City of Cockburn
Coastal Adaptation Plan

Prepared as part of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project

City of Cockburn
wetlands to waves

COCKBURN SOUND
COASTAL ALLIANCE

GHD

Executive Summary

Sections of the Cockburn coast are exposed, and vulnerable to coastal processes, including erosion and inundation. Over time, the coast will become increasingly vulnerable to the impacts of sea level rise, storm surges and changes in sediment regimes.

The City of Cockburn, together with the Cities of Fremantle, Kwinana and Rockingham, forms part of the Cockburn Sound Coastal Alliance, which is delivering the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project. The stages of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project are:

Stage 1 – Coastal Vulnerability Assessment (completed in February 2013):

Stage 2 – Values and Risk Assessment (Completed in November 2014)

Stage 3 – Coastal Adaptation Plan

Stage 4 – Implementation and Monitoring

Stage 3 of the project aims to ensure that coastal communities and local governments along the Owen Anchorage and Cockburn Sound coast are informed of the risks and are prepared to respond to the threats posed by current and future coastal hazards.

This plan has been prepared to adapt to the changing coast in the City of Cockburn, and provides recommended timeframes and trigger points for decision-making and planning. The plan has been prepared as the first iteration of an evolving, long-term planning and decision-making process for the City of Cockburn, the community and key stakeholders to adapt our settlements and infrastructure to coastal processes – including risks of coastal erosion and inundation.

The adaptation plan includes an implementation stage that recommends specific coastal adaptation activities to be delivered in the immediate (15-year) planning horizon. Supporting this, the plan provides a road map for incorporation of adaptation planning into the City of Cockburn's strategic plans, land use planning framework, long-term financial plan, and decision-making processes. The plan also identifies key regional strategic planning activities recommended to be delivered by the state government to facilitate adaptation planning at the local scale.

Irrespective of the lead for preparing adaptation plans, there are a number of stakeholders and decision makers involved in adaptation planning. Successful adaptation planning over time requires cooperation from all levels of government and, the community, together with asset owners and managers. Funding will be a key issue for the implementation of adaptation planning.

The adaptation plan has been prepared based on a number of principles that underpin the adaptation planning process.

- Principle 1 Adaptation planning in the current planning horizon does not impede the ability of future generations to respond to increasing risk beyond current planning horizons.
- Principle 2 Adaptation requires a decision-making framework that enables the right decision to be made at the right time, in line with the values and circumstances of the time.
- Principle 3 Adaptation planning reflects the public's interest in the social, environmental and economic value of the coast.
- Principle 4 Alternative adaptation measures should consider the full range of land uses and values.
- Principle 5 The full life-cycle benefits, costs and impacts of coastal protection works should be evaluated in considering adaptation options.

These principles are the basis of a flexible adaptation pathway for the City of Cockburn.

Flexible Adaptation: we prepare our governance and planning frameworks to maintain flexibility in available adaptation options, so that the right decisions can be made at the right time.

As risk to coastal assets increases from tolerable to intolerable over time, decisions will need to be made about how we adapt to that risk. These points in time, when decisions are required, are trigger points for adaptation planning.

Adaptation planning is cyclical. The flexible adaptation pathway combines decision-making on specific adaptation options (avoid, retreat, accommodate, interim protection) at the time of trigger points with an ongoing strategic planning process that plans for, and therefore maintains, the same range of adaptation options for future decisions in the longer term. In this way, by choosing to accommodate or protect in the short-term, we are not binding future communities to the long-term cost of that decision beyond the design life of the infrastructure or asset.

The adaptation plan includes two planning horizons for decision-making:

Immediate (15-year) planning horizon: test values and act on any immediate trigger points.

Long-term (100-year) planning horizon: monitor, set up planning and governance frameworks.

The flexible adaptation pathway is about enabling the community and decision makers to be ready for these triggers when they occur in the immediate or long-term planning horizon and beyond. The area within Cockburn where decisions are required in the immediate planning horizon is North Coogee (CY O'Connor Reserve).

The table below identifies the key focus areas for implementation to establish the flexible adaptation pathway for the long-term planning horizon, and specific adaptation measures to manage coastal risks in the immediate planning horizon within the City of Cockburn.

Key focus areas for implementation

Focus for implementation	Responsible Agency
Prepare a foreshore management plan for CY O'Connor Reserve to provide an implementation framework for adaptation, and include immediate- term adaptation measures including: – Installation of two groynes or offshore breakwaters at CY O'Connor Beach – Dune management and revegetation – Responsive beach nourishment	City of Cockburn
Prepare a foreshore management plan for Coogee Beach to provide an implementation framework for adaptation and long term retreat, and include immediate-term adaptation measures including: – Dune management and revegetation Responsive beach nourishment	City of Cockburn
Engage with the community on coastal risks, impacts, values and the adaptation plan.	City of Cockburn
Incorporate flexible adaptation pathway into strategic planning and governance frameworks	City of Cockburn
Review regional planning documents to facilitate decisions and implementation regarding long-term managed retreat.	Department of Planning and Western Australian Planning Commission
Commence dialogue with infrastructure and land owners and managers regarding the adaptation plan and coastal risk.	Department of Planning and City of Cockburn
Review local planning strategy and scheme, to include investigation of the introduction of a special control area and necessary development controls for the vulnerable coastal areas.	City of Cockburn
Monitor risk levels to land and infrastructure	City of Cockburn

The adaptation plan identifies focus areas/actions for implementation by state government, particularly in relation to policy, expansion of the foreshore reserve (where necessary in the longer term), and major infrastructure. This plan does not bind state government or other stakeholders to the actions. However, it recognises that long-term adaptation requires the support of these key stakeholders. The City of Cockburn, alongside the Cockburn Sound Coastal Alliance, will work closely with the state government and other key stakeholders to deliver the actions necessary to achieve an adaptation pathway.

The adaptation plan should be reviewed regularly, alongside the ten-yearly reviews of the City of Cockburn Strategic Plan.

Review processes should include targeted community and industry consultation to update values and views about coastal development and assets that will be at risk both within a 15-year planning horizon and beyond. Revised values and new learnings should be used to test recommendations of this adaptation plan, and determine whether adaptation strategies for the 15-year planning horizon require modification as a result of changing values.

It will be necessary to update the hazard mapping from time to time to reflect actual sea level rise, updated projections of future sea level rise and the response of the coast to changing conditions. These updates should occur as new information becomes available.

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Appendices

1. Introduction

1.1 Project background

The City of Cockburn, along with the Cities of Fremantle, Kwinana and Rockingham is part of the Cockburn Sound Coastal Alliance, which is delivering the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project. The stages of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project are to:

Stage 1 – Coastal Vulnerability Assessment (completed in February 2013)

- Improve the understanding of the coastal features, processes and hazards of the study area (coastal landforms, geological features, sediment supplies, sediment distribution and meteo-ocean processes);
- Identify the degree of exposure and sensitivity of the various sections of coastline to the potential impacts of future weather events and sea level rise associated with both natural variability and climate change.
- Develop an understanding of the vulnerability of the coast within each coastal compartment based on an understanding of current and future physical changes (output from Stage 1);
- Identify significant vulnerability trigger points and respective timeframes for each sediment cell to mark the need for immediate or medium term adaptation action;

Stage 2 – Values and Risk Assessment (Completed in November 2014)

- Facilitate the understanding of climate science, coastal hazards and risk management amongst key stakeholders (not including community);
- Identify what assets are situated along the coast and what services and functions those assets provide;
- Identify the 'value at risk' of coastal assets potentially affected by coastal processes and climate change under different timeframes and climate change scenarios
- Identify and evaluate potential adaptation options for vulnerable areas;
- Quantify the risks in terms of consequence and likelihood of those hazards identified.

Stage 3 – Coastal Adaptation Plan

- In consultation with the key stakeholder groups and community, verify the intrinsic current and anticipated economic, socio-economic and ecologic values of assets at risk;
- In consultation with the key stakeholder groups and community, assess and verify the most effective and feasible adaptation options which can include coastal protections, planning instruments and market interventions;
- Share best practices and lessons learnt; and
- Identify critical data gaps.

Stage 3 of the project aims to ensure that coastal communities and local governments in Cockburn Sound are informed of the risks and are prepared to respond to the threats posed by current and future coastal hazards in meaningful adaptation plans.

The project extends for the entire Owen Anchorage and Cockburn Sound coast, extending from Fremantle South Mole to Point Peron in Rockingham. The project is delivering individual adaptation plans for each local government. This plan provides implementation actions and strategies for the City of Cockburn.

1.2 Purpose of this plan

This coastal adaptation plan provides a decision-making framework and recommended adaptation pathways and actions to assist the City of Cockburn adapt to coastal risks in the immediate and long-term.

This coastal adaptation plan is the beginning of the conversation and journey with the community and stakeholders to understand and respond to our changing coast. The plan has a very long-term planning horizon – considering the decisions that will need to be made from now, until 2110.

As the City, stakeholders and the community learn more and understand more about how our coast will change in future, this plan and recommended adaptation responses will evolve to reflect and respond to the values, aspirations, and learnings of our community and stakeholders.

This plan has been prepared to adapt to the changing coast south of the Swan River, and provides recommended timeframes and trigger points for decision-making and planning for the Cockburn coast from South Beach to Naval Base.

1.3 Previous reports

This plan is based on important work undertaken by the Cockburn Sound Coastal Alliance to understand the coastal vulnerability and the values and risks of assets in the coastal areas around Owen Anchorage and Cockburn Sound.

Stage 1 of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project delivered the *Cockburn Sound Coastal Alliance – Coastal Vulnerability Study – Erosion and inundation hazard assessment report*. The report provides a coastal vulnerability assessment for Cockburn Sound, Owen Anchorage and the east coast of Garden Island. The assessment focussed on potential impacts to the coast from coastal processes, influenced by climate change and associated sea level rise. The investigation identified inundation (flooding) and erosion hazards for the study area for present day, 2070 and 2110.

Stage 2 of the project delivered the Cockburn Sound Vulnerability Values and Risk Assessment Study to understand in more detail the potential impact of the coastal hazards on assets along the coast. The study used a risk-based approach to determine the likelihood of impacts to coastal assets, assessed the value of the assets at risk in respect to economic, social and ecosystem services values, and determined the potential consequence of the impacts to understand the cost of the risk. The study also undertook a first pass of potential adaptation options for the coast. This stage incorporated consultation with key stakeholders and asset managers (local governments, Department of Parks and Wildlife, utility providers and several land developers) with community engagement being the focus of Stage 3.

Previous stages of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project

1.4 Strategic context

This plan provides a blueprint for decision-making over time, along with an implementation plan for shorter term adaptation actions. It provides a framework for incorporation of adaptation planning into the City of Cockburn's strategic plans, land use planning framework, and long-term financial plan.

As indicated by Figure 1, this plan is not an individual action plan for delivery. It is a blueprint to assist future iterations of the City's and the state government's strategic plans integrate and deliver coastal adaptation, in consultation with the community. In this way, coastal adaptation planning will be delivered in the City of Cockburn through existing strategic and capital planning processes at the state and local level.

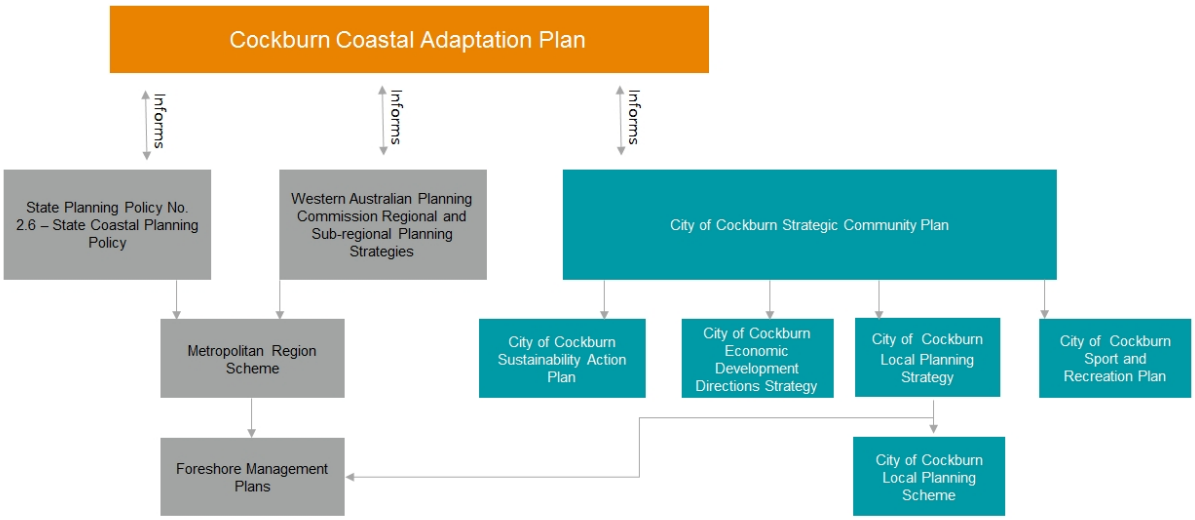


Figure 1 Strategic Context – City of Cockburn Coastal Adaptation Plan

2. The Cockburn coast

2.1 The value of our coast

Historically, industrial land uses including the South Fremantle Power Station and the Robb Jetty Freight Terminal dominated the Cockburn coast. More recently, the coast has emerged as an integral component of the Cockburn community. The coastal area is a key Parks and Recreation reserve, with popular beaches at C.Y. O'Connor Reserve and Coogee Beach that host festivals, events and provide dog exercise areas for the surrounding community. Woodman Point Regional Park is dotted with natural coastal bushland and an appealing beach environment and has been recognised for its ecological and historical value. The Cockburn coast has a strong tourism focus housing the Woodman Point Recreation Camp, one of the premier camps in the state, and the Coogee Beach Holiday Park.

Recently, the coast has been transformed with South Beach redeveloped into a new residential community with multiple dwelling developments and the establishment of a new residential marina at North Coogee (Port Coogee). There are now also works underway to extend the Cockburn coast redevelopment area further, with the coastal area around the former power station expected to be home to 12,000 people over the next 20 years. LandCorp's Shoreline development aims to establish a residential, commercial and entertainment hub linking South Beach with Port Coogee.

2.2 Coastal management units

To plan for Cockburn's changing coast, the coastal strip has been broken into a series of coastal management units. The coastal management units were defined in Stage 1 and Stage 2 of the Cockburn Sound Coastal Alliance Coastal Vulnerability & Flexible Adaptation Pathways Project.

The City of Cockburn includes seven coastal management units:

- Management Unit 3 – North Coogee;
- Management Unit 4 – Port Coogee;
- Management Unit 5 – Coogee Beach;
- Management Unit 6 – Woodman Point Reserve;
- Management Unit 7 – Woodman Point;
- Management Unit 8 – Australian Marine Complex;
- Management Unit 9 – Henderson South.

