase resilience through soft protect options at coastal erosion hotspots e.g. Dune Stabilisation (PR.6), Coastal Revegetation (PR.5).	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts.
Cycle / Walking Paths	**Managed Retreat** - Allow the coast to erode naturally, and monitor paths to ensure safety. Rebuild over time as required, adopting setback level consistent with design life (MR.1 MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts.

9.4 Implementation

9.4.1 Short Term Implementation Plan

The short-term implementation plan for Point Moore CMU over the 15-year period to 2032 is provided in Table 9.4.

Table 9.4: Point Moore CMU Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	The general approach within the CMU is Managed Retreat. This will apply for all CGG coastal infrastructure as well as private property. For residential properties the lease agreements have defined managed retreat conditions set as coastal erosion and inundation triggers. For all other infrastructure, allow use of asset to continue until defined trigger points are reached, at which point asset removal is required.
Aim and strategic direction for coastal management	Adopt a managed retreat approach to allow continued function of the assets in the coastal areas until risk is intolerable. Build understanding of the process of coastal erosion and inundation affecting shoreline areas. Increase resilience of foreshore reserve from erosion through dune building and revegetation of coastal areas, supported by shoreline monitoring to track rate of erosion.
Timing of adaptation response and trigger point at which adaptation commences	Property (Lease conditions, McLeods 2017) – trigger managed retreat if (a) the most landward limit of the horizontal shoreline datum (HSD) is within 25 metres of any structures on the Site;

Item	Comments
	(b) no public road is available, or such road is unable to provide safe and/or legal access, to the Site due to coastal hazards; (c) within any twelve month period any part thereof the Site is flooded or inundated to a depth of 0.3 metres or greater from two or more separate hazard events; (d) the Site (and any buildings on the Site) has sustained damage to the extent that it is deemed irreparable or a total loss or is rendered uninhabitable for an extended period of time; (e) water or electricity to the Site is no longer available because the relevant authority has removed or decommissioned access to water or electricity to the Site. Council maintained roads, pathways, foreshore infrastructure (BBQs, toilets, shelters). Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe.
Indicative cost of preferred adaptation option	Noted lease agreements include collection of an annual demolition charge for end of lease purposes. No cost to CGG is assumed under a managed retreat scenario for the residential property. CGG to budget for o Maintenance of coastal protection structure on the south side of Point Moore (estimate $50,000) o Should the coastal protection structure fail, there will be a need to consider a closure (i.e. retreat) of the section of Marine Terrace on the south side of Point Moore
Responsibilities for implementation of adaptation option	CGG – Updated LCPP with the strategies to be updated to reflect the recommended adaptation approach (infrastructure only, houses covered by lease agreements). CGG - Maintenance of coastal protection structure on the south side of Point Moore CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP
Performance Measures by which the plan can be evaluated	Effective monitoring campaign that leads to improved understanding of coastal erosion processes, developed knowledge of the rate and format of coastal changes through the CMU. Implementation of targeted revegetation and dune building ('soft' protection options) that are successful in maintaining the existing coastal buffer in foreshore areas.

9.5 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for the Point Moore CMU should target the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach and potential erosion of the shoreline. Key locations to include:
    - Section of Grey's beach along Marine Terrace

2. Beach transect analysis should be supplemented by UAV capture of shoreline elevation at lower capture frequency (e.g. bi-annually). This will be used to assess volumetric changes for specific shoreline areas of focus (e.g. Greys Beach)
3. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 3-5 yearly.
4. Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events.
5. Photo monitoring of the beach (continuation of NACC photomon program)
6. Inspection of minor structures (e.g. access, shelters etc) in the foreshore area directly exposed to coastal erosion and inundation for condition / safety twice yearly and after large storm events
7. Inspection of Coastal protection structure south side of Point Moore in front of Marine Terrace

10. Beachlands (CMU8)

10.1 Adaptation Summary and Recommendations

The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- Greys Beach is presently eroding at a rate of 0.2m annually (MRA 2016). The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 shows there are coastal assets at risk of erosion in future planning periods including:
    - Batavia Coast Marine Institute;
    - Rail Lines;
    - Industrial / Commercial lots;
    - Roads (John Wilcock Link, Separation Point Close) and Carparks (Separation Point);
    - Cycle and walking paths; and
    - Dunes and beaches.
- Coastal inundation risk from large storm events and sea level rise in future planning periods is prevented due to the natural land level in the majority of the CMU. There is a low point north of the Batavia Coast Marine Institute, which acts as a flow path for inundation flooding which affects a significant area of inland coast, houses and roads, as shown in hazard inundation mapping for the 500yr ARI inundation event in the planning year 2110, in Appendix A.2. Flooding in large inundation events is directed from the Geraldton Town Centre CMU to low lying properties in the Beachlands CMU
    - The number of residential and commercial properties which are within the 500yr ARI inundation extent for respective planning periods in the CMU is forecast as 162 properties at year 2030, 235 properties at year 2070 and 420 properties at year 2110.

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

Residential and Commercial Development

- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or inundation;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP;
- The coastal erosion hazard in the CMU is forecast to impact 0 properties by 2030 (Extreme Risk), 1 property in the 2030 to 2070 period (High Risk) and 3 properties in the 2070 to 2110 period (moderate Risk). To manage erosion risk for these properties:
    - Place Section 70A notification on titles to inform prospective purchasers to the risk of coastal erosion and / or coastal inundation
    - **Avoid** development of Undeveloped residental or commercial land within the identified 2110 coastal erosion hazard area not classified as Infill under SPP2.6.

- Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level
  - Extreme: 0 properties
  - High: 1 properties. **Accommodate** erosion risk with Section 70a notification on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines required.
  - Moderate: 3 properties. **Accommodate** erosion risk with Section 70a notification on Title. 5 yearly Review of shoreline and updated site-specific assessment of future shoreline hazard lines.

CGG coastal infrastructure:

- The general approach within the CMU for coastal infrastructure is **Managed Retreat**. Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;

Monitoring and Management

- The foreshore reserve area offers a crucial natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Active monitoring and nature based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are strongly recommended. Community groups and local organisations should be included / supported in the delivery of these programs, to provide opportunity to raise awareness and build ownership of the coastal adaptation requirements.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 9.1, based on the risk assessment process completed (Baird 2019). The adaptation timelines in Table 9.1 are based on projected erosion setback lines (Appendix A.1).

Table 10.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Point Moore CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Batavia Coast Marine Institute	MONITOR			MAN.RETREAT					
Rail Lines	MONITOR			MANAGED RETREAT MANAGED					
Non-Infill Developable land within 2110 Erosion Extent	AVOID								
Industrial / Commercial Lots Property classified as Infill in 2030 to 2070 Coastal Erosion Setback extent	MON / ACC.	MANAGED RETREAT							
Industrial / Commercial Lots classified as Infill in 2070 to 2110 Coastal Erosion Setback extent	MONITOR / ACCOM.					MANAGED RETREAT			
John Willcock Link (Main Roads)	MONITOR						MANAGED RETREAT		
Separation Point Close	MONITOR			MANAGED RETREAT					
Car Park Separation Point Lookout	MONITOR		MANAGED RETREAT						
Cycle / Walking Paths	MONITOR		MANAGED RETREAT						
Dunes	MONITOR and BUILD RESILIENCE (Nature Based Options)								

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

John Wilcock Link owned and managed by Main Roads

The assets at highest risk in the CMU are summarised in Table 10.2, along with the adaptation approaches that are recommended to manage the risk.

Table 10.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Property located in 2030 to 2070 Erosion Setback extent	M	H	E	E	Private	City to establish Special Control Area (SCA) and a Local Coastal Planning Policy (LCPP) will provide guidance on development standards which must be met to respond to the risk of coastal erosion and / or inundation.
Property located in 2070 to 2110 Coastal Erosion Setback extent	M	M	H	E	Private	
Dunes	H	H	E	E	Community	Monitor erosion, build resilience through nature based approaches (revegetation programs, sand trapping etc)
Batavia Coast Marine Institute	M	H	E	E	Dept Training and Workforce Devt	Infrastructure is privately owned, and it is the responsibility of the respective owners to determine future adaptation approaches to manage their erosion risk
Rail Lines	M	H	E	E	Aurizon	
John Willcock Link	M	H	H	E	Main Roads	
Separation Point Close	H	H	E	E	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Car Park Separation Point Lookout	H	E	E	E	CGG	
Cycle / Walking Paths	M	H	H	H	Community / CGG	

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

There are a range of utilities infrastructure that are affected by coastal erosion risk through the CMU. Based on the mapping presented in Appendix A.3:

- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling are located in the 2030 – 2070 and 2070 – 2110 coastal erosion hazard extents;

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk.

10.2 Beachlands Coastal Hazard

10.2.1 Coastal Erosion Hazard

The Beachlands shoreline extends approximately 1.5km on the western side of Separation Point along 'Greys Beach'. Beach aspect curves around from facing due south at the western end to facing southwest at the Separation Point. The presence of nearshore reefs reduces the wave impact along the shore which is backed by generally continuous dunes that offer a natural buffer against coastal processes.

Coastal setback lines shown in Appendix A.1 show:

- There are no residential properties sited within the 2110 erosion setback line;
- In future planning periods 2030 to 2070 and 2070 to 2110, the erosion setback lines impact undeveloped vacant industrial land;
- The Batavia Coast Marine Institute is situated within the forecast 2030 to 2070 erosion setback;
- The coastal erosion setback is forecast to impact parts of Separation Point Close in the 2030 to 2070 planning period. The John Wilcock Link is within the forecast 2070 to 2110 erosion setback;
- The rail line corridor is situated within the forecast 2030 to 2070 erosion setback; and
- Light industrial land on the south side of the port is within the forecast 2070 to 2110 erosion setback

10.2.2 Coastal Inundation Hazard

The dune system through the foreshore area is at a height to offer topographic relief from storm surge inundation and sea level rise in future planning periods for the majority of the CMU. There is a low point north of the Batavia Coast Marine Institute, which acts as a flow path for inundation flooding which affects a significant area of inland coast, houses and roads, as shown in hazard inundation mapping for the 500yr ARI inundation event in the planning year 2110, in Appendix A.2.

There is significant inundation of properties as a result of floodwaters that are directed from the Geraldton Town Centre CMU in extreme events.

10.3 Beachlands Coastal Adaptation

10.3.1 General Recommendations

The general approach to manage erosion risk for all City infrastructure and foreshore areas is **Managed Retreat**. The approach will set erosion triggers that allow the use of coastal assets to continue until coastal erosion of the shoreline reaches a threshold distance from the respective asset.

The general approach to manage inundation risk is **Accommodate**. This will apply for all City infrastructure, and foreshore areas. For the low point north of the Batavia Coast Marine Institute, which acts as a flow path for inundation flooding of inland areas in extreme events, the option to build up land levels in the region to prevent this occurring should be investigated.

For development, introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or coastal inundation

- Avoid development of undeveloped residental or commercial land within the erosion setback extents of the SCA not classified as Infill under SPP2.6.

- Allow infill development within the erosion setback extents subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures (Section 15); and
- Investigate Protect measure to raise land level at the Rail Line Corridor to act as a levy / dike to prevent flooding in extreme events for inland areas (houses, road, rail line)

10.4 Adaptation Approaches by Asset

Coastal adaptation approaches for erosion have been considered in the Beachlands CMU in Table 10.3

Table 10.3: Adaptation Options by Asset – Beachlands CMU

Asset / Location	Erosion	Inundation
Existing Houses	No Risk	Inundation risk exists for inland section of existing development on the northeast side of John Wilcox Link. Low point in dune acts as flood pathway. Future **protect** option recommended – raise land level at the Rail Line Corridor to act as a levy / dike to prevent flooding in extreme events
Infill Development (based on SPP2.6 Definition)	Allow infill development on vacant properties in the identified coastal hazard area of the SCA. Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme)	**Accommodate** inundation, dependant on inundation level of lot and based on planning horizon (Ac.1 Ac.2 Ac.4 Ac.5)
Batavia Coast Marine Institute	**Managed retreat.** • Leave assets unprotected (MR.1) • Removal of assets (MR.2) trigger point set for when structures are unsafe	No Risk
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Rail Lines	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Future **protect** option recommended – raise land level at the Rail Line Corridor to act as a levy / dike to prevent flooding in extreme events
Carparks	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach /Dunes	**Managed Retreat / Protect** Allow the coast to erode naturally (MR.1)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

Asset / Location	Erosion	Inundation
	Monitor erosion to identify local areas that are rapidly eroding or dune blowouts and consider dune revegetation and coastal revegetation.	
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

10.5 Implementation

10.5.1 Short Term Implementation Plan

The short-term implementation plan for Beachlands CMU over the 15-year period to 2032 is provided in Table 10.4.

Table 10.4: Beachlands CMU Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	The general approach within the CMU is Managed Retreat. This will apply for all CGG coastal infrastructure as well as private property. The approach will allow use of asset to continue until defined trigger points are reached, at which point asset removal is required.
Aim and strategic direction for coastal management	Close monitoring of the rate of erosion of Grey's beach in front of Separation Point Close, north of the Batavia Coast Marine Institute. Increase resilience of foreshore reserve from erosion through dune management and revegetation of coastal areas, supported by shoreline monitoring to track rate of erosion.
Timing of adaptation response and trigger point at which adaptation commences	Council maintained roads, pathways, foreshore infrastructure (BBQs, toilets, shelters). Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe.
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15) CGG to budget for potential close / modification / removal of road and carpark Separation Point Lookout under forecast erosion potential in the current to 2030 period.
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA

Item	Comments
	CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP
Performance Measures by which the plan can be evaluated	Effective monitoring campaign that leads to improved understanding of coastal erosion processes, developed knowledge of the rate and format of coastal changes through the CMU. Implementation of targeted revegetation and dune building ('soft' protection options) that are successful in maintaining the existing coastal buffer in foreshore areas.

10.5.2 Monitoring

A monitoring plan to continue to assess the rate of shoreline movement for the Beachlands CMU should target the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach and potential erosion of the shoreline. Key locations to include:
    - Shoreline in front of road and carpark Separation Point Lookout
2. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.
3. Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events.
4. Photo monitoring of the beach (continuation of NACC photomon program)
5. Inspection of minor structures (e.g. access, shelters etc) in the foreshore area directly exposed to coastal erosion and inundation for condition / safety twice yearly and after large storm events

11. Mahomet Flats (CMU9)

11.1 Adaptation Summary and Recommendations

The Mahomet Flats management unit extends from north of Tarcoola Beach to Separation Point. The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- The section of coast is presently accreting. The shoreline through the central section of the CMU has accreted by approximately 100m since the 1950's and the surf Club has removed dunes in front of its buildings due to continued accretion. The ongoing accretion is considered due to the protection the shoreline is offered from the Southgate and Point Moore reef and the proximity to the sediment supply from the Southgate dunes area and offshore bars which is forecast to be exhausted over the 2110 planning timeframe (MRA 2017).
- The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates that there are coastal assets at risk of erosion under future coastal erosion scenarios including:
    - Houses (Hadda Way)
    - Surf Club and facilities
    - Roads (Willcock Drive, Hadda Way)
    - Carparks (Surf Club, Hadda Way, South Pipe, Wimps)
    - Foreshore infrastructure (toilets, playgrounds)
    - Dunes and beaches
- For the entire length of the CMU, there is natural topographic relief from storm surge inundation and sea level rise in extreme storm surge events future planning periods.

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

Residential and Commercial Development

- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion;
- The coastal erosion hazard in the CMU is forecast to impact 3 properties in the 2070 to 2110 period (moderate Risk). It is noted the shoreline is not eroding in the CMU currently, however to manage erosion risk for these properties in the 100 years planning period:
    - Place Section 70A notification on titles to inform prospective purchasers to the risk of coastal erosion and / or coastal inundation
    - Avoid development of vacant residential land within the identified 2110 coastal erosion hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve is provided (refer SPP2.6)
    - Allow infill development subject to LCPP provisions for the three properties
        - **Accommodate** erosion risk with Section 70a notification on Title. 5 yearly Review of shoreline and updated future shoreline hazard lines to determine if erosion is occurring along the shoreline.

CGG coastal infrastructure:

- The general approach within the CMU for coastal infrastructure is **Managed Retreat**. Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;

Monitoring and Management

- The foreshore reserve area offers a crucial natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Monitoring of shoreline position at five yearly intervals is sufficient due to the recent continued accretion. Nature based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are supported.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 11.1, based on the risk assessment process completed for the project (Baird 2019). The adaptation timelines in Table 11.1 are based on projected erosion setback lines (Appendix A.1).

Table 11.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Mahomet Flats CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Surf Club – Main Bldg / Storage	MON. RETREAT					MAN.RET			
Surf Club - Foreshore Area	MONITOR					MAN.RETREAT			
Surf Club - Playground	MONITOR						MAN. RETREAT		
Surf Club - Toilets	MONITOR						MAN. RETREAT		
Car Parks	MONITOR							M/R.	
Residential classified as Infill in 2070 to 2110 Coastal Erosion Setback extent (Hadda Way)	MONITOR / ACCOMODATE							MAN. RETR.	
Rail Lines	MONITOR							M/R.	
Car Park - Wimps, Wilcock Drive	MON					MANAGED			
Beaches and Dunes	MONITOR and PROTECT (Nature Based Options)								

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

The assets at highest risk in the CMU are summarised in Table 11.2, along with the adaptation approaches that are recommended to manage the risk.

Table 11.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Surf Club - Main Building	M	H	E	E	Geraldton Surf Club Inc	Accept Risk – Under SPP2.6 Surf Club is a special category. Noted Beach has been continually accreting over a long period, future erosion projections assume coastal processes will change markedly. Monitor ongoing rate of shoreline change
Surf Club - Storage	M	M	H	H	Geraldton Surf Club Inc	

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Surf Club - Foreshore Area, (including lookout structure)	L	L	M	H	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe. Noted Beach has been continually accreting over a long period, future erosion projections assume coastal processes will change markedly. Monitor ongoing rate of shoreline change
Surf Club - Playground	M	M	H	H	CGG	
Surf Club - Toilets	M	M	H	H	Geraldton Surf Club Inc.	
Car Park - Surf Club	M	M	H	H		
Car Park - Hadda Way (north of Surf Club)	M	M	H	H	CGG	
Car Park - South Pipe (south	M	M	H	H	CGG	
Houses	M	M	H	E	Private	City to establish Special Control Area (SCA) and a Local Coastal Planning Policy (LCPP) will provide guidance on development standards which must be met to respond to the risk of coastal erosion and / or inundation.
Rail Lines	M	M	H	E	Aurizon	Infrastructure is privately owned, and it is the responsibility of the respective owner to determine future adaptation approaches to manage their erosion risk
Car Park – 'Whimps', Wilcock Drive	M	M	H	H	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe
Car Park – 'Whimps', Hadda Way	M	M	H	H	CGG	
Hadda Way, Willcock Drive	M	M	H	H	CGG	
Beaches	M	M	H	H	Community	Build resilience through revegetation programs
Dunes	M	H	H	E	Community	

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

There are a range of utilities infrastructure that are affected by coastal erosion risk through the CMU. Based on the mapping presented in Appendix A.3:

- One Water Corp. pump station is located in the 2070-2110 coastal erosion hazard extent;
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the 2070-2110 coastal erosion hazard extents;

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their erosion risk.

11.2 Mahomet Flats Coastal Hazard

11.2.1 Coastal Erosion Hazard

The Mahomet Flats shoreline aspect curves around from facing due south at Separation Point to facing southwest at the start of Tarcoola Beach. Locally referred to as 'Back Beach', the shore is backed by continuous high dunes that offer a natural buffer against coastal processes and vary in width from approximately 70m to 100m width. The shoreline through the central section of the CMU has accreted by approximately 100m since the 1950's and continues to accrete based on analysis in MRA 2017. The surf Club has removed dunes in front of its buildings due to continued accretion. The ongoing accretion is considered due to the protection the shoreline is offered from the Southgate and Point Moore reef and the proximity to the sediment supply from the Southgate dunes area and offshore bars (MRA 2017).

The source of sediment from Southgate Dunes is expected to may be exhausted over the 2110 planning timeframe and this has factored into the calculation of coastal erosion setback allowances (MRA 2017). It is noted the erosion setback calculations assume that accretion will continue along the shoreline for a number of years, after which erosion will occur once the Southgate dune sediment supply is depleted. The overall setback distances for 2110 are based on the present-day HSD which is moving further seaward each year currently. In future revisions of the CHRMAP the HSD line may be revised further seaward, and this in turn would revise the coastal erosion setback lines further seaward.

Coastal setback lines shown in Appendix A.1 show:

- The coastal erosion setback is forecast to impact the coast road (Separation Point Close, Hadda Way Willcock Drive) in the 2070 to 2110 planning period.
- Residential properties along Hadda Way are sited at the limit of the 2110 erosion setback line.
- The rail line corridor is sited at the limit of the 2110 erosion setback line
- The Surf Club is within the forecast 2070 to 2110 erosion setback

11.2.2 Coastal Inundation Hazard

The dune system through the foreshore area varies in height from approximately 6m AHD adjacent Separation Point up to approximately 10m AHD height in southern section of the CMU near the Surf Club. For the entire length of the CMU, there is natural topographic relief from storm surge inundation and sea level rise in future planning periods, with inundation hazard shown for the 500yr ARI inundation event in the planning year 2110, in Appendix A.2.

11.3 Mahomet Flats Coastal Adaptation

11.3.1 General Recommendations

It is recognised the beach has been accreting in the CMU for the past 60 years of analysis (MRA 2017). The general approach to manage erosion risk for CGG structures in the foreshore is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.

For development, introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.

- Avoid development of undeveloped residental or commercial land within the erosion setback extents of the SCA not classified as Infill under SPP2.6.

- Allow infill development within the erosion setback extents subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level;

11.3.2 Adaptation Approaches by Asset

Coastal adaptation approaches for erosion have been considered in the Mahomet Flats CMU in Table 11.3.

Table 11.3: Adaptation Options by Asset – Mahomet Flats CMU

Asset / Location	Erosion	Inundation
Surf Club and structures	**Managed retreat.** • Leave assets unprotected (MR.1) • Removal of assets (MR.2) trigger point set for when structures are unsafe	No Risk
Existing Houses (Hadda Way)	**Accommodate** • Place notification on title (Ac.1) at redevelopment or time of sale	No Risk
Infill Development (based on SPP2.6 Definition)	Allow infill development on vacant properties in the identified coastal hazard area of the SCA. Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme)	No Risk
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	No Risk
Carparks Surf Club, Hadda Way, South Pipe, Wimps	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	No Risk
Beach /Dunes	**Managed Retreat / Protect** Allow the coast to erode naturally (MR.1) Monitor erosion to identify local areas that are rapidly eroding or dune blowouts and consider dune revegetation and coastal revegetation.	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

11.4 Implementation

11.4.1 Short Term Implementation Plan

The short-term implementation plan for Mahomet Flats CMU over the 15-year period to 2032 is provided in Table 11.4.

Table 11.4: Mahomet Flats CMU Short Term Implementation Plan

Item	Comments

Preferred Adaptation Approach	The general approach within the CMU for CGG coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief:
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
	  • For non-infill development, Avoid development of areas at risk of erosion in the SCA.
	  • For infill development, allow development in coastal erosion setback that recognises coastal hazard risk level through LCPP at Accommodate classification. Classification review scheduled at five yearly intervals as part of the CHRMAP review.

Aim and strategic direction for coastal management	Considered that the Southgate dunes will continue to supply Tarcoola Beach Embayment (including Mahomet Flats CMU) beyond the next 15 years. Limited coastal management anticipated over the timeframe
Timing of adaptation response and trigger point at which adaptation commences	Triggers not expected to be activated in the period to 2032
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15)
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP
Performance Measures by which the plan can be evaluated	LCPP that can effectively address managed retreat implementation for existing development and infrastructure.

Item	Comments
	Further development and understanding of coastal processes acting within the CMU through continued monitoring of the shoreline movement.

11.4.2 Monitoring

A monitoring plan to continue to assess the rate of shoreline movement for the Mahomet Flats CMU should target the following:

1. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.

12. Tarcoola Beach (CMU10)

12.1 Adaptation Summary and Recommendations

The Tarcoola Beach management unit covers approximately 3.5km of coastline north of Southgate Dunes. The coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- The section of coast is presently accreting. The shoreline in the Tarcoola Beach CMU has been measured as accreting at a rate of between 0.9m and 1.5m a year since 1945 due to the protection of the shoreline from the Southgate and Point Moore reef and the proximity to the sediment supply from the Southgate dunes area and offshore bars (MRA 2017). The source of sediment from Southgate Dunes may be exhausted over the 100-year planning timeframe and this has factored into the calculation of coastal erosion setback allowances (MRA 2017).
- The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates that there are coastal assets at risk of erosion under future coastal erosion scenarios including:
    - Houses
    - Roads (Willcock Drive, Glendenning Rd)
    - Carparks (Glendenning Rd x 3)
    - Foreshore infrastructure (Beach access, playgrounds)
    - Dunes and beaches
- For the majority of the CMU there is natural topographic relief from storm surge inundation and sea level rise, and it is only in the southern section of the CMU (Queenscliffe Close, Sandown Close, Glendinning Rd) that minor inundation hazard can impact the developed area in future sea level rise scenarios.

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

Residential and Commercial Development

- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or inundation;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP;
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation and / or inundation
- **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures.
- The coastal erosion hazard in the CMU is forecast to impact 126 properties in the 2070 to 2110 period (moderate Risk). To manage erosion risk for these properties:

- Avoid development of vacant residential land within the identified 2110 coastal erosion hazard area not classified as Infill under SPP2.6. For greenfield sites, planning should ensure an appropriate coastal foreshore reserve is provided (refer SPP2.6)
- Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level
  - Extreme: 0 properties
  - High: 0 properties.
  - Moderate: 126 properties. **Accommodate** erosion risk with Section 70a notification on Title. 5 yearly Review of shoreline and updated assessment of future shoreline hazard lines.

CGG coastal infrastructure:

- The general approach within the CMU for coastal infrastructure is **Managed Retreat**. Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;

Monitoring and Management

- The foreshore reserve area offers a crucial natural buffer against coastal erosion and inundation for coastal assets located landward (houses, roads etc), as well as providing highly valued public amenity. Monitoring of shoreline position at five yearly intervals is sufficient due to the recent continued accretion. Nature based approaches (e.g. coastal revegetation, sand trapping fences) to increase resilience of this foreshore reserve from erosion are supported.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 12.1, based on the risk assessment process completed for the project (Baird 2019). The adaptation timelines in Table 12.1 are based on projected erosion setback lines (Appendix A.1).

Table 12.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Tarcoola Beach CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Residential classified as Infill in 2070 to 2110 Coastal Erosion Setback extent	MONITOR / ACCOMODATE							MAN.RET	
Willcock Drive	MONITOR						MAN.RETREAT		
Glendenning Rd	MONITOR						MAN. RETREAT		
Glendenning Park	MONITOR						MAN. RETREAT		
Car Park - Glendenning Rd North	MONITOR							M/R.	
Car Park - Glendenning Rd / Buchanan Place	MONITOR						MAN. RETREAT		
Car Park - Glendenning	MONITOR							M/R.	
Beaches and Dunes	MONITOR and PROTECT (Nature Based Options)								

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

The assets at highest risk in the CMU are summarised in Table 12.2, along with the adaptation approaches that are recommended to manage the risk.

Table 12.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Development classified as 'Infill' under SPP2.6 Definition	M	M	H	E	Private	City to establish Special Control Area (SCA) and a Local Coastal Planning Policy (LCPP) will provide guidance on development standards which must be met to respond to the risk of coastal erosion and / or inundation.
Willcock Drive	M	H	H	E	CGG	Managed retreat trigger - Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe. Noted Beach has been continually accreting over a long period, future erosion projections assume coastal processes will change markedly. Monitor ongoing rate of shoreline change
Glendenning Rd	M	M	H	H	CGG	
Glendenning Park	M	M	H	H	CGG	
Car Park - Glendenning Rd Nth	M	M	H	H	CGG	
Car Park - Glendenning Rd Opp Buchanan Place	M	H	H	E	CGG	
Car Park - Glendenning Foreshore Southern Carpark	M	M	H	H	CGG	
Beaches	M	M	H	H	Community	Build resilience temporary protect / resilience building programs
Dunes	M	H	H	E	Community	

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

There are a range of utilities infrastructure that are affected by coastal erosion risk through the CMU. Based on the mapping presented in Appendix A.3:

- A Water Corp. pressure main is located in the 2030 – 2070 coastal erosion hazard extent;
- One Water Corp. pump station is located in the 2070 – 20110 coastal erosion hazard extent;
- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, ATCO gas lines and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the 2070-2110 coastal erosion hazard extent.