2.2.1 Coastal Management Unit 3 – North Coogee

Coastal Management Unit 3 – North Coogee extends from the City of Cockburn's northern boundary to the southern extent of Robb Road, as shown in Figure 2. The unit's coastline is dominated by C.Y. O'Connor Reserve, which consists of a park reserve with some parking facilities, amenities and footpaths with relatively narrow setbacks from the ocean. This is backed by a freight rail line that is currently managed by Brookfield Rail. This railway is a vital connection to the Fremantle Port, connecting it to the Kwinana Industrial Area, the Kewdale Freight Terminal, and beyond. The heritage-listed South Fremantle Power Station is also located in this unit close to the foreshore, which has potential plans for redevelopment along with some of the nearby vacant land.

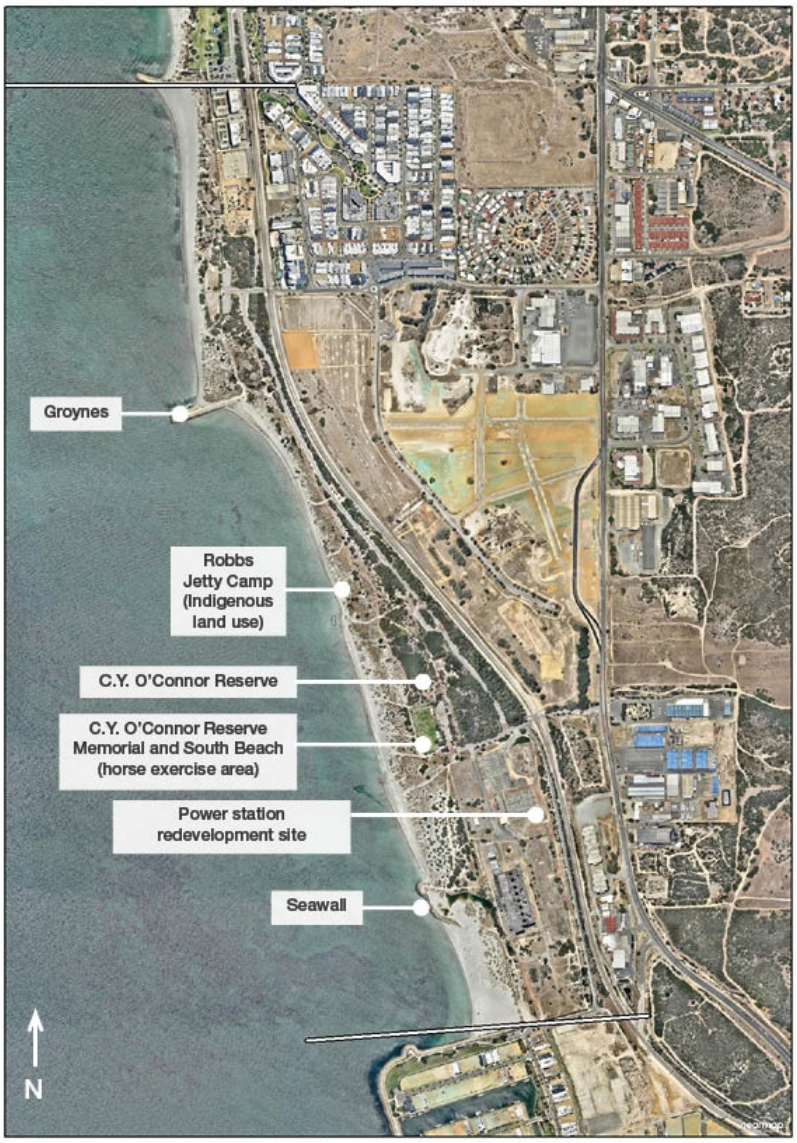


Figure 2 Coastal Management Unit 3 – North Coogee

2.2.2 Coastal Management Unit 4 – Port Coogee

Coastal Management Unit 4 – Port Coogee extends from the southern extent of Robb Road to Socrates Road/Pelinte View intersection, as shown in Figure 3. The coastline of this unit solely consists of Port Coogee, which is a recent development.

Figure 3 Coastal Management Unit 4 – Port Coogee

2.2.3 Coastal Management Unit 5 – Coogee Beach

Coastal Management Unit 5 spans southward from the Socrates Road/Pelinte View intersection to the southern boundary of Coogee Beach Surf Life Saving Club, as shown in Figure 4. This unit's coastline consists of sandy stretches of beach and includes the Coogee Beach Holiday Park, Coogee Beach Surf Life Saving Club and Surfing Lizard Café. Coogee Beach is a frequently visited beach in Cockburn.

Figure 4 Coastal Management Unit 5 – Coogee Beach

2.2.4 Coastal Management Unit 6 – Woodman Point Reserve

Coastal Management Unit 6 extends from the southern boundary of Coogee Beach Life Saving Club to the eastern boundary of the Jervoise Bay Sailing Club, as shown in Figure 5. This unit largely consists of sandy stretches of beach and includes coastal recreation reserves: John Graham Recreation Reserve and portions of Woodman Point Regional Park.

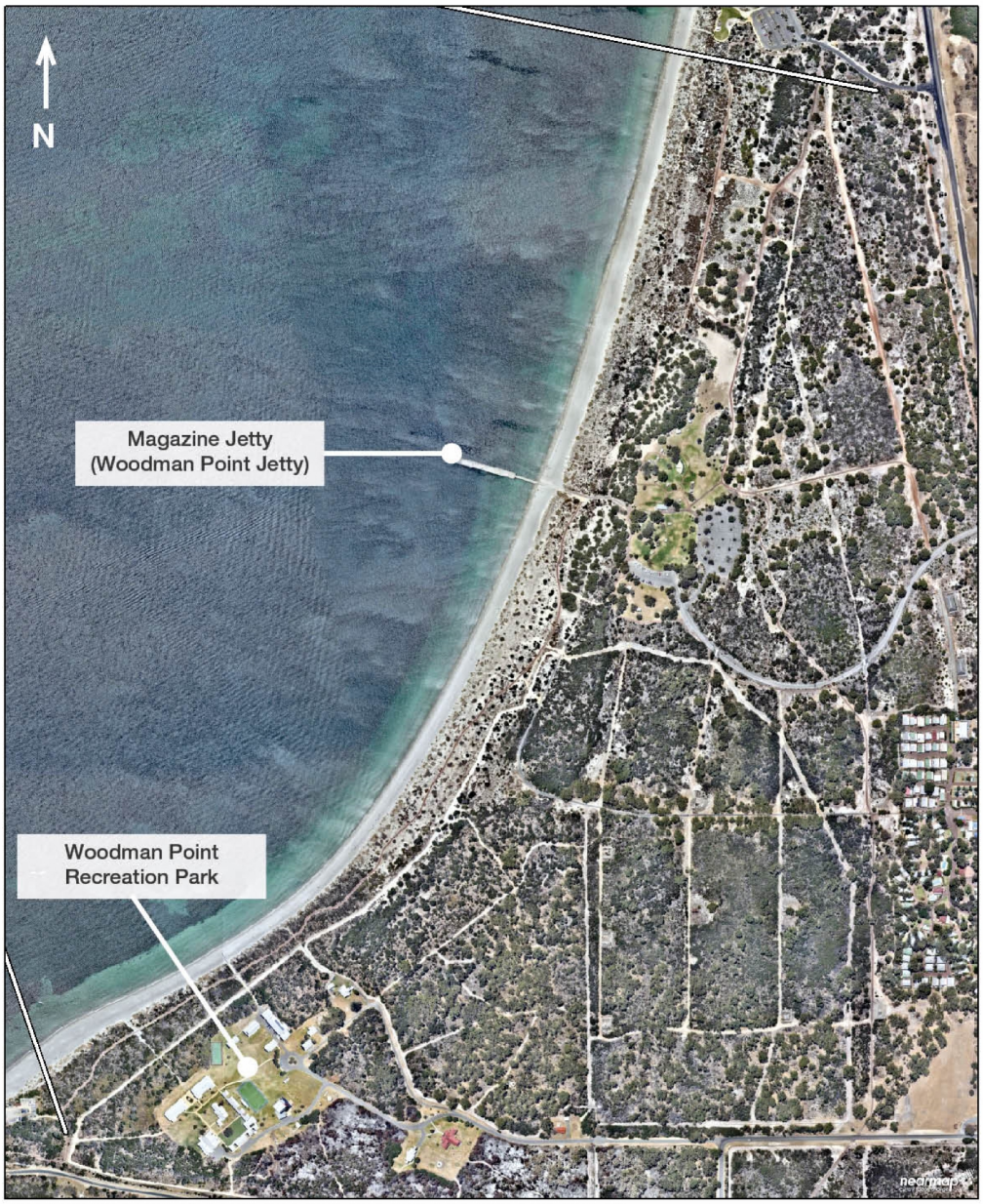


Figure 5 Coastal Management Unit 6 – Woodman Point Reserve

2.2.5 Coastal Management Unit 7 – Woodman Point

Coastal Management Unit 7 wraps around Woodman Point headland, extending from the western boundary of Jervoise Bay Sailing Club to the west boundary of Woodman Point Facility, as shown in Figure 6. The coastline is largely sandy beach and coastal dunes. This unit is a popular recreational space for ocean based activities. Portions of this area, whilst a Parks and Recreation Reserve, are used for other infrastructure and industrial purposes, including dredging infrastructure for Cockburn Cement, and a Water Corporation ocean outfall pipeline.

Figure 6 Coastal Management Unit 7 – Woodman Point

2.2.6 Coastal Management Unit 8 – Australian Marine Complex

Management Unit 8 spans from the western boundary of Woodman Point Recreational Boating Precinct to the south boundary of Australian Marine Complex, as shown in Figure 7. This unit is home to the Australian Marine Complex, a large manufacturing and industrial centre with a focus on shipbuilding. The coastline is used as shipyards and an offshore construction yard, which include several jetties, and existing breakwaters.

Figure 7 Coastal Management Unit 8 – Australian Marine Complex

2.2.7 Coastal Management Unit 9 – Henderson South

Management Unit 9 includes the area from the southern boundary of Australian Marine Complex to the southern boundary of Naval Base Holiday Park, as shown in Figure 8. This unit includes a caravan park and coastal reserve, and includes the section of the Beeliar Regional Park reserve located west of Cockburn Road.

Figure 8 Coastal Management Unit 9 – Henderson South

2.3 An evolving coastline

Sections of the Cockburn coast are exposed and vulnerable to coastal processes, including erosion. Over time, the coast will become increasingly vulnerable to the impacts of sea level rise, storm surges and changes in sediment regimes. The Coastal Vulnerability and Flexible Adaptation Pathways Project was initiated in 2011 to identify the vulnerability of the coast into the future. In Stage 1 of the project, a coastal vulnerability study was undertaken to understand the future influence of coastal processes. Stage 2 of the project undertook a values and risk assessment, to understand the implications of future coastal processes on coastal land and assets.

The learnings of Stage 1 and Stage 2 vulnerability and risk mapping shows that over time, risks to coastal land and assets will increase from tolerable, to intolerable. This will require government and the community to make decisions about how the coast is used in the future.

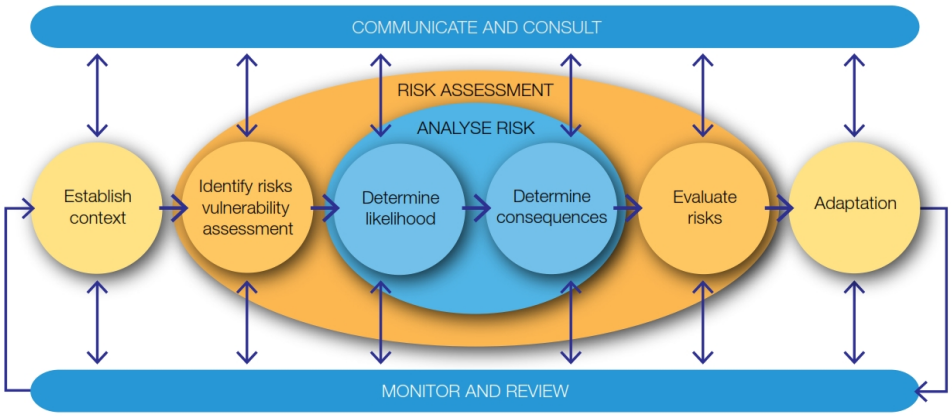
The risk mapping undertaken in Stage 2 for the Cockburn coast is provided in Appendix A.

2.4 Adaptation planning

2.4.1 What is adaptation planning?

The coast has always been a dynamic, changing environment. As we have settled on the coast, continued changing of the coastline presents risk and impacts to our coastal assets – including social, environmental, and economic assets and values. Adaptation planning is about being ready to manage the risks and impacts of changes to our coast line, by planning for the most appropriate decisions and options to implement over time.

A risk management approach is being used increasingly, nationally and internationally, to deal with potential adverse impacts of coastal hazards. A risk management and adaptation planning approach is a systematic way to identify and understand coastal hazard risks, and implement controls and measures to manage those risks in consultation with the community and stakeholders.



Risk management and adaptation process from Coastal hazard risk management and adaptation guidelines (WAPC, 2014)

2.4.2 Who is responsible?

In July 2013, the amended State Coastal Planning Policy No 2.6 (SPP 2.6) was gazetted by the state government. The amended policy included a requirement for 'responsible management authorities' to prepare coastal hazard risk management and adaptation plans, where existing or proposed development is located in an area at risk of being affected by coastal hazards over a 100 year planning horizon. For many areas of the coast, local government is the land manager. Therefore, local government in Western Australia has been leading the development of coastal adaptation plans.

Irrespective of the lead for preparing adaptation plans, there are a number of stakeholders and decision makers involved in adaptation planning. Successful adaptation planning over time requires cooperation from all levels of government, the community, along with asset owners and managers. Key stakeholders and responsibilities for adaptation planning are shown in Table 1.

Table 1 Adaptation Planning – Roles and Responsibilities

Role	Responsibility	Key Stakeholders
Planners and decision makers	*Strategic planning* Prepare adaptation plan for coastal land within their management. Inform coastal asset owners and users about risk and decision-making. *Decision-making* Make adaptation decisions on land and assets within their management.	Western Australian Planning Commission Department of Planning Department of Transport City of Cockburn
Asset owners	Manage assets in the context of coastal risk. Undertake accommodation measures, where consistent with state government decisions. Decommission and relocate assets where required by state government decisions to retreat.	Private land owners Department of Transport (Facilities) Business owners and operators City of Cockburn Infrastructure agencies Public Transport Authority and Brookfield Rail
Other coastal users	Engage with decision makers regarding the values of the coast to inform decision-making.	Community

Funding will be a key issue for the implementation of adaptation planning. The responsibility for paying for coastal adaptation lies with the beneficiaries of those actions. This includes land and asset owners that benefit from protection strategies, and coastal users that benefit from coastal management approaches. This is particularly relevant in coastal areas managed by the City of Cockburn, where coastal management and protection works provide a direct protection benefit to adjacent asset owners (for example, the freight line which is a state government asset). Where public funds are used for coastal adaptation works, there should be a direct public benefit as a result of that investment. Ongoing cooperation between local and state government and key asset owners will be required to consider and address these funding issues and responsibilities.