There are a range of utilities infrastructure that are affected by coastal inundation risk through the CMU. Based on the mapping presented in Appendix A.3:

- Water Corp. pipe and sewer network, Western Power overhead line and underground cabling, ATCO gas lines and Telstra infrastructure (including conduits, cables, pillars, pits) are located in the design flood extent (500yr ARI inundation in year 2110).

It is noted that utilities infrastructure is privately owned, and it is the responsibility of the respective utility owners to determine future adaptation approaches to manage their inundation risk.

12.2 Tarcoola Beach Coastal Hazard

12.2.1 Coastal Erosion Hazard

Tarcoola Beach CMU is fronted by a foreshore reserve of continuous dunes. The dunes offer a natural buffer against coastal processes and vary in width from approximately 60m width in the north of the CMU (fronting Willcox Drive) to between 100m and 130m in the south (Glendinning Drive section). The shoreline in the Tarcoola Beach CMU has been measured as accreting at a rate of between 0.9m and 1.5m a year since 1945 due to the protection of the shoreline from the Southgate and Point Moore reef and the proximity to the sediment supply from the Southgate dunes area and offshore bars (MRA 2017).

The source of sediment from Southgate Dunes may be exhausted over the planning timeframe and this has factored into the calculation of coastal erosion setback allowances (MRA 2017). It is noted the erosion setback calculations assume that accretion will continue along the shoreline for a number of years, after which erosion will occur c. The overall setback distances for 2110 are based on the present-day HSD which is moving further seaward each year currently. In future revisions of the CHRMAP the HSD line may be revised further seaward, which would reduce the coastal erosion hazard in the 2070 to 2110 planning period.

Coastal setback lines in Appendix A.1 show:

- The coastal erosion setback is forecast to impact the coast road (Glendinning Road, Willcock Drive) in the 2070 to 2110 planning period.
- Throughout the CMU, the first line of properties along the coast (Glendinning Road, Willcock Drive) are sited within the 2070 to 2110 erosion setback lines.

12.2.2 Coastal Inundation Hazard

The dune system through the foreshore area varies in height from approximately 8m-10m AHD in the northern section of Tarcoola Beach to a minimum of 3-5m AHD height in the most southern section of the CMU. For the majority of the CMU there is natural topographic relief from storm surge inundation and sea level rise, and it is only in the southern portion of the shoreline (Queenscliffe Close, Sandown Close, Glendinning Rd) that minor inundation hazard can impact the developed area in future sea level rise scenarios.

The inundation hazard is shown as depth associated with the 500yr ARI inundation event in the planning year 2110, shown for the Tarcoola Beach CMU in Appendix A.2. The inundation mapping shows the level of development of houses and roads is above the inundation level forecast at the 2110 planning period, apart from a section of properties along Queenscliffe Close, Sandown Close and Glendinning Rd in the south of the CMU (generally less than 1m depth). Inundation south of Glendinning Rd in the foreshore reserve at the southern limit of the CMU in coastal dunes is noted of up to 2m depth in the mapping in Appendix A.2.

12.3 Tarcoola Beach Coastal Adaptation

12.4 General Recommendations

It is recognised the beach has been accreting in the CMU for the past 60 years of analysis (MRA 2017).

The general approach to manage erosion risk for all CGG infrastructure and foreshore areas is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.

The general approach to manage inundation risk is **Accommodate**. This will apply for all City infrastructure, and foreshore areas through the low section of the CMU to the south.

For development, introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or coastal inundation

- Avoid development of undeveloped residental or commercial land within the erosion setback extents of the SCA not classified as Infill under SPP2.6.
- Allow infill development within the erosion setback extents subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level; and
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures (Section 15).

12.5 Adaptation Approaches by Asset

Coastal adaptation approaches for erosion have been considered in the Tarcoola Beach CMU in Table 12.3.

Table 12.3: Adaptation Options by Asset – Tarcoola Beach CMU

Asset / Location	Erosion	Inundation
Existing Houses	**Accommodate** • Place notification on title (Ac.1) at redevelopment or time of sale Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme)	Risk exists only in lower section of CMU **Accommodate** inundation consistent with planning timeframes to 2110 through LCPP guidance including • Notification on title (Ac.1) • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.4) • Filling Land (Ac.5)
Infill Development (based on SPP2.6 Definition)	Allow infill development on vacant properties in the identified coastal hazard area of the SCA. Subject to conditions on development (Ac.1) that recognise coastal hazard risk will vary from **Accommodate** to **Managed Retreat** dependant on the risk level (High or Extreme)	Risk exists only in lower section of CMU **Accommodate** inundation consistent with planning timeframes to 2110 through • Notification on title (Ac.1) • Building Design (Ac.2) • Appropriate Finished floor levels (Ac.4) • Filling Land (Ac.5)
Roads	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Risk exists only in lower section of CMU. Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Carparks Glendinning Rd South,	**Managed Retreat** - Allow the coast to erode naturally, maintain asset function under defined trigger points for removal (MR.1 > MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

Asset / Location	Erosion	Inundation
Buchanan Place, Hannah Rd		
Beach /Dunes	**Managed Retreat / Protect** Allow the coast to erode naturally (MR.1) Monitor erosion to identify local areas that are rapidly eroding or dune blowouts and consider dune revegetation and coastal revegetation.	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Beach Access Paths	**Managed Retreat** - Allow the coast to erode naturally (MR1), and monitor coastal access paths, to maintain safe access to beach. Formalise beach access routes	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts
Cycle / Walking Paths	**Managed Retreat** - Allow the coast to erode naturally, and monitor paths to ensure safety. Rebuild over time as required, adopting setback level consistent with design life (MR.1 MR.2)	Short term inundation in large events is acceptable (MR.1). Monitor for safety following impacts

12.6 Implementation

12.6.1 Short Term Implementation Plan

The short-term implementation plan for Tarcoola Beach CMU over the 15-year period to 2032 is provided in Table 12.4.

Table 12.4: Tarcoola Beach CMU Short Term Implementation Plan

Item	Comments

Preferred Adaptation Approach	The general approach for all CGG coastal infrastructure is managed retreat. The approach will allow use of asset to continue until defined trigger points are reached, at which point asset removal is required.
	For property
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
	  • For infill development, allow development in coastal erosion setback that recognises coastal hazard risk from LCPP level (Moderate, High or Extreme) and which allows for adaptation response to vary from Accommodate to Managed Retreat. Classification review scheduled at five yearly intervals as part of the CHRMAP review.
	  • For properties with identified inundation risk, accommodate inundation through planning and design measures specified in LCPP.

Aim and strategic direction for coastal management	Considered that the Southgate dunes will continue to supply Tarcoola Beach over the next 15 years (may be exhausted in the next 50 years). Limited coastal management anticipated over the timeframe

Item	Comments
Timing of adaptation response and trigger point at which adaptation commences	Triggers Not expected to be activated in the period to 2032
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15)
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP
Performance Measures by which the plan can be evaluated	Updated planning policy that can effectively address managed retreat implementation for existing development and infrastructure. Further development and understanding of coastal processes acting within the CMU through continued monitoring of the shoreline movement.

12.7 Monitoring

A monitoring plan to continue to assess the rate of shoreline movement for the Tarcoola Beach CMU should target the following:

1. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.

13. Southgate Dunes (CMU11)

13.1 Adaptation Summary and Recommendations

The Southgate Dunes management unit extends across approximately 4km south of Tarcoola Beach. The projected coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- The shorelines of the CMU are experiencing varying degrees of erosion, with the northern section of the CMU eroding at a rate of 0.7 to 0.8m annually, and the southern section considered stable albeit slightly accreting (MRA2016). Southgate dunes is a primary source for sediment supply to the beaches north, forecast to be exhausted within potentially 50 years (MRA 2017).
- The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates that the following at risk of erosion under future coastal erosion scenarios:
    - Dunes
    - Beaches
    - Coastal / Rare Vegetation
    - Aboriginal Heritage Site
    - Undeveloped residential or commercial land (northern extent)
- For the majority of the CMU, there is natural topographic relief from storm surge inundation and sea level rise in extreme storm surge events in future planning periods. The Appendix A.2 inundation mapping shows inundation in low lying coastal dunes in the foreshore area through some sections of coast.

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

- The general approach to manage erosion risk is **Avoid** all development of undeveloped residential or commercial land within the identified coastal hazard area.
- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or inundation;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP;
- For natural coastal areas a **Managed Retreat** approach is recommended, with resilience options including sand fences, dune management and revegetation of coastal areas supported to stabilise the shorelines and dunes of the CMU.

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 13.1, based on the risk assessment process completed for the project (Baird 2019). The adaptation timelines in Table 13.1 are based on projected erosion setback lines (Appendix A.1).

Table 13.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Southgate Dunes CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Developable Land in Erosion Setback Extent to 2110	AVOID								
Southgate Dunes	MONITOR and PROTECT (Nature Based Options)								
Beaches	MONITOR and PROTECT (Nature Based Options)								
Rare Vegetation	MONITOR and PROTECT (Nature Based Options)								
Aboriginal Heritage Site	MON / PROTECT (Nature Based Options)			MANAGED RETREAT					
Trees and Coastal Vegetation	MONITOR and PROTECT (Nature Based Options)								

Note: low value CGG assets have not been included in the table (e.g. bollards, fencing)

The assets at highest risk in the CMU are summarised in Table 13.4, along with the adaptation approaches that are recommended to manage the risk.

Table 13.2: Coastal Adaptation Strategies – Addressing Risks

	Erosion Risk Rating					
Asset	2018	2030	2070	2110	Owner	Measure to Address Risk
Southgate Dunes	M	H	H	E	State Owned Land	Monitoring
Beaches	M	M	H	H	State Owned Land	Monitoring
Rare Vegetation	H	H	E	E	State Owned Land	Monitoring
Aboriginal Heritage Site	H	H	E	E	State Owned Land	Monitoring, Require specialist heritage advice regarding management of registered aboriginal site in managed retreat plan
Trees and Coastal Vegetation	M	H	H	H	State Owned Land	Monitoring

Notes.

1. In certain instances the end user of the asset might differ from the owner e.g. roads are owned by the CGG but community are the end user.

No utilities infrastructure is affected by coastal erosion hazard in this CMU.

13.2 Southgate Dunes Coastal Hazard

13.2.1 Coastal Erosion Hazard

Southgate Dunes CMU is a natural undeveloped section of the coast which is the primary sediment supply for beaches to the north. The shorelines of the CMU are experiencing varying degrees of erosion, with the northern section of the CMU eroding at a rate of 0.7 to 0.8m annually, and the southern section considered stable albeit slightly accreting (MRA2016). The coastal setback lines are shown in Appendix A.1 indicating:

- There are no 'built' CGG assets in the foreshore;
- No existing development is located within the CMU, however vacant undeveloped land is located in the north of the CMU.

13.2.2 Coastal Inundation Hazard

The inundation hazard is shown as depth associated with the 500yr ARI inundation event in the planning year 2110, shown for the Southgate Dunes CMU in Appendix A.2. The inundation mapping shows inundation in low lying coastal dunes in the foreshore area through some sections of coast.

13.3 Southgate Dunes Coastal Adaptation

13.3.1 General Recommendations

Coastal adaptation approaches for erosion have been considered in the Southgate Dunes CMU, based on the summary in Table 13.3.

Table 13.3: Coastal Adaptation Summary – Southgate Dunes CMU, Erosion Risk

Location	Key Considerations	Adaptation Approach
CMU	There is no existing development within the erosion setback area There is no Infrastructure in the foreshore	**Avoid** development of developable land within the identified coastal hazard for the 2110 planning timeframe

13.3.2 Adaptation Approaches by Asset

In Table 13.4, a summary of adaptation approaches and recommendations to mitigate the erosion risk to assets in the Southgate Dunes coastal compartment are presented, based on the key assets at risk identified in the hazard assessment (Baird 2019).

Table 13.4: Adaptation Options by Asset – Southgate Dunes CMU

Asset / Location	Erosion	Inundation
Developable Land	**Avoid** development in identified coastal hazard area (Av1).	No risk
Beach /Dunes	**Managed Retreat** Allow the coast to erode naturally (MR.1) Monitor erosion to identify local areas that are rapidly eroding or dune blowouts. Consider management strategies to increase resilience e.g. dune revegetation or sand fences to trap windblown sand.	Acceptable Risk

Asset / Location	Erosion	Inundation
Rare Vegetation	Formalise beach / dune access routes around known sensitive areas	No risk
Aboriginal Heritage Site	Formalise beach / dune access routes around known sensitive areas	No risk
Trees and Coastal Vegetation	Formalise beach / dune access routes around known sensitive areas	No risk

13.4 Implementation

13.4.1 Short Term Implementation Plan

The short-term implementation plan for Southgate Dunes CMU over the 15-year period to 2032 is provided in Table 13.5.

Table 13.5: Southgate Dunes CMU Short Term Implementation Plan

Item	Comments
Preferred Adaptation Approach	For developable land in the CMU, Avoid development within the coastal erosion setback over the 2110 planning timeframe
Aim and strategic direction for coastal management	Build understanding of the process of coastal erosion affecting shoreline areas through monitoring of shoreline changes.
Timing of adaptation response and trigger point at which adaptation commences	None
Indicative cost of preferred adaptation option	Annual monitoring of coastal erosion in CMU (Refer costs Section 15)
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP
Performance Measures by which the plan can be evaluated	Natural asset management Improved understanding of coastal erosion processes through the CMU.

13.4.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion and monitor the trigger points identified for Southgate Dunes CMU should target the following:

1. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.

14. Cape Burney (CMU 12)

14.1 Adaptation Summary and Recommendations

The Cape Burney management unit is the southernmost CMU extending 1.5km north of Greenough River mouth. The coastal erosion and inundation hazard mapping is shown in Appendix A.1 and Appendix A.2, with a summary of the coastal hazard for the CMU provided as follows:

- The section of coast is presently accreting at a rate of 0.2m annually (MRA 2016).
- The coastal erosion setback allowance for future planning periods 2030, 2070 and 2110 shown in Appendix A.1 indicates that there are coastal assets at risk of erosion under future coastal erosion scenarios including:
    - Beach Lookout and Pathway
    - Greenough River Road
    - Carpark
    - Foreshore infrastructure (Beach access, fencing)
    - Dunes and beaches
- The upper shoreline offers natural topographic relief from extreme storm surge events in future sea level rise scenarios for all CGG infrastructure.

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

- Planning policies will need to be updated as follows:
    - Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval;
    - A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or inundation;
- Accommodate inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP;
- The general approach to manage erosion risk for CGG coastal infrastructure is **Managed Retreat**. This will apply for all City infrastructure in foreshore areas. The approach will set erosion triggers that allow the use of coastal assets to continue until coastal erosion of the shoreline reaches a threshold distance from the respective asset:
    - Council maintained roads, pathways, foreshore infrastructure (BBQs, toilets, shelters etc). Allow continued use until the asset is no longer safe or structurally sound. Minor repair permitted consistent with asset lifecycle and expected planning timeframe;

Long term adaptation pathways for the key at risk assets identified in the CMU are summarised in Table 14.1, based on the risk assessment process completed for the project (Baird 2019). The adaptation timelines in Table 14.1 are based on projected erosion setback lines (Appendix A.1).

Table 14.1: Coastal Adaptation Strategies – Long Term Pathways for assets in the Cape Burney CMU

Asset / Location	Now-2030	2030-2040	2040-2050	2050-2060	2060-2070	2070-2080	2080-2090	2090-2100	2100-2110
Beach Lookout and Pathway	MONITOR			MAN. RETREAT					
Toilet	MONITOR			M/R. RETREAT					
Greenough River Rd	MONITOR							MAN.	

Item	Comments
Indicative cost of preferred adaptation option	CGG to allow budget for • Lookout and coastal pathways forecast to require retreat in the timeframe • Managed Retreat of the Greenough River mouth Carpark forecast to be required removal in the next 15 years. • Sections of Greenough River Rd forecast to require retreat in the timeframe
Responsibilities for implementation of adaptation option	CGG - Planning policies and strategies to be updated to reflect the recommended adaptation approach. Refer final section detail but in brief: • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA CGG – Monitoring program to continue to track rate of erosion along the shoreline and support CHRMAP
Performance Measures by which the plan can be evaluated	Updated planning policy that can effectively address managed retreat implementation for existing development and infrastructure. Improved understanding of coastal erosion processes through the CMU.

14.4.2 Monitoring

A monitoring plan to assess the ongoing rate of erosion in the CMU should target the following:

1. Beach transect survey twice yearly (winter and summer). Used to monitor changes to the profile of the beach. Key locations to include:
   - In front of lookout
2. Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly.

15. Implementation

15.1 Planning framework Special Control Areas

15.1.1 Updates to Current Planning Scheme

An update to the City's current planning scheme is recommended to manage the coastal hazard risk for existing and future residential and commercial development along Geraldton's coast. The recommended approach is as follows:

- It is recommended the CGG introduce a Special Control Area (SCA) with a boundary based on the most landward position of either the 2110 coastal erosion setback line or inundation extent for the 500yr ARI event in the year 2110.
- A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA. The LCPP will provide recommendations in alignment with the adopted CHRMAP.
- All properties within the SCA will require a Section 70A notification to be placed on title to inform prospective purchasers to the risk of coastal erosion and /or coastal inundation. It is noted that the mechanism for a decision maker to impose a requirement to place a Section 70a notification is typically by way of condition of subdivision or development approval.

This CHRMAP is recommending a cascading suite of measures to address immediate, medium and long-term risks that would be directed through the LCPP. A range of future studies that will be required to improve understanding of the study area and inform the development of the planning recommendations in the LCPP have been identified.

15.1.2 Managing Coastal Erosion Risk for Properties in the SCA

Coastal erosion is the dominant coastal hazard impacting the northern CMU's currently. The Geraldton Town Centre and Beresford CMU's have coastal protection structures in place to prevent erosion, but all sections of the coast further north (Bluff Point, Sunset Beach and Drummond Cove) are at significant risk of erosion. Currently Point Moore south (Grey's beach) is at risk of coastal erosion, and over a longer timeframe (2070 to 2110), coastal erosion hazard is forecast to impact all beaches south of the City, once the Southgate Dunes sediment supply is depleted.

The CHRMAP has identified the number of properties within the erosion setback areas in future planning periods as summarised in Table 15.1. This assessment provides a summary of the residential property, commercial property and Council land types based on cadastral information supplied by the City (2017). The CHRMAP has identified the number of properties within the erosion setback areas in future planning periods as summarised in Table E.1. This assessment provides a summary of the residential property, commercial property and Council land types based on cadastral information supplied by the City (2017). In Table 15.1 there are a total of 15 residential properties in the present to 2030 timeframe, a further 220 properties identified through the 2030 to 2070 timeframe and a further 535 properties in the 2070 to 2110 period. In total there are 770 located properties within the erosion setback at planning year 2110 (commercial and residential combined. Of this total 761 of the identified properties are classified as residential (refer base of Table 15.1).

Table 15.1: Coastal Erosion Hazard by CMU and Property Type – Current to 2110 Time Frame

CMU	Number of Properties in Current to 2030 Coastal Erosion Setback Area	Number of Properties in 2030 – 2070 Coastal Erosion Setback Area	Number of Properties in 2070 – 2110 Coastal Erosion Setback Area	TOTAL properties at 2110
1.Drummond Cove	0	98	187	**285**
2.Glenfield	1	1	0	**2**
3.Sunset Beach	0	57	82	**139**
4.Bluff Point	13	61	71	**145**
5.Beresford	0	0	0	**0**
6.Geraldton	0	0	0	**0**
7.Point Moore[3]	0	1	61	**62**
8.Beachlands	0	1	4	**5**
9.Mahomets Flats	0	0	3	**3**
10.Tarcoola Beach	0	0	127	**127**
11.Southgate Dunes	1	1	0	**2**
12.Cape Burney	0	0	0	**0**
TOTAL	**15**	**220**	**535**	**770**
Residential Properties[1]	***15***	*218*	*528*	***761***
Commercial[1]	***0***	*2*	*7*	***9***
Council / Public Purpose	***43***	*12*	*15*	***70***

1. Total includes developed and undeveloped vacant lots

2.Council / Public Purpose Land includes Crown Land, Foreshore Reserve and Foreshore Areas.

3. Point Moore properties are included on this table however risk has already been treated for these properties under new lease agreements and risk management is not required under this CHRMAP.

To manage the erosion risk for properties identified within the SCA over the next 100 years, a range of planning-based approaches are recommended to be implemented in the LCPP. The planning approaches are proposed to provide a basis under which development can occur, in a way that recognises the coastal erosion risk to property in the SCA over time.

- For development approval of undeveloped residential or commercial land that *is not* considered to be infill development under SPP2.6, the planning approach recommended is **Avoid** within the SCA. Development will only be permitted on the portion of a lot landward of the 2110 coastal erosion setback line and any additional allowance required for provision of a foreshore reserve as per SPP2.6 (Clause 5.9). It is noted this 'non-infill' category is not expected to apply to many of the vacant lots in the CMU's.
- For development approval of land that *is* considered infill development under SPP2.6, development approval will be supported under an **Accommodate** and **Managed Retreat** approach with mechanisms to address the identified risk specified within the LCPP. It is proposed that three levels of adaptation planning response are outlined within the LCPP, recognising that the current risk for properties at the seaward edge is much higher than for those properties at the 2110 setback extent. Applying a sliding scale of adaptation response in the LCPP, recognises there is uncertainty in the estimate of the long-term shoreline position (e.g. at 2070, 2110), and that making decisions based on this uncertainty today, may impose needless constraint on development of coastal areas.

It is proposed that three categories be defined in the LCPP to make planning recommendations based on a risk category defined by the location of the property in relation to the coastal erosion setback extent:

- **Extreme Risk. Property located within the Current to 2030 Coastal Erosion Setback Extent**

  There are a total of 15 properties identified within the current to 2030 coastal erosion setback extent (Table 15.1). In the CHRMAP risk assessment (Baird 2019) these properties are classified at extreme risk. Section 70a notifications would be placed on all properties as the opportunity arises. Additionally:

  - 2 of the 15 properties would not be classified as infill, and would have to **Avoid** development seaward of the 2110 coastal erosion setback line (the 2 sites are undeveloped residential located in Glenfield and Southgate Dunes CMU);
  - 13 of the 15 properties are considered infill and located in the Bluff Point CMU. Managed retreat conditions will be imposed on these properties as a condition of development or redevelopment, with details specified consistent with the Managed Retreat guidelines (DPLH 2017); and
  - The specific managed retreat triggers will be determined by the City and it is recommended that the triggers be incorporated into the Local Coastal Planning Policy which determines the specific guidance for properties in the SCA. The triggers are likely to be based on the Point Moore lease conditions (2017) that would trigger vacating the property if:
    - the most landward limit of the horizontal shoreline datum (HSD) is within the S1 distance of any structures on the lot;
    - no public road is available, or such road is unable to provide safe and/or legal access, to the lot due to coastal hazards;
    - the lot (and any buildings on the lot) has sustained damage to the extent that it is deemed irreparable or a total loss or is rendered uninhabitable for an extended period of time;
    - water or electricity to the lot is no longer available because the relevant authority has removed or decommissioned access to water or electricity to the lot.

- **High Risk. Property located within the 2030 to 2070 Coastal Erosion Setback Extent**

  There are 218 residential and 2 commercial properties which are located within the 2030 to 2070 coastal erosion setback area. These are predominantly located in Drummond Cove, Sunset Beach and Bluff Point. In the CHRMAP risk assessment (Baird 2019) these properties are classified as being at high risk. For these properties the LCPP will address the erosion risk through a range of **Accommodate** measures. This will be subject to review in future revisions of the CHRMAP, where properties may be moved to the Extreme level of risk if the shoreline erosion progresses (and managed retreat conditions would then be imposed through the LCPP).

  On this basis, it is recommended:

  - that a Section 70a notification be placed on title to inform prospective purchases to the risk;
  - it is important to consider the uncertainty in relation to future sea level rise projections and also shoreline response in each coastal compartment. Given the number of properties that are potentially at risk in the 2030 to 2110 time within the Drummond Cove, Sunset Beach and Bluff Point CMU's, a site-specific assessment of shoreline changes into the future which incorporates geotechnical and geophysical data is warranted. This is a high priority recommendation from this study; and
  - in addition, targeted annual monitoring of the shoreline position will be undertaken, to track the local rate of shoreline erosion. The coastal erosion setback lines will be recalculated at five yearly intervals to re-assess which properties (if any) will move up to the higher category of 'Managed Retreat'.

- **Moderate Risk. Property located within the 2070 to 2110 Coastal Erosion Setback Extent**

  There are 528 residential and 7 commercial properties which are located within the 2070 to 2110 coastal erosion setback area. These properties are classified as being at moderate risk under the CHRMAP risk assessment and include properties from Drummond Cove, Sunset Beach, Bluff Point, Point Moore, Mahomet Flats and Tarcoola Beach. For these properties it is recommended the erosion risk is **Accommodated** through:

the provision that a Section 70a notification be placed on title to inform prospective purchases to the risk;

desktop review of the shoreline position undertaken in future revisions of the CHRMAP, which will determine if the risk rating moves up to the 'High' category if shoreline erosion progresses. No specific monitoring is required, and the recalculation of the shoreline position can be done based on analysis of aerial imagery at approximately five yearly intervals.

15.1.3 Managed Retreat Pathway

For properties that are designated in the 'Extreme Risk' category of Managed Retreat, there are three pathways the CGG must evaluate, identify the preferred adaptation pathway, and then prepare for:

1. Under a 'Do Nothing' approach, the CGG will allow natural processes to occur through coastal areas at risk of erosion. At the time that coastal erosion of the shoreline results in impacts to existing properties, the City will seek to resume properties under the *Health Act 2011* (condemn property on the grounds of safety). The structures would be removed and the land transferred to public foreshore reserve, providing a buffer for the coastal areas immediately landward protecting the values of the coast in the area;
2. Under a 'Planned Retreat', the CGG would acquire the properties at risk over time, as the coastal erosion trigger is reached (i.e. HSD moves landward to within the S1 distance of structures). Under this scenario, the City would be required to reserve funds to acquire the properties before or at the time of the erosion trigger. Under the Western Australian framework, voluntary or compulsory acquisition is based on the value of the land and its improvements, exercised through the *Land Administration Act 1997.* The resumed properties would have structures removed and the land would be returned to public foreshore reserve, providing a buffer for the coastal areas immediately landward, and protecting the values of the coast in the area; or
3. The CGG shall investigate coastal protection options to protect properties that are under direct erosion threat. The opportunity to recover the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme should be investigated by the CGG, to apportion the costs against the properties that are protected.

The *Draft Planned or Managed Retreat Guidelines* (DPLH 2017) outline in detail the process for transferring land from the private to the public realm. The City will need to determine whether it follows a 'Do Nothing' or 'Planned Retreat' pathway for existing properties at risk of erosion. Whilst the 'Do Nothing' approach does not impose an acquisition cost on the City for the resumption of properties, the City would incur reputational damage and legal costs. The legal precedent is uncertain for the 'Do Nothing' approach and the City would require specialist legal advice prior to adopting this as a formal planning approach. Conversely, the 'Planned Retreat' option comes at significant cost to the City through the acquisition of properties affected (Table 15.2 indicates potential number of properties over 100-year planning timeframe), whilst limiting the associated reputational and legal costs. The CGG will be required to make a decision on its preferred way forward and to update its planning framework to clearly outline how managed retreat will be controlled.

A case study that is relevant to this decision-making process is the example of the properties that were located on the west side of Whitehill Rd in Drummond Cove, which have now been removed. In the late 1970s the then Shire of Greenough adopted to proceed with Town Planning Scheme No.4 Amendment 108 to zone the land west of Whitehill Road as "Recreation" – this based on the original intent of the transfer of land to the Crown by the Upper Chapman Road Board. This planning direction was taken for the long term wider benefit to the Geraldton community and in 1984 Town Planning Scheme No.4 was formally gazetted. In line with the State Coastal Planning policy [District Coastal Planning Policy DC6.1] in place at the time the Shire of Greenough was required by the State to implement retreat of leasehold dwellings at Drummond Cove when the surrounding land was developed. This lengthy process culminated in the area being returned to foreshore reserve in 2017. In the absence of this process 25 leasehold properties would be in the Extreme risk category.