The freight rail line (and its rail reserve) that links the Fremantle Port to the Kwinana Industrial Area and beyond is a major piece of regional infrastructure. Any relocation in the long term, to facilitate retreat strategies, will require planning by the state government. Photograph – P Thompson.

3. Adaptation Principles and Pathways

3.1 Adaptation principles

In developing a pathway to adapt to Cockburn's changing coastal processes, and to guide decisions that are appropriate for the community, the following principles underpin the adaptation planning process.

Principle 1 Adaptation planning in the current planning horizon does not impede the ability of future generations to respond to increasing risk beyond current planning horizons.

Preparation of erosion and inundation risk mapping that informs this plan considered possible scenarios for sea level rise to 2110. The projections for longer term sea level rise are related to the global action taken to mitigate climate change through greenhouse gas emission reductions, and therefore it is uncertain as to which projection will manifest itself. However all scenarios considered by the Intergovernmental Panel on Climate Change (IPCC) give rise to predictions that *"sea level rise will continue for many centuries beyond 2100"(*IPCC 2014). Accordingly the development of adaptation plans must take account of these predictions.

Existing erosion and inundation risk mapping identifies the zone potentially affected to 2110, but inevitably beyond that timeframe the risk in this zone will steadily increase, and the zone itself will extend landwards beyond 2110. As no protection measures can be devised that remain effective for hundreds of years, any coastal protection works that are undertaken within the presently identified zone cannot be considered permanent. Ultimately, retreat may be the most cost effective option in the very long-term if appropriately planned for. As a result, combating long-term sea level rise requires different adaptation options alongside an underlying retreat approach that should be strategically identified in the initial stages. This does not necessarily mean that retreat will be the most appropriate option in the current planning horizon; however mechanisms should be in place to allow for this adaptation option to be implemented should future risk be heightened to the extent that retreat becomes the most appropriate measure.

Principle 2 Adaptation requires a decision-making framework that enables the right decision to be made at the right time, in line with the values and circumstances of the time.

The dynamic nature of community needs and values requires a flexible approach when considering adaptation options. The effects of climate change on the coast have only recently been identified as a potential concern for some in the community. This was apparent in the minimal interest shown by the community during the consultation undertaken during the preparation of this adaptation plan. The interest and values of the community will change over time as more information becomes available, and impacts of climate change become more apparent. Our approach to coastal adaptation will likely change with new technology and information, opening up new approaches to manage risk. It is difficult to pinpoint the ways in which community uses of the coast, the affected land and its assets could be realised through long-term strategic planning when these uses and needs are likely to continue to evolve.

Making decisions based on community values that are likely to change can be considered short-sighted and potentially prevent the best possible outcome when considering short, medium and long-term measures to adapt to changing coastal processes. Adaptation planning should provide opportunity for future action to reflect new technologies and community values at the time of the decision.

Principle 3 Adaptation planning reflects the public's interest in the social, environmental, and economic value of the coast.

Western Australia is renowned for its flowing coastline and beaches. Social and recreation use of such spaces along the coastline form an integral part of Western Australian culture. Public access to the coast and beaches is an iconic part of Western Australia's lifestyle, contributing to the high quality public spaces enjoyed by the community. Our economy and quality of life is supported by coastally dependant infrastructure and industries located on the coast. In addition to existing infrastructure and industries, the coast might house future projects critical to the development of the Western Australian economy. The coast also provides important environmental values, with a unique ecology that includes marine, intertidal, and dune habitats.

Adaptation planning should respect the inherent value of the coast that is ingrained in the state's social, environmental and economic interests.

Principle 4 Alternative adaptation measures should consider the full range of land uses and values.

The objectives of State Planning Policy (SPP) 2.6 include the retention of coastal uses for a range of public and private uses including economic uses, coastal foreshore access and social and environmental uses and values, including:

- housing, tourism, recreation, ocean access, maritime industry, commercial and other activities;
- public coastal foreshore reserves and access to them on the coast; and
- landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

Principle 5 The full life-cycle benefits, costs and impacts of coastal protection works should be evaluated in considering adaptation options.

Coastal engineering works have the potential to provide protection to nearshore coastal assets over their design life, dependent on the rate of future sea level rise. There are two broad categories of protection that have potential for use on the Cockburn Sound Owen Anchorage coast, and these are set out in the Adaptation Options Compendium (which is a companion to this document):

Engineering (hard) measures: seawalls, revetments, levees, groynes/breakwaters

Regenerative (soft) measures: beach nourishment and dune restoration

Seawalls and revetments, if implemented without ongoing beach nourishment, will eventually lead to a loss of beach and coastal habitat seaward of the structures, as sea levels rise. Beach nourishment requires ongoing replenishment in response to storm-related erosion events and

sea level rise. Coastal protection measures taken in a specific location may influence the adjacent coastal cells.

Interim protection measures also bring cost impacts. Engineering works can have a high capital cost, and require ongoing investment in maintenance. The cost impact of coastal engineering works should also consider decommissioning costs. Engineering options are designed to mitigate against a particular level of risk, and have a discrete design life. However, the presence of protection works can give a sense of expectation to asset owners, and can potentially limit future decision-making flexibility.

SPP 2.6 includes a presumption against coastal protection measures unless "*all other options … have been fully explored*".

3.2 Adaptation Pathways

In line with adaptation principles, the most appropriate adaptation pathway is one that enables decision-making on adaptation measures to be made at the right time, in line with the values of that time.

So as to not pre-empt the values of the community in the future, the most appropriate adaptation pathway in Cockburn is:

Flexible adaptation: we prepare our governance and planning frameworks to maintain flexibility in available adaptation options, so that the right decisions can be made at the right time.

As risk to assets increases from tolerable to intolerable, decisions must be made. These points in time when decisions are required become trigger points for adaptation planning.

The Coastal Hazard Risk Management and Adaptation Planning Guidelines (WAPC, 2014) set out coastal adaptation options available when making decisions about managing coastal risk (Figure 9). The options shown in Figure 9 and Table 2 should be considered as a hierarchy – the further down the hierarchy, the less flexibility there is to consider alternative adaptation measures. Effectively, these options become decisions for government and the community to make when planning for the future of coastal assets and land.

The adaption options set out in SPP 2.6 are shown in Figure 9 and Table 2.

Figure 9 Hierarchy of risk management and adaptation options (WAPC, 2014)

Table 2 Levels of risk mitigation

Planned or Managed Retreat:	In the face of intolerable risk;	Existing development
Accommodation:	Design and / or management measures that address the risk	
Protection:	Where there is a need to preserve the foreshore reserve, public access and public safety, property and infrastructure that is not expendable.	
Avoid	Avoiding development in areas at risk	New development

In the absence of coastal protection works (or other obstacles), as sea levels rise, the shore line, beaches and dune systems will gradually move landwards. Accordingly, the risk to nearshore coastal assets will increase, initially leading to loss of land through erosion (on sandy areas) and leading to occasional and then eventually permanent inundation.

As this sequence of events unfolds, the options available in any specific location depend on the likelihood and consequence of the risk at that time. The decision made will be informed by values of the coast, coastal assets and community. Values will change over time – as they have in Cockburn over the last 100 years – therefore it is important that decisions are made at the time of the trigger point.

A successful adaptation pathway is achieved when decisions made now, in 20 years or in 50 years do not prevent other courses of action being chosen later, therefore retaining ongoing flexibility in decision-making in line with the hierarchy of options. For example, at the end of the life cycle of interim protection structures, the hierarchy of adaptation options should be reassessed and the adaptation most appropriate for the point in time progressed. There may be a point when the viability of less flexible measures (such as protection) is compromised due to social or economic costs. This requires ongoing strategic planning to retain the full flexibility of adaptation options for future decisions, even when other options are employed in the shorter term.

The recommended flexible adaptation pathway combines decision-making at trigger points on specific adaptation measures (avoid, retreat, accommodate, interim protection) with an ongoing strategic planning process that plans for, and therefore maintains, all adaptation options (including avoid and retreat) for subsequent trigger points over time. In this way, by choosing to accommodate or protect in early horizons, we are not binding future communities to the long-term cost of that decision beyond the design life of the infrastructure or asset. The pathway and decision points are illustrated in Figure 10. More detailed description of the trigger points is provided in section 3.2.2.

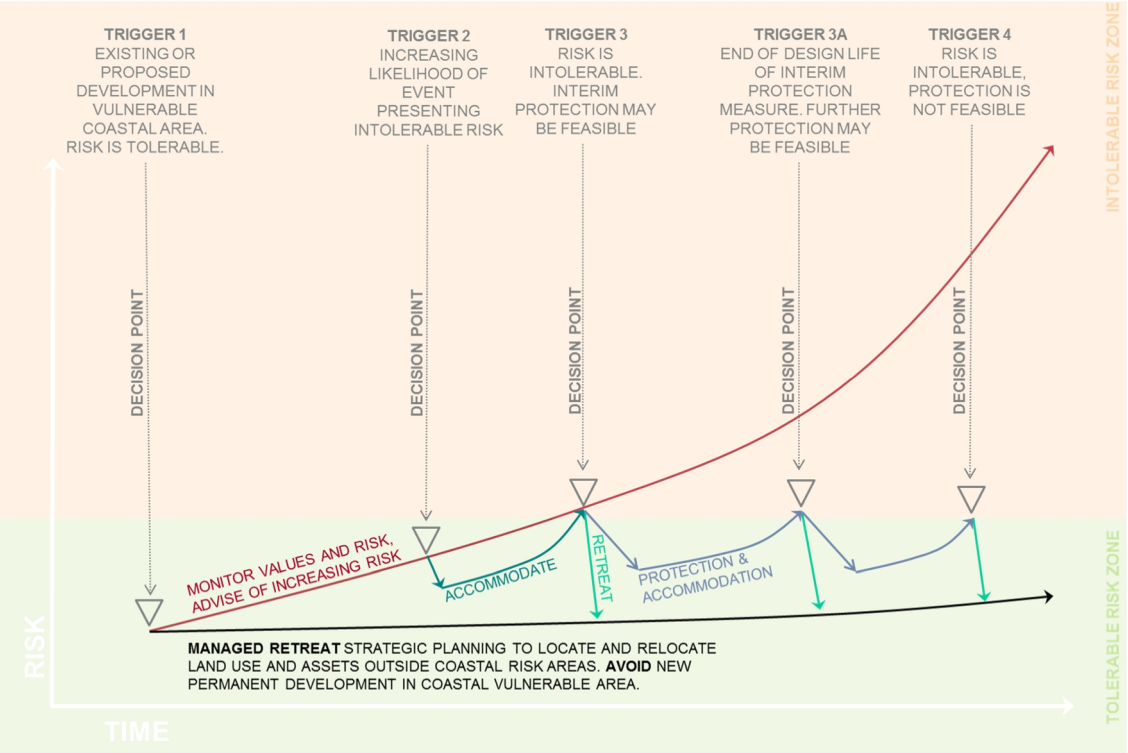


Figure 10 Flexible adaptation pathway

The flexible pathway provides a roadmap to enable retreat from the most vulnerable coastal land in the long-term. The pathway also facilitates responsible interim adaptation measures that continue land uses where those measures are justified on social, economic and environmental grounds.

For assets on vulnerable land, a decision to accommodate and/or protect or retreat is dependent on a wide range of factors, including:

- the consequences of taking no action,
- the feasibility and social/environmental/economic costs associated with accommodation/protection compared to the residual value and life of the asset;
- the disruption and costs involved with relocation.

There are parallel pathways for government and private asset owners. Whether government decides to facilitate interim protection measures on certain sections of coast, or allow the coast to recede, private asset owners retain their ability to determine the pathway that reflects their own circumstances (where it is not incompatible with or less flexible than a government decision). In order for this approach to be workable and provide certainty to asset owners, it is recommended that the following principles apply to government decisions about coastal protection works:

- Decisions about the appropriateness of coastal protection works are made and implemented/facilitated by government alone, and occur on coastal reserves, notwithstanding whether or not private landowners contribute to costs;

- Any such measures are designed for a finite life, after which a new decision is required as to whether further, finite protection is justified or the coast be allowed to naturally recede; and

- Advice is provided to private asset owners about government decisions to protect or otherwise, and the likely residual risk associated with those decisions.

Accommodation measures need to be considered at all times for land identified as being within the vulnerable coastal area, (i.e. at all times after trigger 1 is reached). The nature and extent of accommodation measures will change over time as risks increase, but are still required even in circumstances where interim protection is put in place. All protection options are designed for a certain set of circumstances (e.g. 100 year ARI storm event), and there is a residual risk that either these circumstances will be exceeded or that the protection measure does not perform to expectations. Accordingly, accommodate options are also part of protect options, although the nature of the measures may differ.

3.2.1 Planning horizons

The adaptation plan includes two planning horizons for decision-making:

Long-term (100-year) planning horizon: monitor, set up planning and governance frameworks.

Immediate (15-year) planning horizon: test values and act on any immediate trigger points.

For the long-term (100-year) planning horizon, strategic planning should focus on maintaining the ability of community and stakeholders to choose from the most appropriate adaptation measures at future decision points. This includes provision in planning tools for avoid and retreat measures, even if these measures are not put into action in the immediate term.

In the immediate (15-year) planning horizon, any decision points that will arise from increasing risk in that timeframe should be identified. Community values should be confirmed to understand the social, environmental, and economic influences on the decision. Using the values of the time, the decision on the most appropriate adaptation measure (avoid, retreat, accommodate, or interim protection) should be made and acted upon. This delivers a no-regrets adaptation decision, reserving the right to review investment and protection strategies over time. 15-years is usually sufficient to implement necessary planning controls in local planning schemes if retreat is required, and to commence budgeting for required adaptation measures.

This adaptation plan presents strategic planning measures to incorporate a flexible pathway into immediate (15-year) and long-term (100-year) planning horizons in the City. The plan recommends adaptation measures for the immediate (to 2030) planning horizon, and identifies possible measures for decision points that would occur beyond that. Provisional adaptation measures for planning horizons beyond 2030 should be subject to ongoing review and testing with the community, in line with the recommended long-term strategic planning approach.

3.2.2 Decision triggers

In order to make appropriate decisions it is important to identify the trigger points that separate the options available to decision makers. As noted above it is the decisions of government in relation to the interim protection or retreat of coastal units that are most important. It is recommended that the following trigger points become the basis of those decisions, using the combination of factors giving rise to inundation likelihood developed in the 2014 *Cockburn Sound Coastal Vulnerability Values and Risk Assessment Study* (Table 8.1, pp.).

The triggers occur when, within the immediate planning horizon (e.g. 15-years); the most seaward asset (i.e. parks, road / rail reserve or urban / industrial land) meets the criteria in Table 3. The proposed approach is shown graphically in Figure 11.