The City will need to consider the costs and benefits for taking land through a managed retreat process vs the cost of protecting the vulnerable properties on a case by case basis. The CHRMAP has examined the economic case for coastal protection at two locations to examine the viability of protecting the properties and shoreline areas, compared with a 'do nothing' managed retreat:

- At St Georges Beach, in Bluff Point CMU, a variety of coastal protection structures which would offer protection to both Rundle Park and the properties landward recommended to be classified in Managed Retreat were examined. Cost benefit analysis of a range of alternatives indicated a series of geotextile groynes similar to the one currently installed at the northern end of St Georges Beach could deliver a net return on investment when taking into account the value of the property and public land that is protected (refer Appendix A.5).
- For Drummond Cove, a number of options were considered for protection of the shoreline along the closed section of Whitehill Rd. The analysis of alternatives showed a combination of geotextile groynes backed by a seawall could deliver a net return on investment when taking into account the value of the property and public land that is protected (refer Appendix A.5).

The value of properties being protected is the key driver for the positive economic outcomes in both cases. For the CGG, the ability to protect the coast and preserve the coastal values needs to be balanced against a mechanism where recovery of the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme can be agreed. The proposed framework for managing coastal erosion in the Local Coastal Planning Policy is summarised in Table 15.2.

Table 15.2: Proposed Planning Requirements in the Local Coastal Planning Policy for Properties at risk of Erosion within the Special Control Area

Conditions	Current to 2030 Coastal Erosion Setback Area EXTREME RISK	2030 – 2070 Coastal Erosion Setback Area HIGH RISK	2070 – 2110 Coastal Erosion Setback Area MODERATE RISK
Number of Properties within category (Residential + Commercial)	15	219	474
Planning Requirement 1	CGG introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.		
Planning Requirement 2	Require Section 70A notification to be placed on all titles within the CMU to inform prospective purchasers to the risk of coastal erosion.		
New Development Not Classified as 'Infill' under SPP2.6	AVOID	AVOID	AVOID
Redevelopment or New Development Classified as 'Infill' under SPP2.6	MANAGED RETREAT	ACCOMODATE	ACCOMODATE
Monitoring Requirement	Targeted monitoring annually to track change in local shoreline position.	Targeted monitoring annually to track change in local shoreline position.	No Specific Monitoring Requirement.
Trigger for Changing Category	If CGG elects to protect the shoreline, all properties	As part of CHRMAP review every 5 years, re-calculate	As part of CHRMAP review every 10 years, re-

Conditions	Current to 2030 Coastal Erosion Setback Area EXTREME RISK	2030 – 2070 Coastal Erosion Setback Area HIGH RISK	2070 – 2110 Coastal Erosion Setback Area MODERATE RISK
	landward of protection structure would have Managed Retreat condition removed.	the erosion setback lines based on monitoring results and determine if additional properties move category.	calculate the erosion setback lines based on aerial photo /monitoring and determine if properties move category.
CGG Commitment	Decision on strategy, either: 1. 'Do Nothing' approach, the City will allow natural processes to occur, and resume properties as and when they are impacted through the Health Act (acquisition of properties is not required); 2. 'Planned Retreat', voluntary or compulsory acquisition of properties. City to reserve funds to acquire the properties before or at the time of erosion trigger; or 3. Develop coastal protection options and seek to recover the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme.	Focussed annual monitoring of shoreline position required to reassess the erosion risk for properties at highest risk every 5 years (as part of CHRMAP review). Support projects to increase the natural resilience of the shoreline (revegetation, dune management etc).	Reassess erosion risk every 10 years as part of CHRMAP review.

1.Note the properties identified in Point Moore CMU are not included in this total as they are covered by a separate lease agreement with managed retreat conditions imposed

The definition of the trigger point for managed retreat should be determined in the LCPP by the City. The draft managed retreat guidelines (DPLH 2017) state that managed retreat should be implemented when the shoreline (HSD) is within 40m (S1 value) of a structure on the property (in the absence of site specific storm erosion modelling). Typically, significant shoreline erosion occurs in short duration storm events, and post-storm there is often an initially rapid response and accretion of the shoreline as the cross-shore sediment transport returns towards 'equilibrium' for the normal wave and tide conditions at a site and sand is moved on-shore. Additional guidance on the managed retreat trigger process outlining whether this post storm response can be considered will require consideration by the City in developing its LCPP.

15.1.4 Managing Coastal Inundation Risk for Properties in the SCA

Coastal inundation hazard plots are presented in Appendix A.2 for the 500yr ARI and 100yr ARI storm surge event in the planning year 2110. Storm surge risk for Geraldton is driven by extreme cyclone events, with inundation impacts increased by projected sea level rise of 0.4m by 2070 and 0.9m by 2110. It is

noted that the general tides do not pose an inundation threat to Geraldton's coastal areas, even under projected sea level rise.

The low lying coastal areas where storm surge impacts are most pronounced are the Geraldton City centre, Beachlands and Point Moore CMU's. In future planning periods under projected sea level rise of 0.9m, large sections of the City centre area are inundated in an extreme storm surge event at the 500yr ARI level (refer Appendix A.2). In future planning periods, inundation also affects areas in Drummond Cove, Bluff Point and Beresford CMU's at low-lying sections of the coastline.

An estimate of the number of properties that are located within the 500yr-ARI inundation extent over the planning timeframe is summarised in Table 15.3.

Table 15.3: Properties located within the 500-yr ARI inundation extent over the planning timeframe

CMU	Number of Properties[1] at planning year 2030	Number of Properties[1] at planning year 2070	Number of Properties[1] at planning year 2110
Drummond Cove	18	27	56
Bluff Point	4	9	17
Beresford	30	35	63
Geraldton	328	350	390
Point Moore	272	280	284
Beachlands	162	235	420
Tarcoola Beach	3	6	18
Cape Burney	0	3	4
TOTAL	**817**	**945**	**1252**

1.Total for Residential and Commercial and industrial land uses includes developed and undeveloped vacant lots

It is noted that to develop the property analysis presented in Table 15.3:Table E.3

- the process to identify properties does not take account of the depth or extent of flooding on the property and captures all properties where the inundation extent goes across a property boundary. The number of properties would reduce if minor flooding cases were removed (i.e. 'nuisance' flooding of less than 200mm).
- the assessment does not account for finished floor levels and is based on the land surface (i.e. the LiDAR).
- the assessment of flood inundation is based on the mapping presented in Appendix A.2 which is likely to be conservative (i.e. show greater depth) with increasing distance inland from the coastline. The mapping has been completed based on a 'bathtub' approach which does not account for reduction in the flood level as it propagates landward through the built foreshore area.

The Geraldton Town Centre is particularly impacted by inundation in future planning periods and a key recommendation from the CHRMAP is that a detailed overland flood study be completed for the design inundation events, to more appropriately define current and future flood levels throughout Geraldton Town Centre CMU to set finished floor level requirements for planning purposes in the LCPP.

A preliminary calculation of the potential impacts associated with coastal inundation of the residential and commercial premises in the town centre over the 50-year period to 2068 is presented in Appendix A.5. The assessment is based on examination of the depth of flooding that would impact the properties from the 20yr ARI and 100yr ARI scenarios under assumed sea level rise. Damages are assessed based on typical residential, commercial and industrial damage curves, with the present value of damages estimated at $3.5 million. Whilst there are a number of limitations on this assessment, it provides a reasonable basis for understanding the cost of inundation risk to the City centre and provides input to the decision making of where and when an adaptation option against flooding would become economically viable. Targeted outcomes for low lying sections of the CMU, where civil design could additionally provide flood protection (e.g. raising roads as part of general replacement works) should be investigated further.

Specific guidelines will be provided in the LCPP to address the risk of inundation in future planning periods. The adaptation approach to mitigate the risk of storm surge inundation for properties in the SCA is **Accommodate** to be realised through planning controls, building design and emergency planning which would be detailed in the LCPP as summarised on Table 15.4.

Table 15.4: Planning Requirements for Properties at risk of Inundation within the Special Control Area

Option	Adaptation Approach
Planning Controls	• CGG introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • Specific guidance for properties within the SCA would be provided by the Local Coastal Planning Policy (LCPP). • For any new development seeking planning approval on land prone to storm surge, an opportunity exists for the local government to place a condition on any subsequent approval, requiring the landowner/developer to place a Section 70A notification on the certificate of title pursuant to Section 70A of the Transfer of Land Act 1893 to notify prospective purchasers that the lot(s) is located in an area that may be subject to coastal inundation over the next 100 years.
Building Design Recommendations – to be included in LCPP	• Set minimum Finished Floor Levels (FFL) that must be achieved in the design above the design flood condition. • Ensure that all important services, including electricity, permanent fixtures and plumbing are elevated and / or protected from the impact of flooding; • Ensure buildings are designed and materials are employed to withstand structural loads associated with a storm surge flood event; • Ensure foundations and footings are adequate to withstand potential erosive action during coastal inundation; • Where practical, design lower levels of buildings prone to flooding to be permeable to allow water to flow through, without damaging the structure of the building; • Ensure floorspace that is designed to accommodate stock inventory is located above the modelled storm surge flood level; • Where possible, consider the use of false floors in relation to fitout of existing buildings which raise the floor level above the storm surge flood level (where practical); • Employ the use of materials that are resistant to water damage; • Consider floorplate and internal tenancy wall arrangements which would allow for water to flow through rather than build up in dead-end spaces; and • Consider building evacuation requirements.

Option	Adaptation Approach
Emergency Planning – to be included in LCPP	• The local government should ensure that an Emergency Evacuation Plan is prepared, maintained and implemented to ensure the safe evacuation of occupants within the City Centre during a storm surge event.

15.2 Planning Actions

A summary of planning-based actions that could be implemented in the LCPP is summarised in this section.

15.2.1 Coastal Erosion – Built Form and Design Requirements

For any new development relating to the construction of a dwelling or other substantial building on land located on the seaward side of the 2110 coastal erosion line, the City may require the building to be constructed of materials and secured on site in a way that allows that building to be easily removed or relocated (i.e. transportable dwelling) in the event that the asset is threatened by coastal erosion.

15.2.2 Coastal Erosion – Management Requirements

Notifications on Title

For any new development seeking planning approval on land prone to storm surge, an opportunity exists for the local government to place a condition on any subsequent approval, requiring the landowner/developer to place a Section 70A notification on the certificate of title pursuant to Section 70A of the Transfer of Land Act 1893 to notify prospective purchasers that the lot(s) is located in an area that may be subject to coastal inundation over the next 100 years.

Prohibit further subdivision

Generally, don't support further fragmentation and subdivision of land that would result in the creation of new lot/s that would be substantially compromised with respect to development potential, access and other considerations as a result of coastal erosion processes within the 2110 planning timeframe.

Guidance on Resumption of Properties under Managed Retreat

The City will need to update its planning framework to clearly outline how resumption of properties will be implemented, through either a 'Do Nothing' approach or Planned Retreat' (refer Section 15.1.3).

Identification of Trigger Points

Trigger points have been incorporated into the lease agreement for Point Moore lessees as identified below, and similar trigger points could be adopted in recommendations in the LCPP for new residential development at risk of coastal erosion along the Geraldton coastline. The Point Moore trigger points are when;

- the most landward limit of the horizontal shoreline datum (HSD) is within the S1 distance of any structures on the lot;
- no public road is available, or such road is unable to provide safe and/or legal access, to the lot due to coastal hazards;
- within any twelve-month period any part thereof the lot is flooded or inundated to a depth of 0.3 metres or greater from two or more separate hazard events;
- the lot (and any buildings on the lot) has sustained damage to the extent that it is deemed irreparable or a total loss or is rendered uninhabitable for an extended period of time;
- water or electricity to the lot is no longer available because the relevant authority has removed or decommissioned access to water or electricity to the lot; and

- No acquisition or other consideration shall be payable to or claimable by the landowner / developer as a result of the City granting development approval for development on land prone to coastal erosion and / or storm surge inundation.

The recommendations for planning adaptation measures to be incorporated into a LCPP are summarised in Table 15.5.

Table 15.5: Recommended Planning Measures

No.	Circumstance	Adaptation Approach	Mechanism/s
1	Land defined as infill pursuant to SPP2.6 and identified as being prone to coastal erosion	Accommodate and Managed retreat	Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. Identify trigger points within the LCPP to trigger the requirement for development to be removed or relocated to avoid damage as a result of coastal erosion. Development approvals to be granted on a time limited basis based on the trigger points to be identified in LCPP LCPP to establish development standards to ensure new development can be easily relocated or removed in the event that coastal erosion becomes a threat to that asset. The provisions may also require design to respond to storm surge inundation where applicable. Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and / or storm surge.
2	Land not defined as infill pursuant to SPP2.6 and identified as being prone to coastal erosion	Avoid	Prevent any further subdivision or development of zoned land located on the seaward side of the 2110 coastal erosion hazard line. Require any future structure plans / structure plan modifications to respond to the risk of coastal erosion and coastal inundation in line with the requirements of SPP 2.6. Prepare a Foreshore Management Plan to define potential future foreshore reservation requirements.
3	Community infrastructure exempted by Part 7 of Schedule One of SPP 2.6 on land located on the seaward side of the 2110 coastal erosion hazard line.	Accommodate	Consider on an as needs basis. Applications for such uses should be accommodated by necessary justification, including, but not limited to: • Community demand for such a facility; • Emergency evacuation plan (where appropriate); • Lifespan of structure / use; Design measures to withstand coastal events (where appropriate); Other matters as deemed appropriate by the determining authority.

15.2.3 Coastal Inundation – Built Form and Design Requirements

With a majority of the land within the City Centre already developed below the potential inundation levels, it is not practical to take a dramatically modified approach to built form (i.e. substantially raise property / floor levels) to accommodate the risk of storm surge inundation. Firstly, it is not possible to require existing buildings to be modified to accommodate the risk, and secondly, it would not represent a good urban design outcome for the City Centre to require new buildings to sit substantially above the existing street level and surrounding built form context to accommodate the risk of storm surge.

Notwithstanding the above, the following design considerations could be employed the Local Coastal Planning Policy for any new development within the City Centre to better accommodate and reduce the risk of storm surge inundation whilst also maintaining the integrity of built form outcomes for the City Centre:

- Ensuring that all important services, including electricity, permanent fixtures and plumbing are elevated and / or protected from the impact of flooding;
- Ensuring buildings are designed and materials are employed to withstand structural loads associated with a storm surge flood event;
- Ensuring foundations and footings are adequate to withstand potential erosive action during coastal inundation;
- Where practical, designing lower levels of buildings prone to flooding to be permeable to allow water to flow through, without damaging the structure of the building;
- Ensuring floorspace that is designed to accommodate stock inventory is located above the modelled storm surge flood level;
- Where possible, consider the use of false floors in relation to fitout of existing buildings which raise the floor level above the storm surge flood level (where practical);
- Employ the use of materials that are resistant to water damage;
- Consider floorplate and internal tenancy wall arrangements which would allow for water to flow through rather than build up in dead-end spaces; and
- Consider building evacuation requirements.

15.2.4 Coastal Inundation – Management Requirements

Notifications on Title

For any new development seeking planning approval on land prone to storm surge, an opportunity exists for the local government to place a condition on any subsequent approval, requiring the landowner/developer to place a Section 70A notification on the certificate of title pursuant to Section 70A of the Transfer of Land Act 1893 to notify prospective purchasers that the lot(s) is located in an area that may be subject to coastal inundation over the next 100 years.

Emergency Evacuation Planning

The local government should ensure that an Emergency Evacuation Plan is prepared, maintained and implemented to ensure the safe evacuation of occupants within the City Centre during a storm surge event.

The recommendations for planning adaptation measures are summarised in Table 15.6

Table 15.6: Recommended Planning Adaptation Measures for Inundation

No.	Circumstance	Adaptation Approach	Mechanism/s
1	Land prone to storm surge flooding	Accommodate	Prepare a Local Coastal Planning Policy to establish development standards to ensure new development can withstand storm surge events. Introduce a Special Control Area to trigger the requirement for normally exempt development to require planning approval. Section 70A notification on title to inform prospective purchasers to the risk of storm surge events. Prepare an Emergency Evacuation Plan to employ measures to manage the safety of the community during storm surge events.

15.3 Monitoring and Evaluation Plan

A monitoring plan will need to be undertaken to target coastal areas where there is high risk to coastal assets and more broadly to continue to develop understanding of the changes occurring along Geraldton's shoreline areas. The information obtained from the monitoring program will be used to inform implementation of adaptation actions. The monitoring will be targeted to track shoreline changes in key locations of interest and monitor the erosion trigger points identified for assets within the CMU.

A range of monitoring actions across the 12 CMU's will be required nominally:

- Analysis of the shoreline vegetation movement from aerial photo data (sourced from Landgate), to continue the record established in the CVS. Frequency recommended 5 yearly;
- Beach transect survey, ideally twice yearly (winter and summer). Used to monitor changes to the profile of the beach at key locations of interest and potential erosion of the shoreline;
- UAV capture of shoreline elevation at lower capture frequency (e.g. bi-annually). This will be used to supplement transect survey and can assess volumetric changes for specific shoreline areas of focus;
- Analysis of extent of acute erosion (storm bite) at the foreshore following large storm events;
- Photo monitoring of the beach (through continuation of NACC photomon program);
- Inspection of minor structures (e.g. access, shelters etc) in the foreshore area directly exposed to coastal erosion and inundation for condition / safety twice yearly and after large storm events ; and
- Inspection of coastal protection structures (e.g. revetments in Beresford, Geotextile breakwater at St Georges Beach) for condition and performance at minimum yearly and after large storm events

Opportunities to involve local community groups or schools in the monitoring process should be sought at the time of design to foster opportunities for local based groups to be involved with furthering the understanding of the coastal areas.

A summary of the monitoring requirements within each CMU's is provided in Table 15.7. The indicative budget for the monitoring of coastal management units based on the outline in Table 15.7 is $25,000 annually.

The results of the monitoring will inform the CHRMAP review process which will occur approximately every 5 years (indicative budget $15,000 per review).

Table 15.7: Key Focus areas and approaches for Monitoring Program

CMU	Analysis of shoreline movement (aerial	Beach Transect Survey	UAV data capture - analysis of volumetric	Analysis of acute erosion (S1) following	Photo Monitoring	Inspection of minor CGG infrastructure in foreshore	Inspection of coastal protection structures	Key Areas of Focus For Monitoring
1.Drummond Cove	✓	✓	✓	✓	✓	✓	✓	Whitehill Rd Closed Section Foreshore Reserve South of Community Hall Narrow shoreline in front of Surfside Terrace
2.Glenfield	✓	✓		✓	✓			Shoreline in front of WWTP
3.Sunset Beach	✓	✓	✓	✓	✓	✓		In front of Swan foreshore reserve In front of caravan park In front of Volute Drive In front of Outrigger Drive
4.Bluff Point	✓	✓	✓	✓	✓	✓	✓	North of the Beresford coastal protection structures St Georges Beach in front of Rundle Park North of Rundle Park – Elphick Avenue to Champion Bay Rise Shoreline north of Fuller Street to Chapman River mouth
5.Beresford		✓	✓	✓	✓		✓	Sections of beach in front of new revetments Sections of shoreline not protected by revetment
6.Geraldton Town Centre						✓	✓	
7.Point Moore / West End	✓	✓		✓	✓	✓	✓	South Side Point Moore
8.Beachlands	✓	✓		✓	✓	✓	✓	Shoreline in front of Road and Carpark at Separation Point
9.Mahomet Flats	✓							
10.Tarcoola Beach	✓							
11.Southgate Dunes	✓							
12.Cape Burney	✓	✓						In Front of Lookout

15.4 Additional Studies

The recommended studies required to improve understanding in the CMU and support the CHRMAP in future revisions are:

- Geophysical study of the shoreline areas to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term (Drummond Cove, Sunset Beach, Bluff Point) Estimated cost $25,000 for each section of coast ($75,000 total); and
- Overland flood study to more appropriately define current and future flood levels throughout the Geraldton CMU as input to decision on setting finished floor level requirements in a Coastal Planning Policy. Estimated Cost $60,000.

15.5 Implementation Budget

A proposed timeline and cost for the execution of the recommended studies and monitoring over the next five years is presented in Figure 15.1. The full-size project timeline is attached in **Appendix A.6**.

The monitoring activities and additional studies budget for the five-year period 2019 – 2023 shown in Figure 15.1 are summarised in Table 15.8 at a cost of $273,500.

Task	Description (Frequency/Location)	Start	Cost
Year 1	**2019 (Baseline)**		**$102,500**
1.1	Analysis of Shoreline Movements (5 Yearly)	07-Jan-19	$1,500
1.2	Beach Transect Survey (Summer)	04-Mar-19	$3,500
1.3	Beach Transect Survey (Winter)	02-Sep-19	$3,500
1.4	UAV Survey (2 Yearly)	25-Mar-19	$4,000
1.5	Storm Bite Analysis (post storm)	01-Jan-19	$1,500
1.6	Photo Monitoring (Summer and post storm)	01-Apr-19	$2,500
1.7	Photo Monitoring (Winter and post storm)	02-Sep-19	$2,500
1.8	Minor Structure Inspection (Summer and post storm)	01-Apr-19	$2,500
1.9	Minor Structure Inspection (Winter and post storm)	30-Sep-19	$2,500
1.10	Coastal Protection Structure Inspection (Yearly and post storm)	04-Nov-19	$3,500
1.11	Geophysical Assessment (D, BP, SB)	11-Feb-19	$75,000
Year 2	**2020**		**$82,000**
2.1	Beach Transect Survey (Summer)	02-Mar-20	$3,500
2.2	Beach Transect Survey (Winter)	31-Aug-20	$3,500
2.3	Storm Bite Analysis (post storm)	01-Jan-20	$1,500
2.4	Photo Monitoring (Summer and post storm)	02-Mar-20	$2,500
2.5	Photo Monitoring (Winter and post storm)	31-Aug-20	$2,500
2.6	Minor Structure Inspection (Summer and post storm)	06-Apr-20	$2,500
2.7	Minor Structure Inspection (Winter and post storm)	31-Aug-20	$2,500
2.8	Coastal Protection Structure Inspection (Yearly and post storm)	02-Nov-20	$3,500
2.9	Detailed Flood Study (GTC)	10-Feb-20	$60,000
Year 3	**2021**		**$26,000**
3.1	Beach Transect Survey (Summer)	01-Mar-21	$3,500
3.2	Beach Transect Survey (Winter)	30-Aug-21	$3,500
3.3	UAV Survey (2 Yearly)	29-Mar-21	$4,000
3.4	Storm Bite Analysis (post storm)	01-Jan-21	$1,500
3.5	Photo Monitoring (Summer and post storm)	01-Mar-21	$2,500
3.6	Photo Monitoring (Winter and post storm)	30-Aug-21	$2,500
3.7	Minor Structure Inspection (Summer and post storm)	05-Apr-21	$2,500
3.8	Minor Structure Inspection (Winter and post storm)	30-Aug-21	$2,500
3.9	Coastal Protection Structure Inspection (Yearly and post storm)	01-Nov-21	$3,500
Year 4	**2022**		**$22,000**
4.1	Beach Transect Survey (Summer)	28-Feb-22	$3,500
4.2	Beach Transect Survey (Winter)	01-Aug-22	$3,500
4.3	Storm Bite Analysis (post storm)	03-Jan-22	$1,500
4.4	Photo Monitoring (Summer and post storm)	28-Feb-22	$2,500
4.5	Photo Monitoring (Winter and post storm)	05-Sep-22	$2,500
4.6	Minor Structure Inspection (Summer and post storm)	04-Apr-22	$2,500
4.7	Minor Structure Inspection (Winter and post storm)	05-Sep-22	$2,500
4.8	Coastal Protection Structure Inspection (Yearly and post storm)	31-Oct-22	$3,500
Year 5	**2023**		**$41,000**
5.1	Beach Transect Survey (Summer)	06-Mar-23	$3,500
5.2	Beach Transect Survey (Winter)	31-Jul-23	$3,500
5.3	UAV Survey (2 Yearly)	27-Mar-23	$4,000
5.4	Storm Bite Analysis (post storm)	02-Jan-23	$1,500
5.5	Photo Monitoring (Summer and post storm)	06-Mar-23	$2,500
5.6	Photo Monitoring (Winter and post storm)	31-Jul-23	$2,500
5.7	Minor Structure Inspection (Summer and post storm)	03-Apr-23	$2,500
5.8	Minor Structure Inspection (Winter and post storm)	04-Sep-23	$2,500
5.9	Coastal Protection Structure Inspection (Yearly and post storm)	30-Oct-23	$3,500
5.10	CHRMAP Review	07-Aug-23	$15,000
TOTAL	**Cost for All Activities over 5 Years (2019-2023)**		**$273,500**

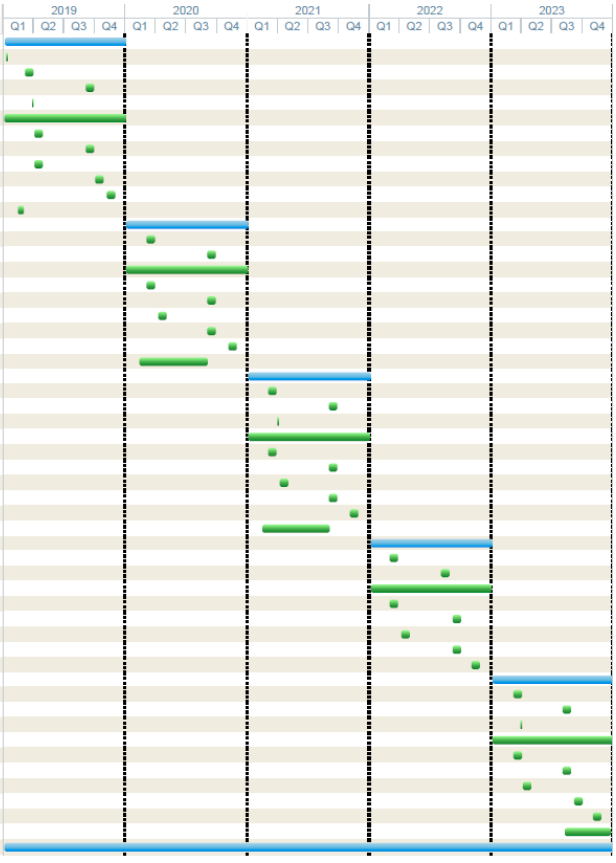

Figure 15.1: Proposed Implementation Plan for Monitoring and additional Studies

Table 15.8 Proposed Timeline and Budget for Monitoring and Additional Studies: 2019 – 2023 Period

Task	Description	Start	Duration	Budget
Year	*2019 (Baseline)*		*52wks*	*$102,500*
1.1	Analysis of Shoreline Movements (5 Yearly)	07-Jan-	1wk	$1,500
1.2	Beach Transect Survey (Summer)	04-Mar-	4wks	$3,500
1.3	Beach Transect Survey (Winter)	02-Sep-	4wks	$3,500
1.4	UAV Survey (2 Yearly)	25-Mar-	1wk	$4,000
1.5	Storm Bite Analysis (post storm)	01-Jan-	52wks (assessed as	$1,500
1.6	Photo Monitoring (Summer and post storm)	01-Apr-	4wks	$2,500
1.7	Photo Monitoring (Winter and post storm)	02-Sep-	4wks	$2,500
1.8	Minor Structure Inspection (Summer and post	01-Apr-	4wks	$2,500
1.9	Minor Structure Inspection (Winter and post storm)	30-Sep-	4wks	$2,500
1.10	Coastal Protection Structure Inspection (Yearly	04-Nov-	4wks	$3,500
1.11	Geophysical Assessment (D, BP, SB)	11-Feb-	2wks	$75,000
Year	*2020*		*52wks*	*$82,000*
2.1	Beach Transect Survey (Summer)	02-Mar-	4wks	$3,500
2.2	Beach Transect Survey (Winter)	31-Aug-	4wks	$3,500
2.3	Storm Bite Analysis (post storm)	01-Jan-	52wks (assessed as	$1,500
2.4	Photo Monitoring (Summer and post storm)	02-Mar-	4wks	$2,500
2.5	Photo Monitoring (Winter and post storm)	31-Aug-	4wks	$2,500
2.6	Minor Structure Inspection (Summer and post	06-Apr-	4wks	$2,500
2.7	Minor Structure Inspection (Winter and post storm)	31-Aug-	4wks	$2,500
2.8	Coastal Protection Structure Inspection (Yearly	02-Nov-	4wks	$3,500
2.9	Detailed Flood Study (GTC)	10-Feb-	28wks	$60,000
Year	*2021*		*52wks*	*$26,000*
3.1	Beach Transect Survey (Summer)	01-Mar-	4wks	$3,500
3.2	Beach Transect Survey (Winter)	30-Aug-	4wks	$3,500
3.3	UAV Survey (2 Yearly)	29-Mar-	1wk	$4,000
3.4	Storm Bite Analysis (post storm)	01-Jan-	52wks (assessed as	$1,500
3.5	Photo Monitoring (Summer and post storm)	01-Mar-	4wks	$2,500
3.6	Photo Monitoring (Winter and post storm)	30-Aug-	4wks	$2,500
3.7	Minor Structure Inspection (Summer and post	05-Apr-	4wks	$2,500
3.8	Minor Structure Inspection (Winter and post storm)	30-Aug-	4wks	$2,500