Table 3 Decision triggers

Trigger	Risk Level	Location of most seaward asset:	Government options	Landowner / asset manager options
Trigger 1	Tolerable	Landward of the 500 year ARI inundation event/acute erosion line*	Advise of increasing risk	Do nothing or Retreat
Trigger 2	Increasing likelihood of intolerable risk.	Landward of the 100 year ARI inundation event/acute erosion line* but seaward of 500 year ARI inundation line.	Accommodate	Accommodate or Retreat
Trigger 3	Intolerable. Interim protection may be viable.	Landward of the 50 year ARI inundation event/acute erosion line* but seaward of 100 year ARI inundation line.	Protect + accommodate or Retreat	Accommodate or Retreat
Trigger 4	Intolerable. Protection is not viable.	Seaward of the 50 year ARI inundation event/acute erosion line*	Retreat	Retreat

* reflects the S1 erosion allowance in SPP 2.6, which is the allowance of land required to absorb the current risk of storm erosion.

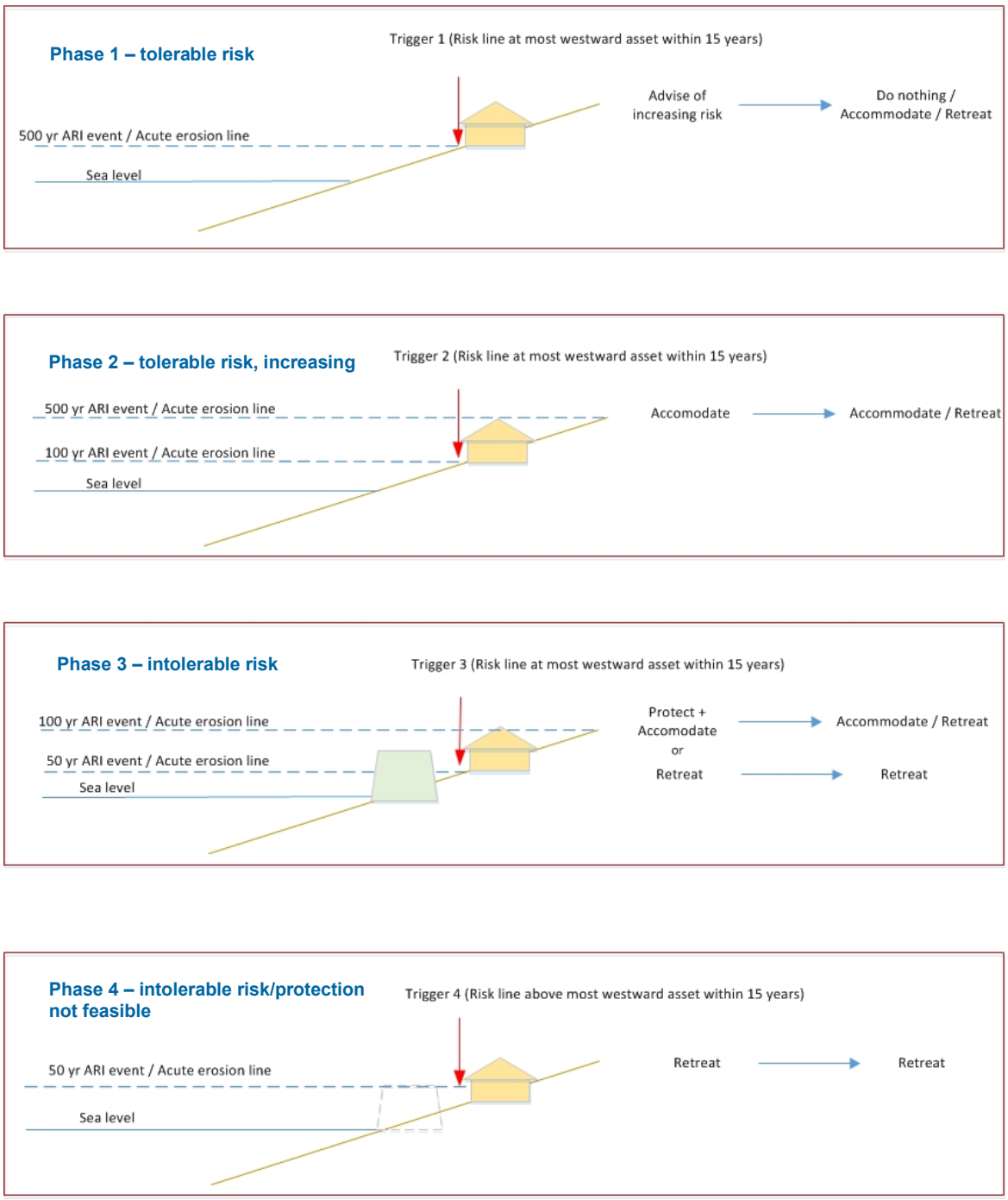


Figure 11 Decision triggers

4. Strategic Planning Framework

4.1 Development and planning control in the coastal zone

Developing a strategic planning framework that will adequately respond to coastal vulnerability over time needs to consider how planning and development decisions are made in relation to the coast, and who makes them. This depends on who owns the land that the development is on and the policies and strategies that govern land use and development, as shown in Figure 12.

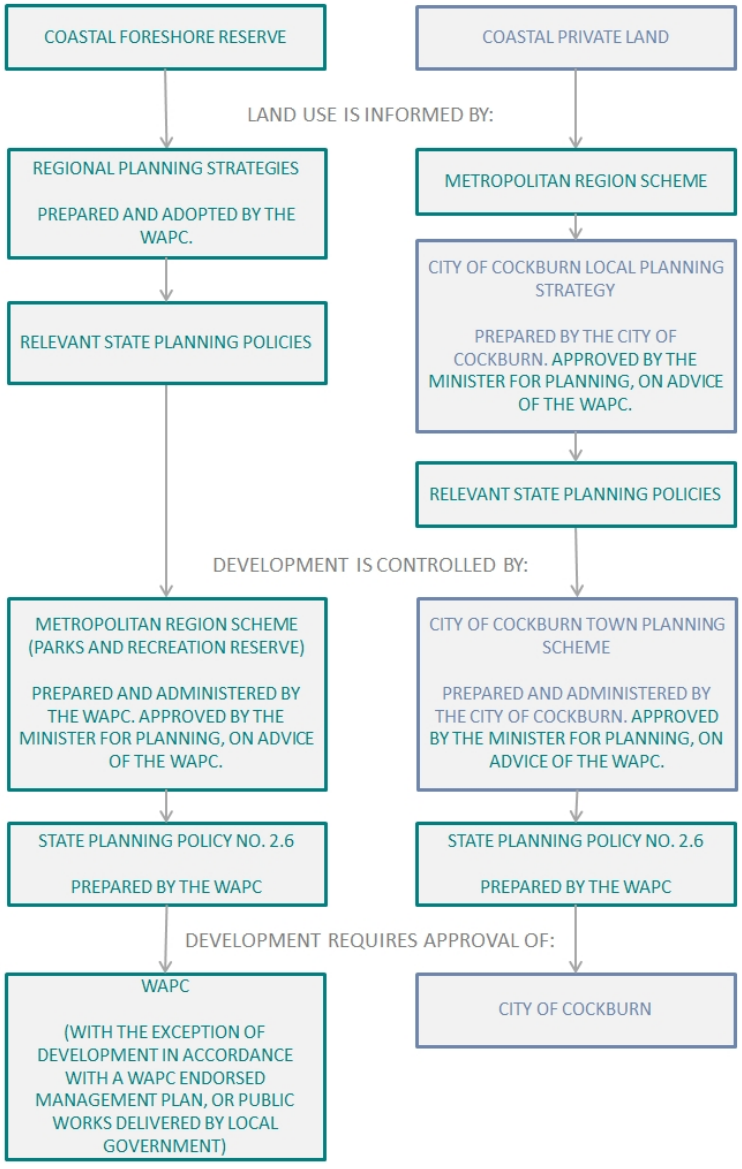


Figure 12 Overview of the statutory planning framework that applies to coastal development in the City of Cockburn

As shown in Figure 12, much of the planning authority in Western Australia is centralised at the state government level. Whilst the City of Cockburn is responsible for preparing its local planning scheme and strategy, these documents must be consistent with higher level state planning documents, and must be approved by the state government. Therefore, strategic decisions regarding land use change and coastal reserves are ultimately confirmed by the state government, and not the City of Cockburn.

The Western Australian Planning Commission (WAPC) is responsible for much of the relevant planning and decision-making on coastal land. In addition to being responsible for the coastal foreshore reserve (which is classified as Parks and Recreation Reserve in the Metropolitan Region Scheme), the WAPC makes recommendations to the Minister for Planning on the acceptability of land use change proposed by the City of Cockburn outside that coastal reserve.

The City of Cockburn has responsibility for development on zoned land and therefore can use their planning system to influence development on private land near the coast. The City of Cockburn can also actively engage with the WAPC to encourage the state and regional planning framework to respond to long-term coastal vulnerability.

Several projects are necessary to develop the strategic planning framework for implementation of the measures set out in this document and to maintain flexibility in adaptation over time. Strategic planning projects are necessary to generate a policy framework that facilitates future, longer term avoidance and retreat strategies beyond the design life of interim protection in the City of Cockburn.

4.2 Regional planning strategies and Metropolitan Region Scheme

Recommended strategic adaptation measure

The WAPC should review the RMS and other regional planning documents including strategic landuse and infrastructure plans to provide the necessary land use framework to support the flexible adaptation pathway. This includes identifying:

- Necessary expansions to the Parks and Recreation Reserve (foreshore reserve); and
- New locations and reservations for infrastructure currently located in the vulnerable coastal area, to enable retreat as relevant triggers are reached.

The City of Cockburn, together with the Cockburn Sound Coastal Alliance, should request state government to review the MRS and regional planning documents.

Considerations in strategic adaptation measure

Regional plans and strategies – including the most recent Perth and Peel at 3.5 million – identify future urban and industrial development areas, strategic infill areas, and regional infrastructure locations. These plans form the strategic basis for the Metropolitan Region Scheme (MRS), which zones and reserves land for development and public purposes. The MRS is the statutory planning scheme which applies the Parks and Recreation Reserve, which is the formal reserve applied to the foreshore reserve in the City of Cockburn. Key infrastructure within the City of Cockburn planned for in regional planning documents includes:

- The former South Fremantle Power Station, forming part of the future Shoreline development;
- The freight rail reserve linking the inner harbour to the Kwinana Industrial Area (and potentially to the new outer harbour) and linking to Kewdale and Forrestfield;
- Port Coogee Marina;
- Australian Maritime Complex; and
- Cockburn Foreshore Reserve.

Future iterations of regional plans and strategies should consider infrastructure, reservations and zoned land that that may be at risk within the immediate (15 year) planning horizon, or infrastructure in longer-term risk areas that is nearing the end of their its design life and requiring renewal. Where the interim protection of infrastructure or land is not supported by community values of the time, regional plans and strategies should include strategic planning projects to identify new locations and reservations for infrastructure outside areas of coastal risk, and plan for the appropriate expansion of the Parks and Recreation reserve.

The Metropolitan Region Scheme will require amendment to be consistent with future iterations of regional plans and strategies. This will include incorporating appropriate reservations for:

- Parks and recreation (coastal foreshore)
- Public purposes (as required by servicing agencies)
- Road and rail reservations (as required by transport agencies)

Amendments to the MRS should be progressed where land will be required or impacted within the immediate (15 year) planning horizon.

4.3 Review of State Planning Policy No. 2.6 State Coastal Planning Policy

Recommended strategic adaptation measure

The WAPC should review SPP2.6 to provide greater policy guidance for coastal dependant development, in particular to manage the longer-term decommissioning or protection costs of such development as risk levels become intolerable.

The City of Cockburn, together with the Cockburn Sound Coastal Alliance, should request the state government to review SPP2.6.

Considerations in strategic adaptation measure

SPP2.6 lists a number of development types that are variations to the policy, and that might be considered appropriate within areas identified as being potentially impacted by physical coastal processes. These include:

- Public recreation facilities with finite lifespan;
- Coastally dependent and easily relocatable development;
- Department of Defence operational installations;
- Industrial and commercial development (including marinas);
- Coastal nodes; and
- Surf life saving clubs

Coastal nodes and commercial development – in particular marinas – provide important community access and enjoyment of the coast. However they also create community and landowner expectations of ongoing protection and retention of such facilities and land beyond the design life of these coastal assets. This presents potential for significant decommissioning or protection costs in the long-term to retain those facilities and protect any land sold in the area.

A review of the SPP to provide greater policy guidance for these types of development is necessary, where the policy supports their location in areas of risk. Additional policy measures to manage potential costs of protection or decommissioning following the design life or current long-term (100 year) planning horizon include:

- Consideration of impermanent land tenure (such as release of leasehold land) for coastal development to avoid future need for acquisition or compensation of private land;
- Incorporation of notifications on title to identify that the land is located in a vulnerable coastal area, and there is no long-term expectation of protection; and
- Consideration of the need for development contributions to support decommissioning or longer-term interim protection costs.

Such policy measures will help future communities – beyond the current long-term planning horizon – retain flexibility in the adaptation pathways available for coastal settlements, and do not bear unreasonable costs of protection, land acquisition or decommissioning.

Foreshore management plans (discussed later in this section) are a suitable tool to require public recreation facilities, relocatable development and surf lifesaving clubs to be planned and managed according to coastal risk.

4.4 City of Cockburn Strategic Plan

Recommended strategic adaptation measure

Future iterations of the City of Cockburn strategic plan should test values and act on any triggers that are predicted to occur in the immediate planning horizon of the plan.

Considerations in strategic adaptation measure

The current City of Cockburn strategic plan is, though a long-term community plan until 2022, due to be updated by 2017. Incorporation of coastal adaptation planning into the strategic plan will be necessary to provide a local governance framework for integrated decision-making in relation to strategic land use and infrastructure and capital works planning. In particular, the plan should reflect the adaptation pathway set out in section 3.

Five-yearly reviews of the strategic plan should operate as a trigger to undertake targeted community and industry consultation to test and update values and views about coastal development and assets that will be at risk both within a 15-year planning horizon and beyond. Revised values and any new information available (for example any reviews of risk and vulnerability mapping) should be used to determine whether adaptation strategies for the 15-year planning horizon require modification as a result of changing values.

Based on the strategic plan, the costs to the City of any interim protection works or associated measures required to be delivered within the 15-year planning horizon should be incorporated into the City of Cockburn long-term financial plan.

4.5 City of Cockburn Local Planning Strategy and Scheme

Recommended strategic adaptation measure

The City of Cockburn local planning strategy and scheme should be reviewed to incorporate a special control area for the vulnerable coastal area.

The local planning strategy and scheme should provide a policy framework to apply SPP 2.6 to infill development to manage location of increased densities. Future land use change should avoid intensifying density and development opportunity within the vulnerable coastal area.

Considerations in strategic adaptation measure

The City of Cockburn Local Planning Strategy was adopted in 1999. The City of Cockburn Town Planning Scheme No. 3 was gazetted in 2002.

These planning documents are scheduled for review. The review of these documents should incorporate the requisite planning framework to adapt to coastal risks in the immediate (15 year) term, which reflects the typical life of these documents.