3.9	Coastal Protection Structure Inspection (Yearly	01-Nov-	4wks	$3,500
Year	*2022*		*52wks*	*$22,000*
4.1	Beach Transect Survey (Summer)	28-Feb-	4wks	$3,500
4.2	Beach Transect Survey (Winter)	01-Aug-	4wks	$3,500
4.3	Storm Bite Analysis (post storm)	03-Jan-	52wks (assessed as	$1,500
4.4	Photo Monitoring (Summer and post storm)	28-Feb-	4wks	$2,500
4.5	Photo Monitoring (Winter and post storm)	05-Sep-	4wks	$2,500
4.6	Minor Structure Inspection (Summer and post	04-Apr-	4wks	$2,500
4.7	Minor Structure Inspection (Winter and post storm)	05-Sep-	4wks	$2,500
4.8	Coastal Protection Structure Inspection (Yearly	31-Oct-	4wks	$3,500
Year	*2023*		*52wks*	*$41,000*
5.1	Beach Transect Survey (Summer)	06-Mar-	4wks	$3,500
5.2	Beach Transect Survey (Winter)	31-Jul-	4wks	$3,500
5.3	UAV Survey (2 Yearly)	27-Mar-	1wk	$4,000
5.4	Storm Bite Analysis (post storm)	02-Jan-	52wks (assessed as	$1,500
5.5	Photo Monitoring (Summer and post storm)	06-Mar-	4wks	$2,500
5.6	Photo Monitoring (Winter and post storm)	31-Jul-	4wks	$2,500
5.7	Minor Structure Inspection (Summer and post	03-Apr-	4wks	$2,500
5.8	Minor Structure Inspection (Winter and post storm)	04-Sep-	4wks	$2,500
5.9	Coastal Protection Structure Inspection (Yearly	30-Oct-	4wks	$3,500
5.10	CHRMAP Review	07-Aug-	20wks	$15,000
TOTAL COST over 5 years (2019-2023)				**$273,500**

* All activities recommended to be carried out at the dates specified. Activities with 'post storm' included in their description should be carried out following large storms events, as soon as practicable.

A budget of approximately $515,000 will be required over the 14-year period 2019 to 2032 to address the cost of annual monitoring, complete the recommended additional studies to inform the LCPP and undertake review of the CHRMAP twice in the 14-year period.

There are a number of funding streams that could be used to support the cost of the monitoring process (outlined in Section 15.6). Opportunities to involve local community groups or schools in the monitoring process should be sought, to foster opportunities for local based groups to be involved and take ownership of developing the understanding of both coastal hazard and coastal adaptation.

15.6 Funding Sources Available to support Implementation

15.6.1 Department of Transport Coastal Adaptation and Protection Grants.

Coastal Adaptation and Protection (CAP) grants are available to public bodies responsible for coastal management in Western Australia, including:

- Local governments;
- State government agencies;
- Aboriginal land councils; and
- Other corporate bodies directly involved with coastal management.

Coastal Adaptation and Protection (CAP) grants are available for coastal projects such as:

- Coastal monitoring;
- Investigations;
- Asset management;
- Coastal adaptation; and
- Maintenance works.

There is a project application minimum of $10,000 ex GST and project application maximum of $300,000 ex GST. Up to $1 million grant funding is available annually.

Up to 50 per cent of the total project cost is available for all project types; the remainder of the project cost is to be funded by the applicant. The DoT grants page provides details of recently awarded grants. (http://www.transport.wa.gov.au/capgrants)

15.6.2 Coastwest

Coastwest is a State Government initiative aimed at providing opportunities for Western Australians to learn about, conserve and protect our coast. The Department of Planning administers the Coastwest program on behalf of the West Australian Planning Commission.
https://www.planning.wa.gov.au/coastwest.asp

The objectives of Coastwest grants are to:

- contribute to the implementation of local and regional coastal plans and strategies especially those devised in accordance with SPP2.6;
- assist in the identification, protection and maintenance of environmental values, aesthetic qualities, biodiversity and water quality in the coastal zone;
- foster sustainable recreational and tourist use of the coast by assisting in the maintenance of the recreational amenity and provision of public access to the coast; and
- build capacity in Western Australian communities in order to increase their involvement in coastal zone management activities, through joint coastal research activities, education and training.

Up to $325,000 is available with applications invited for grants of between $5,000 and $ 50,000.

15.6.3 NACC Funding

NACC's Coastal Community Grants Program aims to improve the management and protection of the coastal environment to ensure its ecological values are retained for future generations.

The Coastal Community Grants provide resources to assist community groups to undertake on-ground coastal management and adaptation activities, enhance community skills and knowledge in rehabilitation, restoration and conservation of the coast.

Two separate grants cater for different community needs:

- The Coastal Community Grants provide funds from $2,000 to $10,000 and are available only through a competitive assessment process at the start of each financial year.

- Quick Step Grants provide funds up to $2,000 and are available as “first come, first served” throughout the year.

https://www.nacc.com.au/project/small-coastal-grants-program/

16. Summary and Recommendations

The initial stages of the Geraldton CHRMAP project delivered a risk-based assessment for the 12 coastal management units that make up the approximately 30km of Geraldton's coastline (Baird 2019). The risk from coastal erosion and coastal inundation was assessed over a range of planning timeframes for the 100 years planning period (to 2110).

In this Coastal Adaptation report, the key assets identified at high to extreme risk in the next 100 years, have been analysed to develop a range of coastal adaptation strategies to address the risk, using the hierarchy of strategies from Avoid-Managed Retreat-Accommodate and Protect (WAPC 2013). The CHRMAP process recommends a range of planning and management-based approaches that can be applied in the CMU to address the coastal risk across the planning periods.

Managing the coastal hazard risk for new and existing residential and commercial development along Geraldton's coast is recommended through a suite of planning-based approaches, requiring an update to the current planning scheme. The planning mechanisms to address immediate and longer term coastal hazard risks are:

- It is recommended the CGG introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. The SCA will be based on the most landward position of either the 2110 coastal erosion setback line or inundation extent for the 500yr ARI event in the year 2110.
- A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
- To manage the risk to Residential and Commercial properties, all properties within the SCA will require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion and /or coastal inundation. It is noted that Section 70a notification can only be applied to a property at time of sale, development application or redevelopment of the property.

Within the SCA boundary, this CHRMAP is recommending the LCPP include a cascading suite of measures to address immediate, medium and long-term risks; and uncertainties with future sea level rise and shoreline responses.

- For development approval of undeveloped residential or commercial land at risk of erosion that *is not* considered to be infill development under SPP2.6, the planning approach recommended is **Avoid**. Development will only be permitted on the portion of a lot landward of the 2110 coastal erosion setback line and an appropriate foreshore reserve allowance.
- For development approval of land at risk of erosion that *is* considered infill development under SPP2.6, development approval will be supported under an **Accommodate** and **Managed Retreat** approach with mechanisms to address the identified risk specified within the LCPP.
- The adaptation approach to mitigate risk of storm surge inundation is **Accommodate** to be realised through planning controls, building design and emergency planning specified in the LCPP

The CHRMAP has examined the economic case for coastal protection at two locations to examine the viability of protecting the properties and shoreline areas, compared with a 'do nothing' managed retreat:

- At St Georges Beach, in Bluff Point CMU a variety of coastal protection structures which would offer protection to both Rundle Park and the properties landward recommended to be classified in Managed Retreat were examined. Cost benefit analysis of a range of alternatives indicated a series of geotextile groynes similar to the one currently installed at the northern end of St Georges Beach could deliver a net return on investment when taking into account the value of the property and public land that is protected (refer Appendix A.5).
- For Drummond Cove, a number of options were considered for protection of the shoreline along the closed section of Whitehill Rd. The analysis of alternatives showed a combination of geotextile groynes

backed by a seawall could deliver a net return on investment when taking into account the value of the property and public land that is protected (refer Appendix A.5).

The value of properties being protected is the key driver for the positive economic outcomes in both cases. For the CGG, the ability to protect the coast and preserve the coastal values needs to be balanced against a mechanism where recovery of the capital cost and ongoing maintenance through a beneficiary pays or differential rating scheme can be agreed.

For the Geraldton Town Centre, a preliminary calculation of the potential impacts associated with coastal inundation of the residential and commercial premises in the town centre over the 50-year period to 2068 is presented in Appendix A.5. Damages are assessed based on typical residential, commercial and industrial damage curves, with the present value of damages estimated at $3.5 million. Whilst there are a number of limitations on this assessment, it provides a reasonable basis for understanding the cost of inundation risk to the City centre and provides input to the decision making of where and when an adaptation option against flooding would become economically viable. Targeted outcomes for low lying sections of the CMU, where civil design could additionally provide flood protection (e.g. raising roads as part of general replacement works) should be investigated further.

The CGG and the local community have led coastal adaptation and management for its coastal areas over a long period of time, and in the future the continued active involvement to respond to coastal risk from erosion and inundation will be critical under forecast climate change and sea level rise. The following recommendations for future studies and monitoring are made to support the CHRMAP process:

- A geophysical study of the critical shoreline areas in the northern coastal management units at Drummond Cove, Sunset Beach and Bluff Point should be undertaken to examine for the presence of rock strata beneath the foreshore. Based on the findings, specific analysis and potentially modelling of shoreline response to sea level rise and storm erosion could then be completed, to redefine coastal erosion setback extents shoreward. The current coastal erosion setback allowances in these sections of coast have been calculated based on SPP2.6 recommendations assuming the shoreline is composed of sand, with no underlying rock. Confirmation of the presence of underlying rock in foreshore areas would improve the understanding of how shorelines in these areas may respond to erosion threat and on this basis setback lines calculated under SPP2.6 (components S1, S2, S3) could be re-examined. These types of geophysical studies have been completed in many similar foreshore areas in Western Australia (e.g. Seabird, Two Rocks, Binningup, Quinns Beach, Trigg Beach) to define rock profiles in coastal areas for input into coastal erosion assessments and CHRMAP studies;
- It is recommended the City undertake a detailed overland flood study to more appropriately define current and future flood levels throughout the SCA (in particular Geraldton Town Centre) before setting finished floor level for new structures in the planning requirements. The mapping of inundation areas in Appendix A.2 applied in the CHRMAP assessment is suitable for initial assessment of the flooding of coastal areas, however a more detailed assessment of flooding impacts is required for planning purposes.
    - The Appendix A.2 inundation mapping shows flood depth determined by applying the design flooding levels to the land surface, as defined by LiDAR data flown in March 2013 (NACC 2013). Baird developed the flood maps based on an initial ‘bathtub’ type approach, improved by applying a ‘hydro-connectivity’ algorithm. Hydro-connectivity ensures that the flooded areas inland connect to the offshore ocean region. The hydro-connected surface overcomes the limitation of the standard bathtub method where isolated inland pockets of inundation will occur noting there are still limitations in this approach. The key limitations of the Appendix A.2 mapping that would be overcome by a detailed flood study are cited as:
        - The LiDAR dataset is based on land levels in 2013. Additional ground survey to capture changes in landform in foreshore areas since the 2013 survey data capture could be incorporated in the assessment;
        - the finished floor levels of properties in the coastal areas is not considered in the inundation mapping. Defining the floor height at property level will provide a more robust definition of flood risk; and

- The calculated depth of inundation for inland areas is based on the offshore ocean level and does not consider the loss of vertical height inland associated with propagation of the flood level across the foreshore area (i.e. surface roughness, drainage infrastructure, wave setup effects reducing inland).

The flood study would provide improved understanding of flooding impacts for planning purposes within the SCA and refine the inundation extents reported in Appendix A.2. Adaptation options for flood control could also be further assessed through this process. The overland flood study should adopt a modelling methodology that incorporates all key processes including coastal water levels and wave forcing, vegetation and surface roughness, high resolution ground and building elevation data, rainfall on grid and drainage infrastructure; and

- A targeted monitoring program to support the CHRMAP recommendations and build understanding of coastal erosion and inundation impacts in key coastal areas has been developed (Section 15); and
- CGG should fund, implement and support community projects to increase the natural resilience of the shoreline through revegetation and dune management. A focus of the CGG should be to encourage community organisation and involvement in those activities.

This CHRMAP has identified a budget of approximately $515,000 will be required over the 14-year period 2019 to 2032 to address the cost of annual monitoring, complete the recommended additional studies to inform the LCPP and undertake review of the CHRMAP twice in the 14-year timeframe.

A projected timeline and cost for the execution of the recommended studies and monitoring over the next five years is presented in Figure 16.1. The total cost for the five-year period 2019 – 2023 is $273,500. The full-size project timeline is attached in **Appendix A.6**.

There are a number of funding streams that could be used to support the cost of the monitoring process (outlined in Section 15). Opportunities to involve local community groups or schools in the monitoring process should be sought, to foster opportunities for local based groups to be involved and take ownership of developing the understanding of both coastal hazard and coastal adaptation.