The purpose of local planning strategies is to set out the local government's objectives for future planning and development and includes a broad framework by which to pursue those objectives. The strategy can therefore be a useful document to clearly enunciate the longer-term nature of the challenges arising from sea level rise and its associated effects on the coastline, and the City of Cockburn's response to those challenges. Inclusion of planning measures in the strategy will be the precursor to the introduction over time of statutory measures in the local planning scheme, which provides the statutory framework for land use on private land adjacent to the coast.

The City of Cockburn local planning strategy and scheme is required to be consistent with regional plans, strategies, and the Metropolitan Region Scheme. For example, the City of Cockburn scheme will include the high level land uses and reserves determined by the state government in the Metropolitan Region Scheme and other regional plans.

CY O'Connor Beach

4.5.1 Special control area for vulnerable coastal area

The local planning strategy review should incorporate a clear local coastal planning strategy in accordance with SPP 2.6. A key planning mechanism to deliver the local coastal planning strategy could be a special control area applied to the vulnerable coastal area, which provides additional planning controls for a specific area. In developing a special control area for the vulnerable coastal area, the following elements should be considered in the local planning strategy review:

- Determination of an appropriate special control area that encompasses land that would be impacted by a) physical processes plus b) an appropriate foreshore reserve for a 100 year planning horizon:
  - Determination of the physical processes setback for a 100 year planning horizon in accordance with SPP 2.6 using best available information – this would include the coastal vulnerability mapping undertaken by the *Cockburn Sound Coastal Alliance – Coastal Vulnerability Study. Erosion and Inundation Hazard Assessment Report* (2013) supplemented by any further or more detailed investigations undertaken subsequent to the project;
  - Determination of the future foreshore reserve width for a 100 year planning horizon in accordance with Section 8 of the State Coastal Planning Policy Guidelines;
- A presumption that the special control area will expand landwards over time as sea levels rise;
- Investigation of necessary development controls for the special control area, and the timing or trigger points for inclusion of those controls in the scheme. This would include consideration of:
  - Notifications on title for properties within the special control area which are reviewed and updated over time; and
  - Policy provisions requiring coastal processes setback for future redevelopment within the special control area, which would facilitate incremental relocation of private development in the longer term (beyond the immediate developments of Port Coogee and Cockburn Coast).

The timing for inclusion of development controls should respect immediate new development that has been approved by the Western Australian Planning Commission and Port Coogee and along the Cockburn Coast. However, the local planning strategy and special control area can provide early policy guidance for subsequent planning horizons as risk levels increase.

The local planning strategy should clearly identify at what point the scheme should incorporate controls on development or redevelopment in vulnerable areas.

The local planning scheme, informed by the strategy, should incorporate the special control area to advise land owners and planners that the area is in a vulnerable coastal area for the long-term (100 year) planning horizon. The extent of development controls included should reflect whether or not intolerable risk will be experienced in the immediate (15 year) planning horizon. If risks are tolerable in the immediate planning horizon, development controls may not

be necessary. If risks are considered intolerable in the immediate planning horizon, then controls should be introduced.

The local planning strategy will be a key consultation and communication tool that will engage the community in decision-making and communicate triggers and timeframes for additional controls of coastal land use to manage coastal risks.

4.5.2 Coastal Settlement Planning

Whilst SPP 2.6 requires that infill development consider the adaptation planning hierarchy, such infill development may not be subject to the same requirement for setbacks and ceding of foreshore reserves as new development and settlements, particularly where it is not contiguous with the current foreshore reserve. The local planning strategy review should consider the long-term implications of this, and investigate policy measures to provide a consistent approach to new and infill development.

In particular, the local planning strategy review should investigate:

- Policy measures that require infill development and proposals to increase density to be assessed against SPP2.6 as if it were new development;
- Density recommendations to locate future increased densities outside the coastal vulnerable area;
- Infrastructure locations and strategies that avoid placing future infrastructure within the physical processes setback and adjacent long-term foreshore reserve, and avoid placing linear servicing infrastructure (including roads) that run parallel to the coast, therefore potentially becoming a threatened asset in longer-term planning horizons.

The settlement recommendations identified in the local planning strategy review should be incorporated into the local planning scheme at the appropriate time.

4.6 Foreshore Management Plans

Recommended strategic adaptation measure

The City of Cockburn should prepare foreshore management plans for CY O'Connor Beach and Coogee Beach reserve to provide an implementation framework for adaptation measures.

Considerations in strategic adaptation measure

Management plans are formal planning documents prepared for areas of Parks and Recreation Reserve under the MRS. These plans provide additional land use controls regarding appropriate development within the reserve, and also provide a tool to prioritise management activities.

The foreshore management plans will be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities. Therefore, they reflect a key opportunity to encourage awareness of the dynamic nature of the coast, the impermanent nature of coastal development, and how that will influence the future form of these areas.

Key elements to be considered in the foreshore management plans are:

- Identification, prioritisation, and funding of natural coastal and dune management techniques to enhance the ability of the natural system to buffer coastal processes;
- Consideration of sea level rise and coastal risk, defining any relevant trigger points for the reserve and whether there is a need for the relocation or decommissioning of existing assets as required;
- Identification of appropriate, impermanent community facilities to meet demand for coastal infrastructure in the immediate (15 year) planning horizon;
- Policy requirements for development, including:
  - Design life for assets to reflect risk timeframes;
  - Architectural and construction requirements for development to portray a temporary aesthetic – communicating to the community the impermanent nature of facilities;
  - Incorporation of community education, including interpretive signage – to reinforce messages that coastal facilities are not permanent.
- Coastal interim protection works required in the immediate (15 year) planning horizon, including estimated costs, maintenance responsibility, and impacts on the reserve.
- Provisional coastal interim protection works that may be required in the long-term (up to 100 year) planning horizon, including costs and impacts on the reserve, to engage the community in future strategic planning cycles to test values and confirm adaptation options for these locations over time.

The level of information to be included in foreshore management plans – in particular related to detailed erosion and inundation modelling – will be dependent on the level of risk, and the timeframe to anticipated trigger points. Foreshore management plans should be reviewed on a five year cycle and updated to reflect changing values and adaptation options in line with future iterations of the City of Cockburn strategic plan.

Foreshore management plans are also an important tool to plan for tourist developments located within the foreshore reserve in the City of Cockburn, such as the Coogee Holiday Park and the Naval Base Holiday Park. Preparation of foreshore management plans should consider how lease arrangements can be transitioned over time, with the relocation of facilities to areas within the reserve where coastal risk is tolerable.

5. Adaptation Measures

The following trigger points and decisions were analysed for the immediate and long-term planning horizons:

- Trigger 1 (risk tolerable): decision to avoid future development in vulnerable coastal area
- Trigger 2 (increasing likelihood of intolerable risk): decision to avoid and accommodate
- Trigger 3 (risk is intolerable, interim protection may be viable): decision required between interim protection and retreat
- Trigger 4 (risk is intolerable, protection is not viable): decision to retreat

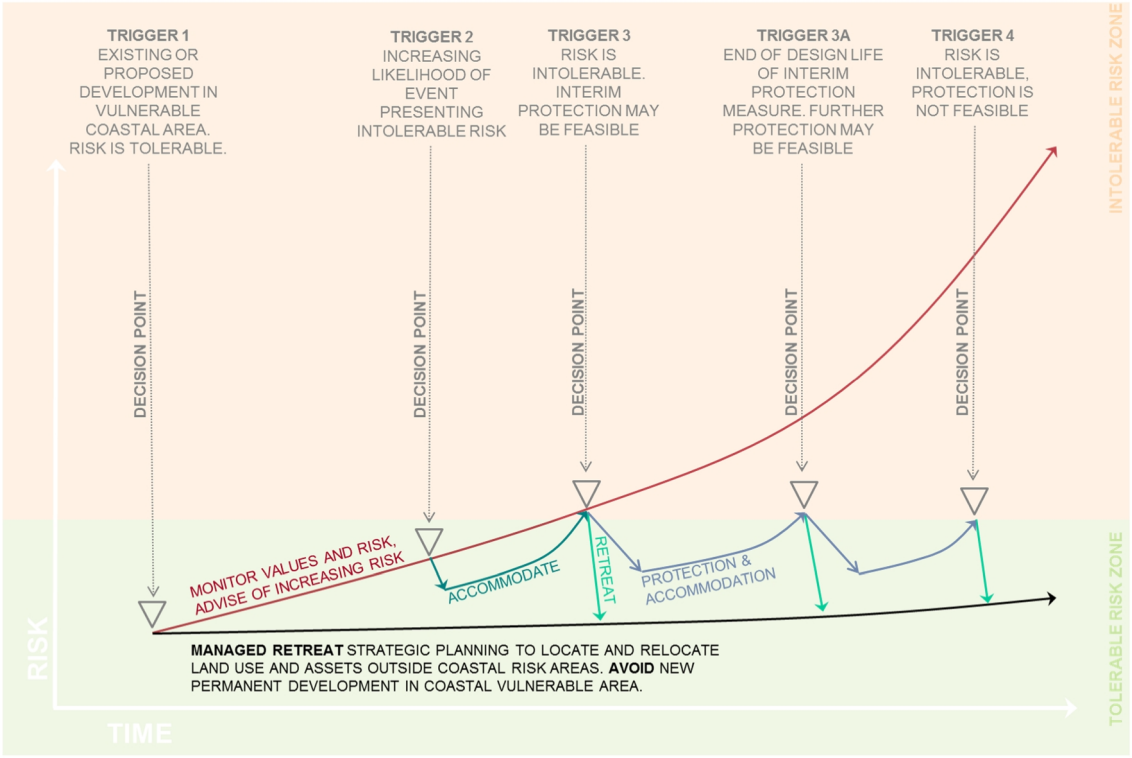


Figure 13 Flexible adaptation pathway

5.1 Developing adaptation measures

5.1.1 Avoid

Avoid measures involve avoiding the location of new development in an area of coastal vulnerability. This does not preclude the use and enjoyment of the coast; however it avoids locating future development in an area that would experience intolerable risk, at some stage during the life of that development. Strategies associated with avoid measures are set out in Section 4.

5.1.2 Managed Retreat

Managed retreat means relocating assets outside the area of risk, to allow land at risk to naturally experience erosion and/or inundation. Retreat can be on a small scale, for example relocating a car park within a large foreshore reserve to an area outside immediate risk. In the long-term, retreat strategies can occur on a significant scale, for example the expansion and remediation of the foreshore reserve, which requires the relocation of infrastructure (such as road, rail, and sewer) and inclusion of private land within the expanding foreshore reserve. Large-scale strategic retreat will require coordination and partnership across state and local government. A potential model to deliver these outcomes is provided in *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016).*

5.1.3 Accommodation

Accommodation measures are asset specific activities that enable an asset to continue to operate whist being affected by coastal impacts. In the face of erosion, this includes measures to accommodate increased risk, such as dune revegetation to reduce the immediate impact of wave erosion. In relation to inundation, this includes measures to enable an asset to manage occasional flooding, such as flood gates on buildings and emergency management plans.

Key accommodation options are presented in section 5.12.

5.1.4 Interim Protection

The role of coastal interim protection is to reduce the risks associated with the coastal hazards of erosion and inundation to land and assets. Engineering measures suitable to protect against these hazards can involve either soft or hard and passive or active engineering approaches. Descriptions and examples of these approaches are shown in Table 4.

Table 4 Interim Protection Measures

Approach	Description	Examples
Soft – Passive	Foreshore protection works that mitigate the adverse impacts of erosion and inundation but do not involve construction of structures and do not directly affect coastal processes.	Sand nourishment and dune stabilisation
Hard – Passive	Foreshore protection works that involve the construction of structures which alter how the coastal processes act on the land/beach with the intention to maintain or improve beach amenity through retention of sand.	Groynes and offshore breakwaters
Hard – Active	Works that involve the construction of structures which offer a source of protection to landside assets in proximity to the foreshore. The construction of hard active engineering options can alter the way coastal processes act on the land/beach interface. These changes to the shape of the land (e.g. erosion of a beach in front of a seawall) can have implications on land use (e.g. loss of beach amenity).	Seawalls and Levees

* Refer to the *Cockburn Sound Coastal Adaptation Plan – Adaptation Options Compendium (GHD, 2016)* for the definition of foreshore protection examples

Interim protection options are only considered for implementation at the point where coastal assets are deemed to be reaching intolerable risk (i.e. at trigger point 3) during the near term planning horizon. This is based on the present land use, its consequence category and whether the relevant intolerable likelihood event crosses the land use area (i.e. beyond the beach / dune zone).

Offshore breakwaters and groynes are examples of hard passive interim protection measures. This groyne example is made from geotextiles. Groynes can also be constructed from rocks to extend their design life. Offshore breakwaters can interrupt open views of the ocean, and groynes can create a barrier along the beach.

Sea walls are an example of hard active interim protection measures. Designed well, they can integrate well into the development of beach amenities, although they can exacerbate erosion (beach loss) in front of the wall over time if ongoing sand nourishment is not undertaken.

5.2 Assessing the available adaptation options

A full description of the option evaluation process is set out in *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016)* which accompanies this adaptation plan. The following sections provide a summary to inform the recommendations presented in this adaptation plan.

5.2.1 Triggers 1 and 2

Where trigger points 1 or 2 are anticipated to occur in the immediate or long-term planning horizons, avoid and accommodation measures are considered appropriate for implementation.

Soft – passive protection measures, including reactive beach nourishment to major storm events, in the short-to-medium-term (subject to the availability of materials) are also considered as management tools available to replenish beaches, and slow down the loss of land from erosion processes.

5.2.2 Trigger 3

The option analysis (including but not limited to financial costs) for trigger point 3 compared the following options:

– Retreat when risk becomes unacceptable; and

– Interim protection incorporating a range of options for short to long-term protection measures that delay retreat for the life of the structure (until the next trigger point is reached, be it another trigger point 3 or trigger point 4).

Accordingly, the purpose of the option evaluation process is to compare the costs and benefits of retreat to one or more interim protection measures for each coastal management unit.

The technique known as multi-criteria decision analysis (MCDA) was used to make these comparisons. The results of the MCDA, including the sensitivity analysis, are set out in Appendix B.

For those areas where trigger 3 has been reached in the immediate planning horizon, two levels of analysis were undertaken to inform decision-making:

1. MCDA analysis to decide between interim protection and retreat; and
2. If interim protection is preferred, more detailed assessment of the preferred protection strategy (passive vs active) to recommend an appropriate option for detailed planning.

5.3 Coastal Management Unit 3 – North Coogee

5.3.1

5.3.1 Decisions in the immediate planning horizon (to 2030)

Risk Profile

The Cockburn Sound Hazard Assessment Report (2013) indicates that critical assets in Coastal Management Unit 3 – North Coogee (CMU 3) are currently and becoming increasingly vulnerable to erosion and a loss of beach area from coastal actions and sea level rise.

Areas within CMU 3 – North Coogee have reached trigger 3 within the immediate planning horizon. This requires a decision between retreat and appropriate interim protection options in the immediate planning horizon as the storm event and sea level rise vulnerability mapping shows that the current risk associated with erosion is becoming increasingly intolerable (refer Appendix A) (BMT Oceanica Pty Ltd, 2014).

Protection Options

Three provisional protection options were considered for assessment and comparison in the MCDA process. The options represent conceptual hard-passive and hard-active measures that would offer protection to the coastline and its assets. These options recommend investigating modifications to the existing Catherine Point Groyne and either actively protecting the coastal assets with seawalls or passively with offshore breakwaters.

Option 1:	Initial stage (Present) – Investigate modifications to Catherine Point Groyne (~80 metres) – Install a seawall between the northern groynes (~550 metres) Later stage (2070) – Install a seawall between the southern groynes (~1,700 metres)
Option 2:	Initial stage (Present) – Investigate modifications to Catherine Point Groyne (~80 metres) – Undertake beach nourishment – Undertake dune redevelopment Later stage (2070) – Install a seawall along full length (~2,250 metres)
Option 3:	Initial stage (Present) – Investigate modifications to Catherine Point Groyne (~80 metres) – Undertake beach nourishment – Undertake dune redevelopment – Install initial offshore breakwaters or groynes Later stage (2070) – Install additional offshore breakwaters or groynes – Undertake beach nourishment – Undertake dune redevelopment

Cost of Options

A summary of the capital, maintenance and decommissioning costs are provided in Table 5. The basis for costing the protection options is described fully in Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016).

Table 5 Cost Estimate of Preliminary Concept options

	Option 1			Option 2			Option 3		
	Capital ($k)	Annual ($k)	Decom ($k)	Capital ($k)	Annual ($k)	Decom ($k)	Capital ($k)	Annual ($k)	Decom ($k)
Present	6,032	57		7,332	257		4,992	98	
2070	17,680	177		23,400	234		7,800	277	
2110	-	-	9,900			9,900			3,060

Recommended Adaptation Decision

MCDA results suggest that interim protection is an appropriate decision over retreat, based on assumed values (criteria weightings) in the immediate planning horizon.

The MCDA highlighted the value placed by the community on maintaining the amenity of coastal assets in CMU 3 – North Coogee. With Options 2 and 3 scoring well ahead of retreat and Option 1, the MCDA clearly indicated that capital spending on interim protection measures that could help maintain the recreational beach and reserve area while offering some protection to urban assets is warranted.

The recommended option involves implementing soft and hard passive interim protection measures that will maintain beach areas and defend the current shoreline position against erosion in the short to medium-term. The nature and extent of works will be guided by the cost and availability of funding. A sketch of a potential arrangement is included in Appendix C, which includes the following items.

- Beach Nourishment and Dune Redevelopment:

  Proactive coastal management (including dune management and revegetation) will be important so that natural erosion processes are not accelerated by poor quality environments. In addition, beach nourishment, in the short to medium term (subject to the availability of materials) is a management tool available to replenish beaches, and slow the loss of land from erosion processes.

- Offshore breakwaters and groynes:

  Offshore breakwaters and groynes are structures that offer protection to the coastline in various ways to control coastal erosion and longshore transport while maintaining beach amenity and therefore present a viable solution for use in CMU3. The positioning, size/length and spacing can have a significant impact on their effectiveness at providing erosion protection and the implications to coastal processes and sediment transport experienced at other locations both upstream and downstream of the protection.

  The stretch of coastline south of Catherine Point is the primary current erosion concern with the coastal hazards increasing but not intolerable in the current planning horizon. Construction of offshore breakwaters or groynes could therefore be undertaken in a staged approach to defer capital expenditure while addressing the concerns.

- Catherine Point Groyne Investigations:

  The current length of the existing Catherine Point groyne appears to be effectively maintaining the beach to the north but is limiting the sand bypassing it resulting in downstream erosion on the southern side. By shortening or modifying the groyne a larger volume of sand may be able to bypass the structure, supplementing downstream sand levels. Further studies would be required to confirm the suitability of this solution.

Further assessment of interim protection for CMU 3

An additional evaluation was undertaken to compare the benefits of two hard-passive interim protection measures as recommended by the MCDA. These options were compared by assessing their perceived performance within CMU 3 and the potential costs of works. The focus of the proposed options is to first implement measures to address the critical erosion location south of Catherine Point and then the coastline in general, while maintaining beach amenity and land use.

As outlined in the *Cockburn Sound Coastal Adaptation Plan – Adaptation Options Compendium* (GHD, 2016), groynes and offshore breakwaters are structures that offer protection to the coastline in various ways to control coastal erosion and longshore transport while maintaining beach amenity and therefore present a viable solution for use in CMU 3. The primary negative impact of these structures is the potential for coastal erosion down drift of these structures, as is being experienced south of Catherine Point.

Nominal refinements to the proposed arrangements that could benefit the coastline in CMU 3 are listed and summarised in the following sections. Modelling, design and data acquisition would be required to confirm the short-term coastal response expectations and assist in understanding the long-term implications of any installations.

Table 6 CMU 3 – North Coogee – Hard Passive Foreshore Protection Options

Option 3a: Offshore Breakwaters	– Investigate groyne modifications to enhance sediment transport to most vulnerable areas – Install 4 to 6 offshore breakwaters in two stages, starting with the near-term implementation of two 100 metre long structures to protect the coastline south of Catherine Point followed by the additional structures to protect the complete section of vulnerable coastline in the medium term as risks increases. – Undertake post construction monitoring and ongoing reactive beach nourishment – Undertake ongoing dune redevelopment
Option 3b: Groynes	– Investigate groyne modifications to enhance sediment transport to most vulnerable areas – Install an additional two to four groynes in two stages, starting with the near term implementation of one or two 100 metre long structures to protect the coastline south of Catherine Point followed by the additional structures to protect the complete section of vulnerable coastline in the medium term as risks increases. – Undertake post construction monitoring and ongoing reactive beach nourishment – Undertake ongoing dune redevelopment

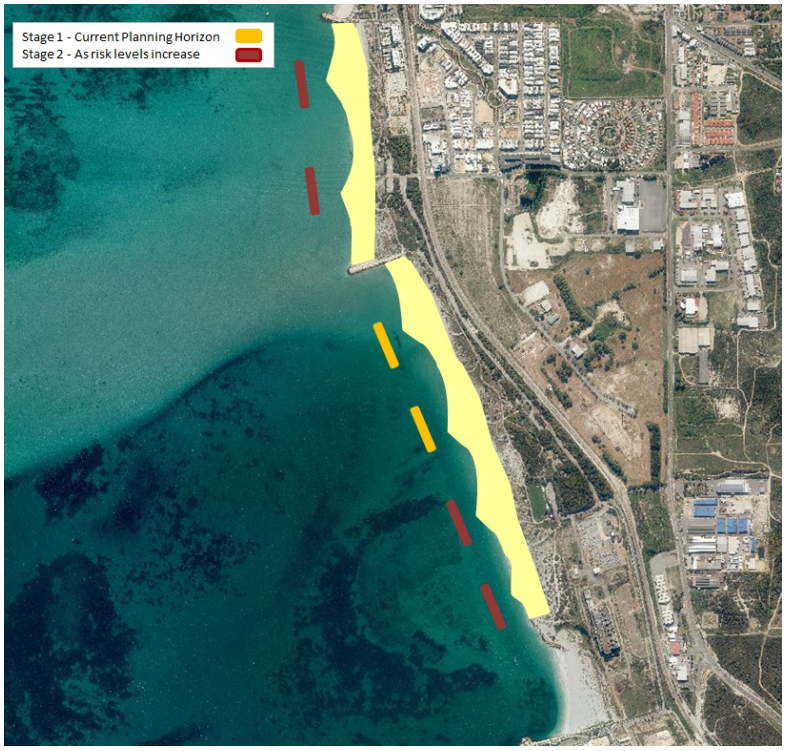


Figure 14 Additional Foreshore Protection Option 3a

Figure 15 Additional Foreshore Protection Option 3b

The results of the additional assessment for CMU 3 (Appendix D) determined that the installation of groynes will provide a simpler design and construction methodology while providing a similar performance then offshore breakwaters (in the long-term) and offer a lower initial cost. However, due to potential storm response erosion, ongoing renourishment costs associated with the groynes may be higher than that of breakwaters. Concept design development and modelling is recommended to confirm these findings and determine the most suitable configuration from a performance and feasibility perspective.

In relation to beach amenity impacts, community consultation is recommended to assess the two concepts and define a preference on the basis of social impacts. Offshore breakwaters can be perceived to present an impact to views from the beach, whilst groynes can bisect the beach environment. Engagement with the community, as a step in preparing a foreshore management plan, will explore these impacts and assist in determining a preferred outcome from the perspective of amenity.

Interim protection works should be accompanied by accommodation strategies described in Section 5.12.

In addition to the freight rail line, commercial and residential development within the North Coogee area justifies interim protection in a way that maintains beach amenity

5.4 Coastal Management Unit 4 - Port Coogee

5.4.1 Decisions in the immediate planning horizon (to 2030)

According to current vulnerability assessment and risk mapping (refer Appendix A), there are areas in these management units which are currently vulnerable to inundation and erosion. However, an intolerable risk level (representing a trigger point 3 or 4) is not expected to be reached in the immediate planning horizon (15 years).

Adaptation in the immediate planning horizon relates to trigger points 1 and 2, and the following should be implemented:

Trigger point 1 (development in vulnerable coastal area; risk is tolerable)

- Monitor values and risk
- Advise land and asset owners of increasing risk over time
- Deliver the strategic planning framework discussed in section 4

Trigger point 2 (increasing likelihood of event presenting intolerable risk

- Responsive beach nourishment to erosion events
- Dune management and revegetation
- Advising land owners and uses of current and future likelihoods of inundation and possible building retrofitting, inundation resilient design options
- Other accommodation options listed in section 5.12

5.4.2 Long-term planning horizon (post-2030)

Risk mapping suggests that trigger point 3 (risk is intolerable, interim protection may be viable), at which point a decision is required to either implement interim protection or retreat for this area will not occur until well into the future. Therefore, that decision should be made closer to the time of the trigger point, in line with the flexible, trigger based adaptation approach presented in section 3.

To gain a sense of what the future might look like at the time of trigger point 3, the MCDA provides a provisional recommendation of what decision might be made. This information should only be considered as provisional, and a future, actual decision will depend on:

- An ongoing risk assessment;
- The cost and technical feasibility of these and other options that might be identified in future;
- Future developments proposed in the area;
- Any changing attitudes to appropriate measures to address sea level rise in general and in these location specifically.

Risk Profile

The Cockburn Sound Hazard Assessment Report (2013) identified that Coastal Management Unit 4 – Port Coogee (CMU 4) has a relatively low level of risk of inundation or erosion in the short and medium term due to the existing protection structures and development levels. The storm event mapping showed that the risks associated with inundation may become intolerable for some lower lying areas by 2110 (refer Appendix A).

This will likely require a decision between retreat and appropriate interim protection options in planning horizon leading up to 2110, or as risk becomes intolerable.

Protection Options

The CMU 4 – Port Coogee coastline consists solely of the Port Coogee marina infrastructure, which is a recent development and at relatively low risk of coastal erosion or inundation. When the effects of sea level rise begins to take effect and the breakwaters and revetments begin to be more regularly overtopped further protection measures could be implemented. Due to the built nature of this section of coastline, there are limited interim protection options available to protect assets besides additional hard-active works. An appropriate, hard passive protection concept is listed below.

Option 1:	Initial stage (2110) • Adjust the reclamation levels • Build additional seawalls

Cost of Options

A summary of the capital, maintenance and decommissioning costs for the hard passive protection concept is provided in . The basis for costing the protection options is described fully in *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016)*.

Table 7 Cost Estimate of Preliminary Concept options

	Option 1		
	Capital ($k)	Annual ($k)	Decom ($k)
Present	-		
2070	-	-	
2110	16,277	101	3,388

Provisional Adaptation Measure

MCDA results suggest that interim protection – at the time of the trigger point – may be an appropriate decision over retreat, based on assumed values (criteria weightings) for the current planning horizon. The MCDA should be reviewed prior to the trigger point to confirm if this decision is viable at the time of the trigger.

A sketch of a preferred interim protection, as identified in this MCDA is included in Appendix C. The preferred decision will need to be reviewed in more detail once the risks levels rise closer to an intolerable level in the long-term planning horizon. As an area which is already heavily modified, suitable protection options will stem around improving and raising the height of the existing revetments and seawalls and raising the general ground levels of the urban areas.

5.5 Coastal Management Unit 5 – Coogee Beach

5.5.1 Decisions in the immediate planning horizon (to 2030)

According to current vulnerability assessment and risk mapping (refer Appendix A), there are areas in this management unit which are currently vulnerable to inundation and erosion. However, an intolerable risk level (representing a trigger point 3 or 4) is not expected to be reached in the immediate planning horizon (15 years).

Adaptation in the immediate planning horizon relates to trigger points 1 and 2, and the following should be implemented:

Trigger point 1 (development in vulnerable coastal area; risk is tolerable)

- Monitor values and risk
- Advise land and asset owners of increasing risk over time
- Deliver the strategic planning framework discussed in section 4

Trigger point 2 (increasing likelihood of event presenting intolerable risk

- Responsive beach nourishment to erosion events
- Dune management and revegetation
- Advising land owners and uses of current and future likelihoods of inundation and possible building retrofitting, inundation resilient design options
- Other accommodation options listed in section 5.12

5.5.2 Long-term planning horizon (post-2030)

Risk mapping suggests that trigger point 3 (risk is intolerable, interim protection may be viable), at which point a decision is required to either implement interim protection or retreat for this area will not occur until well into the future. Therefore, that decision should be made closer to the time of the trigger point, in line with the flexible, trigger based adaptation approach presented in section 3.

To gain a sense of what the future might look like at the time of trigger point 3, the MCDA provides a provisional recommendation of what decision might be made. This information should only be considered as provisional, and a future, actual decision will depend on:

- An ongoing risk assessment;
- The cost and technical feasibility of these and other options that might be identified in future;
- Future developments proposed in the area;
- Any changing attitudes to appropriate measures to address sea level rise in general and in these location specifically.

Risk Profile

The *Cockburn Sound Coastal Alliance – Coastal Vulnerability Study. Erosion and Inundation Hazard Assessment Report* (2013) indicated that Coastal Management Unit 5 – Coogee Beach (CMU 5) is not an area which is currently or in the future expected to be significantly vulnerable to purely inundation events. However, the area has been identified as currently and becoming increasingly vulnerable to erosion and a loss of beach area from coastal actions and sea level rise. Coastal vulnerability and risk assessment mapping shows that the risk associated with erosion will likely become intolerable before 2040 for some assets (refer Appendix A), reflecting a trigger point 3.

This will require a decision between retreat and appropriate interim protection options in planning horizon leading up to 2040, or as risk becomes intolerable.

Protection Options

As a section of sandy coastline, there could be several protection methods and material options which could be suitable to protect against the potential coastal hazards in this area. Two preliminary protection options were considered for assessment and comparison to retreat in the MCDA process. The options listed below represent conceptual hard-passive and hard-active coastal protection approaches to defend the coastline and assets.