Task	Description (Frequency/Location)	Start	Cost
Year 1	2019 (Baseline)		$102,500
1.1	Analysis of Shoreline Movements (5 Yearly)	07-Jan-19	$1,500
1.2	Beach Transect Survey (Summer)	04-Mar-19	$3,500
1.3	Beach Transect Survey (Winter)	02-Sep-19	$3,500
1.4	UAV Survey (2 Yearly)	25-Mar-19	$4,000
1.5	Storm Bite Analysis (post storm)	01-Jan-19	$1,500
1.6	Photo Monitoring (Summer and post storm)	01-Apr-19	$2,500
1.7	Photo Monitoring (Winter and post storm)	02-Sep-19	$2,500
1.8	Minor Structure Inspection (Summer and post storm)	01-Apr-19	$2,500
1.9	Minor Structure Inspection (Winter and post storm)	30-Sep-19	$2,500
1.10	Coastal Protection Structure Inspection (Yearly and post storm)	04-Nov-19	$3,500
1.11	Geophysical Assessment (D, BP, SB)	11-Feb-19	$75,000
Year 2	2020		$62,000
2.1	Beach Transect Survey (Summer)	02-Mar-20	$3,500
2.2	Beach Transect Survey (Winter)	31-Aug-20	$3,500
2.3	Storm Bite Analysis (post storm)	01-Jan-20	$1,500
2.4	Photo Monitoring (Summer and post storm)	02-Mar-20	$2,500
2.5	Photo Monitoring (Winter and post storm)	31-Aug-20	$2,500
2.6	Minor Structure Inspection (Summer and post storm)	06-Apr-20	$2,500
2.7	Minor Structure Inspection (Winter and post storm)	31-Aug-20	$2,500
2.8	Coastal Protection Structure Inspection (Yearly and post storm)	02-Nov-20	$3,500
2.9	Detailed Flood Study (GTC)	10-Feb-20	$40,000
Year 3	2021		$46,000
3.1	Beach Transect Survey (Summer)	01-Mar-21	$3,500
3.2	Beach Transect Survey (Winter)	30-Aug-21	$3,500
3.3	UAV Survey (2 Yearly)	29-Mar-21	$4,000
3.4	Storm Bite Analysis (post storm)	01-Jan-21	$1,500
3.5	Photo Monitoring (Summer and post storm)	01-Mar-21	$2,500
3.6	Photo Monitoring (Winter and post storm)	30-Aug-21	$2,500
3.7	Minor Structure Inspection (Summer and post storm)	05-Apr-21	$2,500
3.8	Minor Structure Inspection (Winter and post storm)	30-Aug-21	$2,500
3.9	Coastal Protection Structure Inspection (Yearly and post storm)	01-Nov-21	$3,500
3.10	Detailed Flood Study (GRM)	12-Feb-21	$15,000
Year 4	2022		$22,000
4.1	Beach Transect Survey (Summer)	28-Feb-22	$3,500
4.2	Beach Transect Survey (Winter)	01-Aug-22	$3,500
4.3	Storm Bite Analysis (post storm)	03-Jan-22	$1,500
4.4	Photo Monitoring (Summer and post storm)	28-Feb-22	$2,500
4.5	Photo Monitoring (Winter and post storm)	05-Sep-22	$2,500
4.6	Minor Structure Inspection (Summer and post storm)	04-Apr-22	$2,500
4.7	Minor Structure Inspection (Winter and post storm)	05-Sep-22	$2,500
4.8	Coastal Protection Structure Inspection (Yearly and post storm)	31-Oct-22	$3,500
Year 5	2023		$41,000
5.1	Beach Transect Survey (Summer)	06-Mar-23	$3,500
5.2	Beach Transect Survey (Winter)	31-Jul-23	$3,500
5.3	UAV Survey (2 Yearly)	27-Mar-23	$4,000
5.4	Storm Bite Analysis (post storm)	02-Jan-23	$1,500
5.5	Photo Monitoring (Summer and post storm)	06-Mar-23	$2,500
5.6	Photo Monitoring (Winter and post storm)	31-Jul-23	$2,500
5.7	Minor Structure Inspection (Summer and post storm)	03-Apr-23	$2,500
5.8	Minor Structure Inspection (Winter and post storm)	04-Sep-23	$2,500
5.9	Coastal Protection Structure Inspection (Yearly and post storm)	30-Oct-23	$3,500
5.10	CHRMAP Review	07-Aug-23	$15,000
TOTAL	Cost for All Activities over 5 Years (2019-2023)		$273,500

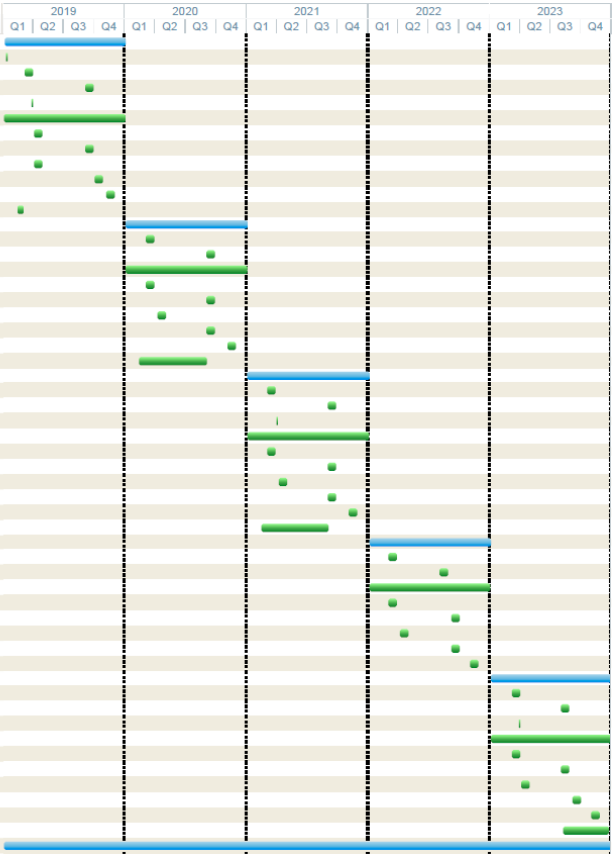

Figure 16.1: Projected Implementation Plan for Monitoring and additional Studies

The CHRMAP process is a continual process that will be revised regularly in the future to ensure its recommendations are meeting the goal of addressing the identified coastal hazard risks. As the understanding of coastal processes through Geraldton improves over time and dynamic coastal areas change under general conditions and extreme events, there will be a need to update the CHRMAP document to maintain its relevance. The first review of the CHRMAP is scheduled within 5 years. Ongoing review after that time should every be 5 or 10 years depending on risk and changes in shoreline and sea level rise projections.

A summary of the planning-based recommendations and approaches for managing property and CGG coastal infrastructure in each of the CMU is presented in Table 16.1. The two general categories cover:

• Property – private dwellings and business premises including vacant lots; and

• CGG Coastal Infrastructure – coastal structures and coastal areas managed by the CGG (e.g. playground areas, toilets, carparks, roads, foreshore reserve)

Table 16.1: Summary Coastal Adaptation Approaches to Manage Risk by CMU

CMU	Erosion	Inundation

Drummond Cove	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA.
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6.
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 98 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines.
	  • Moderate: 187 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Initial 5-year review of shoreline and updated site-specific assessment of future shoreline hazard lines.
	CGG coastal infrastructure:
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
		Property – Planning Recommendations
		• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation.
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.
		CGG coastal infrastructure:
		• Consider future raising of Whitehill Rd to provide flood protection for houses in the section south of Hester Street (timeframe is post 2070 based on assumed rate of sea level rise).
		• Full flood study recommended to confirm flooding impacts to properties in future planning

CMU	Erosion	Inundation
	• The coastal protection structure in front of the Community Hall should be maintained consistent with the design life of the structure. Note the coastal protection feature is not recognised as a long-term commitment for this section of the CMU. • A coastal protection structure for Drummond Cove, north of the Community Hall in front of the closed section of Whitehill Rd warrants further assessment based on high level economic assessment of a protect structure. • Geophysical study of the shoreline areas to examine presence of rock strata that could reduce the erodibility of critical sections over the longer term.	periods and set finished floor level requirements of LCPP.

Glenfield	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area.
	• Summary of risk level in CMU:
	  • Extreme: 0 properties.
	  • High: 0 properties.
	  • Moderate: 0 properties.
	CGG coastal infrastructure:
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• The Water Treatment Plant is recommended to be placed on a Managed Retreat erosion trigger of 30m distance from the site boundary to the HSD.
		Property – Planning Recommendations
		• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation.
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.

Sunset Beach	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA	No Risk of Inundation

CMU	Erosion	Inundation

	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6.
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 57 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD). and updated site-specific assessment of future shoreline hazard lines.
	  • Moderate: 82 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Initial 5-year review of shoreline and updated site-specific assessment of future shoreline hazard lines.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• Critical at-risk assets to 2030 are Triton Place Carpark, Caravan Park, Foreshore Reserve areas, Swan Drive Park Toilets and Grassed Areas.	

Bluff Point	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6. • Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level: • Extreme: 13 properties in addition to Section 70a notification on Title, **Managed Retreat** condition would be imposed at time of development	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation. • **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning

CMU	Erosion	Inundation
	application / redevelopment, with trigger set when erosion of shoreline reduces horizontal distance from HSD to structure to less than (S1). • High: 61 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD) and updated site-specific assessment of future shoreline hazard lines. • Moderate: 69 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Initial 5-year review of shoreline and updated site-specific assessment of future shoreline hazard lines. CGG coastal infrastructure • The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • Critical at-risk assets to 2030 are St Georges Beach / Rundle Park and amenities, Heritage Site, Kempton St. • A coastal protection approach for Rundle Park at St Georges Beach warrants further assessment, based on MCA and CBA analysis of options which recommended a protection through a series of geotextile groynes could deliver a net return on investment on the value of assets it protects on the landside.	time frame through design and planning measures outlined in the LCPP.
Beresford	Property – Planning Recommendations • The CMU is **Protected** from erosion through the revetment structures constructed for the Beresford Foreshore Protection Project. The CGG has elected to continue protection of the CMU. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU CGG coastal infrastructure • The sand nourishment program currently delivered by the Geraldton Port Authority will be required to continue to support the ongoing requirements for sediment supply to the CMU.	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation. • **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and

CMU	Erosion	Inundation
		planning measures outlined in the LCPP.
Geraldton Town Centre	Property – Planning Recommendations • The CMU is **Protected** from erosion through a series of groynes, seawalls and revetment structures. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU CGG coastal infrastructure • The sand nourishment program currently delivered by the Geraldton Port Authority will be required to continue to support the ongoing requirements for sediment supply to the CMU.	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation. • Undertake overland flood study to more appropriately define current and future flood levels throughout the CMU and set finished floor level requirements in the LCPP. • **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP. • **Accommodate** inundation risk to people through emergency evacuation and emergency response planning outlined in the LCPP.
Point Moore / West End	Property – Planning Recommendations • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Lease agreements for Point Moore residents have specified **managed retreat** conditions based on erosion and inundation triggers (McCleods 2017). • Summary of risk level in CMU:	Property – Planning Recommendations • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Lease agreements for Point Moore residents have specified

CMU	Erosion	Inundation
	• Not rated in CHRMAP – erosion risk for Point Moore residents was assessed prior to CHRMAP in determination of the renewed lease agreements (CGG2017c). CGG coastal infrastructure • The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • Critical at-risk assets to 2030 are Marine Terrace South Side. • The coastal protection structure on the south side of Point Moore should be maintained, consistent with the design life of the structure. Note the coastal protection feature has not been recognised as a long-term commitment for this section of coast.	**managed retreat** conditions based on erosion and inundation triggers.

Beachlands	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6.
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 1 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. Annual Monitoring of shoreline (HSD).
	  • Moderate: 4 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. 5 yearly Review of shoreline.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
		Property – Planning Recommendations
		• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
		• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA
		• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal inundation.
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.
		• Future **Protect** option recommended for further assessment which would raise the land level at the Rail Line Corridor to act as a levy / dike to prevent flooding of inland areas in extreme events.

CMU	Erosion	Inundation
	• Critical at-risk assets to 2030 are Separation Point Carpark / Rd.	

Mahomet Flats	Property – Planning Recommendations
	• Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval.
	• A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion.
	• **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6.
	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 0 properties.
	  • Moderate: 3 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. 5 yearly Review of shoreline.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• No Critical at-risk assets to 2030.
		No Risk of Inundation.

Tarcoola Beach	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • **Avoid** development of vacant residential land within the identified 2110 coastal hazard area not classified as Infill under SPP2.6.	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the SCA • Require Section 70A notification to be placed on titles to inform

CMU	Erosion	Inundation

	• Allow infill development subject to LCPP provisions, which use either Accommodate or Managed Retreat depending on risk level:
	  • Extreme: 0 properties.
	  • High: 0 properties.
	  • Moderate: 127 properties. **Accommodate** erosion risk on the provision that a Section 70a notification is placed on Title. 5 yearly Review of shoreline.
	CGG coastal infrastructure
	• The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required.
	• No Critical at-risk assets to 2030.
		prospective purchasers to the risk of coastal inundation.
		• **Accommodate** inundation risk to houses and property to ensure risk is mitigated over the planning time frame through design and planning measures outlined in the LCPP.

Southgate Dunes	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU • Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • **Avoid** development of vacant residential land within the identified 2110 coastal hazard area. CGG coastal infrastructure: • The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • No Critical at-risk assets to 2030.	Risk of inundation in dune system in extreme events is an Acceptable risk.
Cape Burney	Property – Planning Recommendations • Introduce a Special Control Area (SCA) to trigger the requirement for normally exempt development to require planning approval. • A Local Coastal Planning Policy (LCPP) will be developed and provide Statutory Planning guidelines and prescriptive recommendations for development of properties within the CMU	Risk of inundation in dune system in extreme events is an Acceptable risk.

CMU	Erosion	Inundation
	• Require Section 70A notification to be placed on titles to inform prospective purchasers to the risk of coastal erosion. • **Avoid** development of vacant residential land within the identified 2110 coastal hazard area. CGG coastal infrastructure • The general approach within the CMU for coastal infrastructure is **Managed Retreat**. The approach will allow use of the asset to continue until defined trigger points are reached, or a safety risk is presented at which point asset removal is required. • Critical at-risk assets to 2030 - beach lookout and pathway.	

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Appendix A

Technical Appendices

A.1 Coastal Erosion Allowances (Setback)

A.2 Coastal Inundation Mapping

A.3 Coastal Asset Mapping

A.4 Adaptation Toolbox

A.5 Economic Analysis

A.6 Projected Timeline and Budget for Monitoring and Additional Studies