Option 1	Initial stage (2040) • Install a seawall in front of more vulnerable assets (~500 metre) Later stage (2070) • Install a seawall along remaining section (~650 metre)
Option 2	Initial stage (2040) • Install two new groyne structures • Undertake beach nourishment to establish artificial beach Later stage (2070) • Install an additional third groyne to the northern side

Cost of Options

A summary of the capital, maintenance and decommissioning costs are provided in . The basis for costing the protection options is described fully in the *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016)*.

Table 8 Cost Estimate of Preliminary Concept options

	Option 1			Option 2		
	Capital ($k)	Annual ($k)	Decom ($k)	Capital ($k)	Annual ($k)	Decom ($k)
Present	5,200	52		9,971	377	
2070	6,760	68		1,346	7	
2110	-	-	5,060	-	-	1,760

Provisional Adaptation Measure

MCDA results suggest that retreat may be an appropriate decision over interim protection, based on assumed values (criteria weightings) for the current planning horizon. The recommended adaptation decision is therefore accommodate and if required retreat.

Adaptation measures to deliver the accommodate and retreat decision include:

- Accommodate impacts where possible
    - Dune management and revegetation
    - Other accommodation options listed in section 5.12.
- Retreat from short-term risks
    - Prepare foreshore management plan to guide relocation and decommissioning of assets at immediate risk
- Plan for strategic, long-term retreat
    - Whole of government approach to retreat private and public assets from risk, and maintain a viable, public foreshore that meets the requirements of State Planning Policy 2.6. A potential model, including triggers, is provided in Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016)

With retreat proposed, stakeholders should be aware that there is the potential for a loss of land. As the coastline erodes and risk levels increase it is noted that particular assets may need to be temporally protected and/or relocated. This would include foreshore infrastructure, the surf club, holiday park and private houses at the northern end of the CMU. Interim protection works could involve seawall construction and raising land levels being however these works should be undertaken with an understanding of long-term retreat and ensuring any new or relocated assets have sufficient setback according to SPP2.6. This should be planned for in a foreshore management plan.

5.6 Coastal Management Unit 6 – Woodman Point Reserve

5.6.1 Decisions in the immediate planning horizon (to 2030)

Risk Profile

The *Cockburn Sound Coastal Alliance – Coastal Vulnerability Study. Erosion and Inundation Hazard Assessment Report* (2013) identified that Coastal Management Unit 6 – Woodman Point Reserve (CMU 6) is currently vulnerable to coastal actions that may cause erosion and inundation which are likely to increase in risk in the future with sea level rise (refer Appendix A). This stretch of coastline is relatively undeveloped and there is a large buffer zone (approx. 120 metres) to any built assets. Coastal hazard risk mapping does not anticipate intolerable risk to built assets in the long-term planning horizon. However conservation values of the Woodman Point Reserve are at risk in the immediate planning horizon.

Recommended Adaptation Measure

This area is recommended for an accommodate and retreat approach. This recommendation is based on the nature of the coastline being relatively undeveloped while having a large coastal dune buffer zone which could be allowed to be gradually lost while maintaining coastal amenity and a low risk to infrastructure in the medium term. Long-term protection of this coastline through large capital expenditure would be impractical.

The adaptation measures to deliver the proposed accommodate and retreat decision which would assist to maintain the use of this land and delay the impacts of erosion and inundation include:

- Accommodate impacts where possible
  - Dune management and revegetation
  - Other accommodation options listed in section 5.12.
- Retreat from short-term risks
  - Prepare foreshore management plan to guide relocation and decommissioning of assets at immediate risk
- Plan for strategic, long-term retreat
  - Whole of government approach to retreat private and public assets from risk, and maintain a viable, public foreshore that meets the requirements of State Planning Policy 2.6. A potential model, including triggers, is provided in Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016)

Natural recession of the coast (retreat) is considered the most appropriate response at Woodman Point Reserve. This will require strategic retreat implementation by state government.

5.7 Coastal Management Unit 7 – Woodman Point

5.7.1 Decisions in the immediate planning horizon (to 2030)

The *Cockburn Sound Coastal Alliance – Coastal Vulnerability Study. Erosion and Inundation Hazard Assessment Report* (2013) identified that CMU 7 was currently vulnerable to coastal actions that may cause erosion and inundation which are likely to increase in risk in the future with sea level rise (refer Appendix A). As a point with an average width of approximately 250 metres, the area is susceptible to coastal actions from both sides. The industrial assets, parkland and recreational assets located in this unit have short setbacks and are currently susceptible to coastal events.

This requires a decision between retreat and appropriate interim protection options in the immediate planning horizon. The nature of the coastline in this unit makes it unfeasible for long-term protection, representing trigger point 4. Therefore this area is proposed for an accommodate and retreat process.

Adaptation measures to deliver the accommodate and retreat decision include:

- Accommodate impacts where possible
  - Dune management and revegetation
  - Other accommodation options listed in section 5.12.
- Retreat from short-term risks
  - Prepare foreshore management plan to guide relocation and decommissioning of assets at immediate risk
- Plan for strategic, long-term retreat
  - Whole of government approach to retreat private and public assets from risk, and maintain a viable, public foreshore that meets the requirements of State Planning Policy 2.6. A potential model, including triggers, is provided in Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan (GHD, 2016)

The land tenure and existing land uses at Woodman Point will limit the role of the City of Cockburn in initiating these measures. The Jervois Bay Sailing Club, Cockburn Cement, the Water Corporation and the Department of Parks and Wildlife have current interests in the land at Woodman Point and will need to be engaged in the development of any adaptation measures, and will need to agree to the long-term retreat from the area. None of these stakeholders have yet been engaged regarding the vulnerability of this coastal management unit. The state government should lead the development of plans for long-term retreat, which will require amendment of the MRS.

5.8 Coastal Management Unit 8 – Australian Marine Complex

5.8.1 Decisions in the immediate planning horizon (to 2030)

According to current vulnerability assessment and risk mapping (refer Appendix A), there are areas in this management unit which are currently vulnerable to inundation and erosion. However, an intolerable risk level (representing a trigger point 3 or 4) is not expected to be reached in the immediate planning horizon (15 years).

Adaptation in the immediate planning horizon relates to trigger points 1 and 2, and the following should be implemented:

Trigger point 1 (development in vulnerable coastal area; risk is tolerable)

- Monitor values and risk
- Advise land and asset owners of increasing risk over time
- Deliver the strategic planning framework discussed in section 4

Trigger point 2 (increasing likelihood of event presenting intolerable risk

- Advising land owners and uses of current and future likelihoods of inundation and possible building retrofitting, inundation resilient design options
- Other accommodation options listed in section 5.12

5.8.2 Long-term planning horizon (post-2030)

The Cockburn Sound Hazard Assessment Report (2013) indicates that the port infrastructure located in Coastal Management Unit 8 – Australian Marine Complex (CMU 8) was adequately prepared for inundation and erosion events in the short to medium term (up to 2070), refer Appendix A.

From 2070, it is expected that areas in close proximity to the port infrastructure may begin to be more significantly threatened by inundation. To combat this it is expected that the breakwater, seawalls and general ground levels would be raised to accommodate sea level rise. The responsibility of this will likely fall on the private operators of the facilities and therefore no interim protection measures were assessed in the MCDA process. If these measures are not undertaken then an accommodate and retreat process would need to be implemented in the long-term.

5.9 Coastal Management Unit 9 – Henderson South

5.9.1 Decisions in the immediate and long-term planning horizon (to 2030)

The Cockburn Sound Hazard Assessment Report (2013) identifies that Coastal Management Unit 9 – Henderson South (CMU 9) is not currently vulnerable to coastal actions. Risk mapping suggests that the likelihood of inundation or erosion is expected to vary little over time in this CMU, refer Appendix A.

The area is adequately resilient to inundation and erosion events in the long-term (beyond 2110). Therefore no specific adaptation measures are recommended in the long-term planning horizon to 2110.

5.10 Implementation of Interim Protection

Prior to the construction of coastal engineering protection structures, there are several steps that should be undertaken to develop the basis of design and confirm that the proposed interim protection methods are the most suitable approach from a performance and financial viability perspective. The following steps (as a minimum) are proposed:

1. Develop a data register and acquire long-term information on the Cockburn Sound and near shore site specific locations including: erosion and accretion patterns, wave climate, water levels, sediment processes, bathymetric data and shoreline area surface levels.
2. Review the data register to identify gaps in information required to inform design works.
3. Undertake the required investigations to fill any gaps in the data. This may require installation of data recording devices, survey work and modelling.
4. Develop a basis of design with available information.
5. Develop several concept designs based on the preferred approach to be optimised to confirm the most suitable design.
6. Obtain environmental approvals for the preferred design.
7. Once a final design option has been selected, detailed design and documentation can then be prepared.

The earlier that steps 1 to 3 can be undertaken in advance of any construction works the better informed the design work will be.

Existing interim protection (groyne) at the north of the City of Cockburn.

5.11 Outstanding issues to resolve prior to interim protection

5.11.1 Materials availability and cost

The increase in construction and infrastructure development to support the expected population growth of Perth and Peel will increase the demand for basic raw materials including those commonly used in coastal works such as sand, limestone, and hard rock (EPA, 2015). This may limit the supply of suitable materials required for protection options.

Additionally, beach nourishment is proposed for a number of areas across the Owen Anchorage and Cockburn Sound in order to maintain public beach amenity. This will place a long-term demand on a limited supply. Sand may be sourced at localised accretion locations and from offshore dredging. However, the availability of suitable sources is likely to become increasingly limited in the future.

There are many variables to consider when predicting the potential future availability and cost of coastal protection materials that may be required for a long-term planning horizon. Developing a long-term material resource plan would require a detailed feasibility assessment for the entire Owen Anchorage and Cockburn Sound. The same may apply for other sections of the Perth metropolitan and Peel region coastline.

It is recommended that the City of Cockburn, together with the Cockburn Sound Coastal Alliance undertakes or seeks for the relevant state government agencies to undertake a study of the current and potential sources of materials suitable for coastal protection works and any potential environmental impacts of their sourcing in order to adequately plan for the options identified over the long-term planning horizon. If it is determined that obtaining the required volumes of materials is unlikely, then alternative techniques or pathways may be required.

5.11.2 Relocation of railway and future developments

Future decisions to protect against erosion and inundation in CMU 3 should take into account the possibility of relocating the freight rail line that is currently managed by Brookfield Rail. This railway is noted to be a vital link between the Kwinana industries, the Kewdale/Forrestfield marshalling yards and Fremantle Ports. The heritage listed South Fremantle Power Station is also located in this CMU close to the foreshore which has potential plans for redevelopment along with some of the vacant land located along this CMU.

The MCDA identified that there was some sensitivity in regards to the value placed on beach areas, the railway and other landside assets. Relocating the railway and developments to an area of lower risk, if at all feasible, could alter the most preferred approach identified for coastal management units in the City of Cockburn and should be considered in the planning process.

5.11.3 Environmental impact

The environmental impact of the proposed works on both the shoreline and benthic habitat would need to be established in further studies of the options. This should also include consideration of the impacts of adaptation decisions on neighbouring coastal management units. Potential issues to be resolved would include consultation with affected local government areas - especially if proposed measures were to accelerate a problem elsewhere, how impacts will be measured and monitored, and the reassessment of adaptation options under changed conditions.

5.12 Accommodation Measures

5.12.1 Proactive coastal management

Proactive coastal management (including dune management and revegetation) will be important so that natural erosion processes are not accelerated by poor quality coastal environments. These management techniques are less of a response to the changing coast and more a management tool to delay the need for interim protection and planning responses.

5.12.2 Building retrofitting

Private building and land owners who wish to accommodate the risk of inundation rather than retreat, should consider the options available to retrofit their premises to better mitigate the risk of inundation during these extreme events. A number of flood proofing measures are outlined in the Building Code of Australia. When considering the potential accommodation measures available it is important to not only address the potential effects of flooding on the building fabric but also on services, particularly electrical equipment and their cables.

5.12.3 Public infrastructure

Increased risk of inundation also needs to be accommodated by infrastructure owners including roads (local government), electricity, gas, water, wastewater and drainage. It is recommended that state government engage with infrastructure providers with assets in the coastal vulnerable zone (and/or proposed special control area) to develop plans for accommodation / protection and eventual removal of their assets over time.

5.12.4 Emergency Planning

Emergency safety management plans and suitable forward planning should be maintained to address the risk of rare events and adequately plan for sea level rise, as risk increases over time.

5.13 Ocean and Shoreline Monitoring

As indicated in the 2014 *Cockburn Sound Coastal Vulnerability Values and Risk Assessment Study*, management of the coast would benefit from ongoing monitoring and interpretation. A list of monitoring and data acquisition/analysis that would be beneficial for coastal management in the City is listed below.

- The Department of Transport and other state agencies currently undertake monitoring and data collection within the Cockburn Sound. Long-term historic wave and water levels are publically available, as well as coastal surveys, vegetation line mapping, and ongoing scientific studies. Regular review of these data by the City is recommended to allow for trends d that may be affecting their coastline to be identified and to ensure that the information required for the design of coastal structures is readily available.

- Installation of nearshore hydrodynamic instrumentation to collect wave and water level conditions at locations where interim protection is expected to be implemented will enable better calibration and validation of any modelling required.

- Photo monitoring should be undertaken biannually (winter/summer) and during/post significant storm events, in accordance with the methodology recommended by Department of Transport (DaSilva 2012). Visual comparison of site photos provides context for interpretation of the measured profile, vegetation line and bathymetric changes.

- Continued annual or twice yearly monitoring and annual reporting of the transect profiles established through the Metropolitan Redevelopment Authority along the City of Cockburn coastline.

- LIDAR survey and aerial photography of the coastline should be repeated on a regular basis (~5 to 10 years). When undertaken, it should be compared with previous datasets to identity coastal trends and interpret coastal management pressures.

- Local tidal stations should be established to record storm water level extremes and monthly mean sea level, to help interpret coastal management pressures, along with annual means (and exceedance levels). A local and global understanding of recorded sea level rise and future projections should also be maintained to inform future studies.

Working with and sharing relevant coastal data with the other members of the Cockburn Sound Coastal Alliance would allow for resources to be pooled and trends across LGA boundaries to be identified.

6. Implementation Plan

Key adaptation measures recommended by this adaptation plan are summarised in Table 9, and Figures 16 to 20.

In line with the preferred adaptation responses, a range of specific implementation actions will be required over time alongside key strategic planning activities to deliver the trigger based, flexible adaptation approach. Table 10 provides a consolidated list of all recommendations and required actions from across this adaptation plan, for delivery by relevant stakeholders in the immediate planning horizon.

The adaptation plan identifies focus areas/actions for implementation by state government, particularly in relation to policy, expansion of the foreshore reserve (where necessary in the longer term), and major infrastructure. This plan does not bind state government or other stakeholders to the actions, however recognises that long term adaptation requires the support of these key stakeholders. The City of Cockburn, alongside the Cockburn Sound Coastal Alliance, will work closely with the state government and other key stakeholders to deliver the actions necessary to achieve adaptation principles.

Table 9 Summary of coastal vulnerability and preferred adaptation responses

Coastal Management Unit	Coastal Vulnerabilities	Immediate Planning Horizon (to 2030)	Long-term Planning Horizon (to 2110)
CMU 3 – North Coogee	Erosion, with intolerable risk presented to assets and a loss of beach area in the immediate planning horizon for some areas, increasing in the lead up to 2070.	Interim protection using hard-passive engineering measures in the form of groynes of offshore breakwaters	Continued interim protection (using hard-passive engineering measures such as groynes or offshore breakwaters) may be feasible
CMU 4 – Port Coogee	Inundation, with intolerable risk presented to some assets and a loss of beach area leading up to 2110.	Avoid Accommodate	Interim protection (using hard-active engineering measures) may be feasible
CMU 5 – Coogee Beach	Erosion, with intolerable risk presented to assets and a loss of beach area leading up to 2040	Avoid Accommodate	Avoid Accommodate Retreat

Coastal Management Unit	Coastal Vulnerabilities	Immediate Planning Horizon (to 2030)	Long-term Planning Horizon (to 2110)
CMU 6 – Woodman Point Reserve	Erosion and inundation, with intolerable risk presented to some conservation assets in the immediate planning horizon.	Avoid Accommodate Retreat	Avoid Accommodate Retreat
CMU 7 – Woodman Point	Erosion and inundation, with intolerable risk presented to some conservation assets in the immediate planning horizon.	Avoid Accommodate Retreat	Avoid Accommodate Retreat
CMU 8 – Australian Marine Complex	Adequately prepared for inundation and erosion events in the short to medium term (up to 2070)	Do nothing Monitor	Do nothing Monitor
CMU 9 – Henderson South	Not vulnerable to coastal actions	Do nothing Monitor	Do nothing Monitor

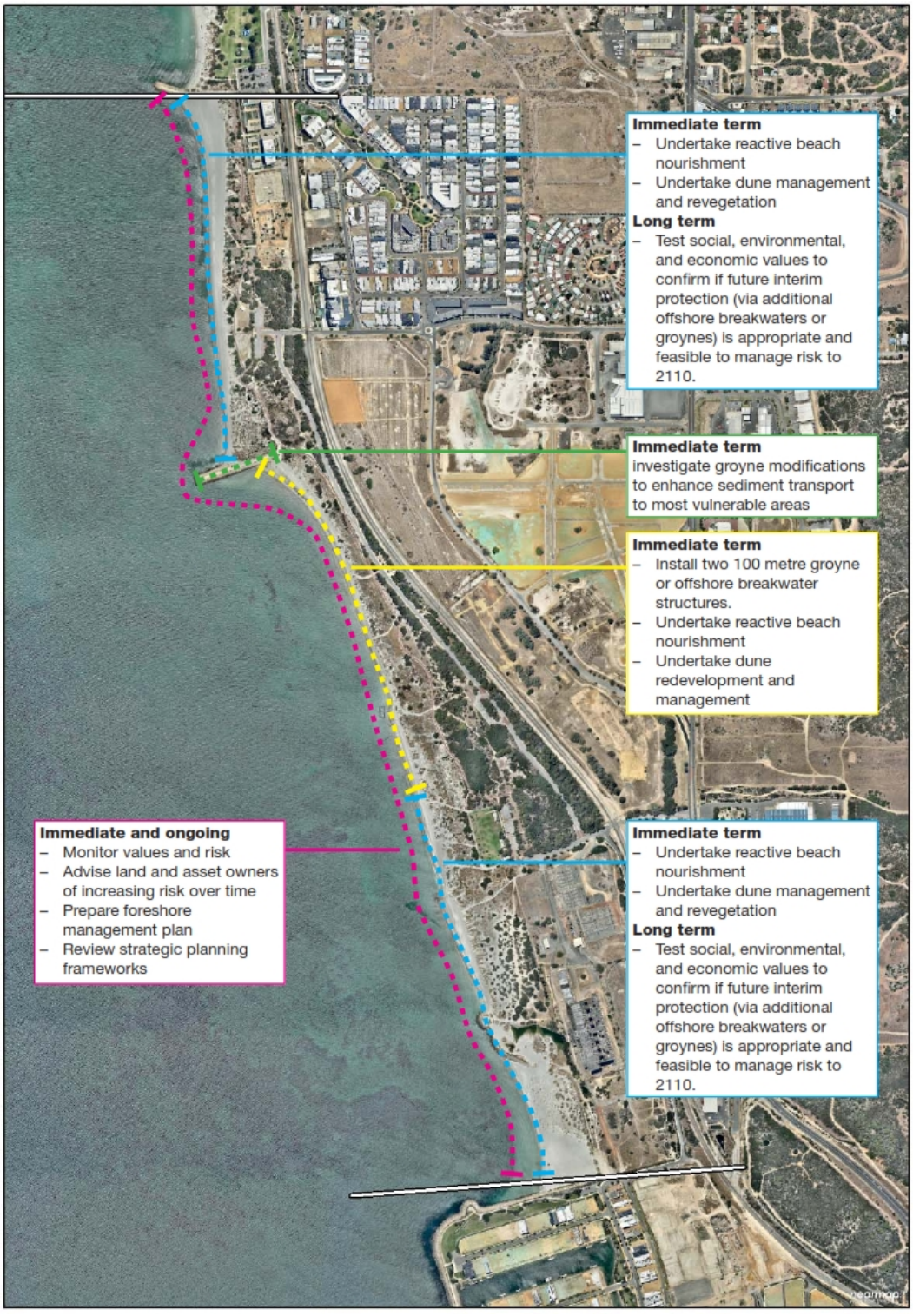


Figure 16 Recommended adaptation measures – North Coogee

Figure 17 Recommended adaptation measures – Port Coogee

Figure 18 Recommended adaptation measures – Coogee Beach

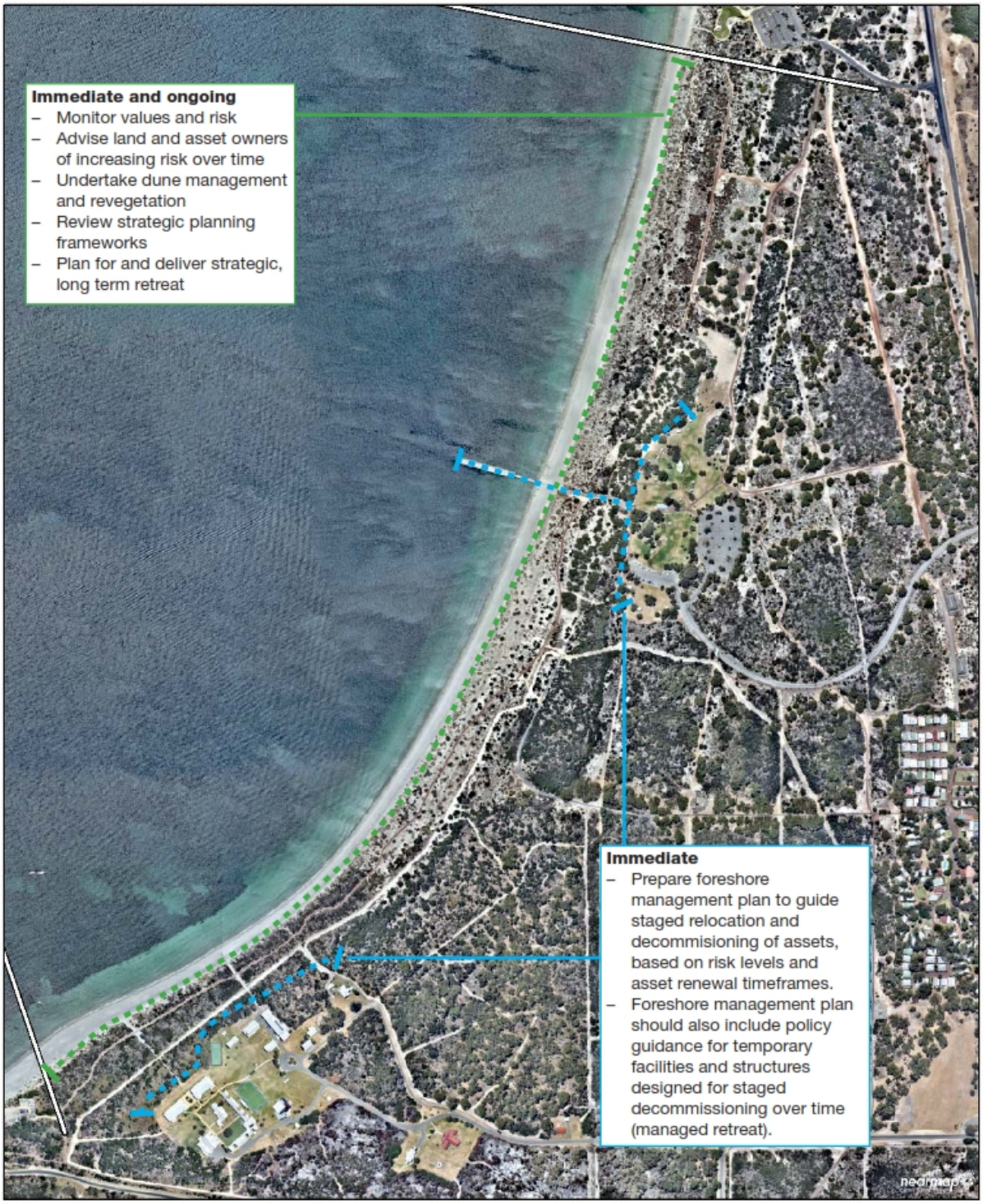


Figure 19 Recommended adaptation measures – Woodman Point Reserve

Figure 20 Recommended adaptation measures – Woodman Point

Table 10 Implementation Plan

Action	Lead Stakeholder	Supporting Stakeholders
Strategic Actions		
Investigate funding responsibilities and opportunities for implementation of coastal adaptation across Western Australian.	Department of Planning	Department of Transport Infrastructure agencies Local government
Review State Planning Policy 2.6 to incorporate additional policy measures to manage development that is a variation to the policy.	Western Australian Planning Commission	Department of Planning City of Cockburn Department of Transport (Facilities Management)
Develop and deliver a community awareness campaign regarding coastal risks and impacts, and the adaptation plan.	City of Cockburn	Department of Planning Department of Transport
Review strategic plan, including significant community awareness and engagement regarding coastal adaptation and values.	City of Cockburn	Cockburn community.
Review local planning strategy, to include investigation of special control area and necessary development controls for the coastal vulnerable area.	City of Cockburn	Department of Planning Western Australian Planning Commission Land owners and managers
Review local planning scheme to incorporate special control area and development controls as recommended by the local planning strategy review.	City of Cockburn	Department of Planning Western Australian Planning Commission Land owners and managers
Prepare foreshore management plan for CY O'Connor Reserve and Beach	City of Cockburn	Department of Planning Western Australian Planning Commission

Action	Lead Stakeholder	Supporting Stakeholders
Prepare foreshore management plan for Coogee Beach	City of Cockburn	Department of Planning Western Australian Planning Commission
Prepare management plan for Woodman Point	Department of Parks and Wildlife	Department of Planning Western Australian Planning Commission
Commence dialogue (through advisory groups) with infrastructure owners and managers regarding adaptation plan and coastal risk.	Department of Planning	City of Cockburn Cockburn Sound Coastal Alliance
Prepare emergency safety management plan for extreme events.	City of Cockburn	
Review regional plans and strategies to plan for relocation of key infrastructure and expansion of the foreshore Parks and Recreation Reserve. Investigate strategic retreat models.	Western Australian Planning Commission	Department of Planning Public Transport Authority (asset owner) Main Roads Western Australia Water Corporation Fremantle Port Authority Department of Transport (Facilities Management)
Specific Adaptation Actions – Coastal Management Units		
Monitor risk levels to land and infrastructure	City of Cockburn Department of Parks and Wildlife Australian Marine Complex	
Provide information to land owners in vulnerable area regarding increasing coastal risk	City of Cockburn	

Action	Lead Stakeholder	Supporting Stakeholders
Undertake community consultation, concept design and detailed scoping study for establishment of groynes or other structures to manage immediate risk at CY O'Connor Beach.	City of Cockburn	Department of Transport
Undertake responsive beach nourishment at CY O'Connor and Coogee Beach	City of Cockburn	
Undertake a regular program of dune management and revegetation for all coastal reserves	City of Cockburn	
Additional investigations		
Investigate materials availability and cost for all potential long-term coastal protection options across Owen Anchorage and Cockburn Sound.	Cockburn Sound Coastal Alliance	Department of Planning Department of Transport Department of Resources and State Development Perth Region NRM
Undertake strategic environmental impact review of cumulative impact of all potential long-term coastal protection options across Owen Anchorage and Cockburn Sound.	Cockburn Sound Management Council	Department of Planning Department of Transport
Develop and implement coordinated coastal risk monitoring program.	Cockburn Sound Coastal Alliance	Department of Planning Department of Transport

7. Review framework

7.1 Adaptation plan review

This adaptation plan should be reviewed regularly, alongside the review of the City of Cockburn Strategic Plan. Ongoing liaison with the Cockburn Sound Coastal Alliance should occur to consider opportunities for coordinated review of adaptation plans, particularly if major state planning or infrastructure initiatives are undertaken that would influence decisions beyond local government boundaries (e.g. relocation of the freight rail line over time alters the economic value of the coast in that location, and may result in a different decision).

Review processes should include targeted community and industry consultation to update values and views about coastal development and assets that will be at risk both within a 15-year planning horizon and beyond. Revised values and new learnings should be used to test recommendations of this adaptation plan, and determine whether adaptation strategies for the 15-year planning horizon require modification as a result of changing values.

The regular testing of values and adaptation measures will involve the following actions incorporated into the review of future strategic plans, for land and assets identified as being at risk within 15 years of the strategic plan review:

- Identification of any new or alternative adaptation options based on greater information and new technology;
- Review of criteria used in the multi-criteria assessment;
- Community, stakeholder and industry consultation on the weighting of criteria;
- Review of the weighted scoring of adaptation options;
- Confirmation of adaptation options for a 15 year planning horizon;
- Adjustment to account for planning and infrastructure actions implemented and the further development implemented in coastal areas, e.g. Cockburn Coast and North Coogee.

7.2 Future hazard assessment

It will be necessary to update the hazard mapping from time to time to reflect actual sea level rise, updated projections of future sea level rise and the response of the coast to changing conditions. These updates should occur as new information becomes available.

It is recommended that the erosion and inundation hazard assessment is updated following the release of the next Intergovernmental Panel for Climate Change (IPCC) assessment report which is expected in 2020/21.

8. References

BMT Oceanica Pty Ltd in conjunction with BMT WBM Pty Ltd, Coastal Zone Management Pty Ltd, SGS Economics and Planning Pty Ltd and Damara WA Pty Ltd (2014) Cockburn Sound Coastal Vulnerability Values and Risk Assessment Study.

Coastal Zone Management Pty Ltd, the UWA School of Environmental Systems Engineering, Damara WA Pty Ltd and Oceanica Consulting Pty Ltd (2013) Cockburn Sound Coastal Alliance – Coastal Vulnerability Study. Erosion and Inundation Hazard Assessment Report.

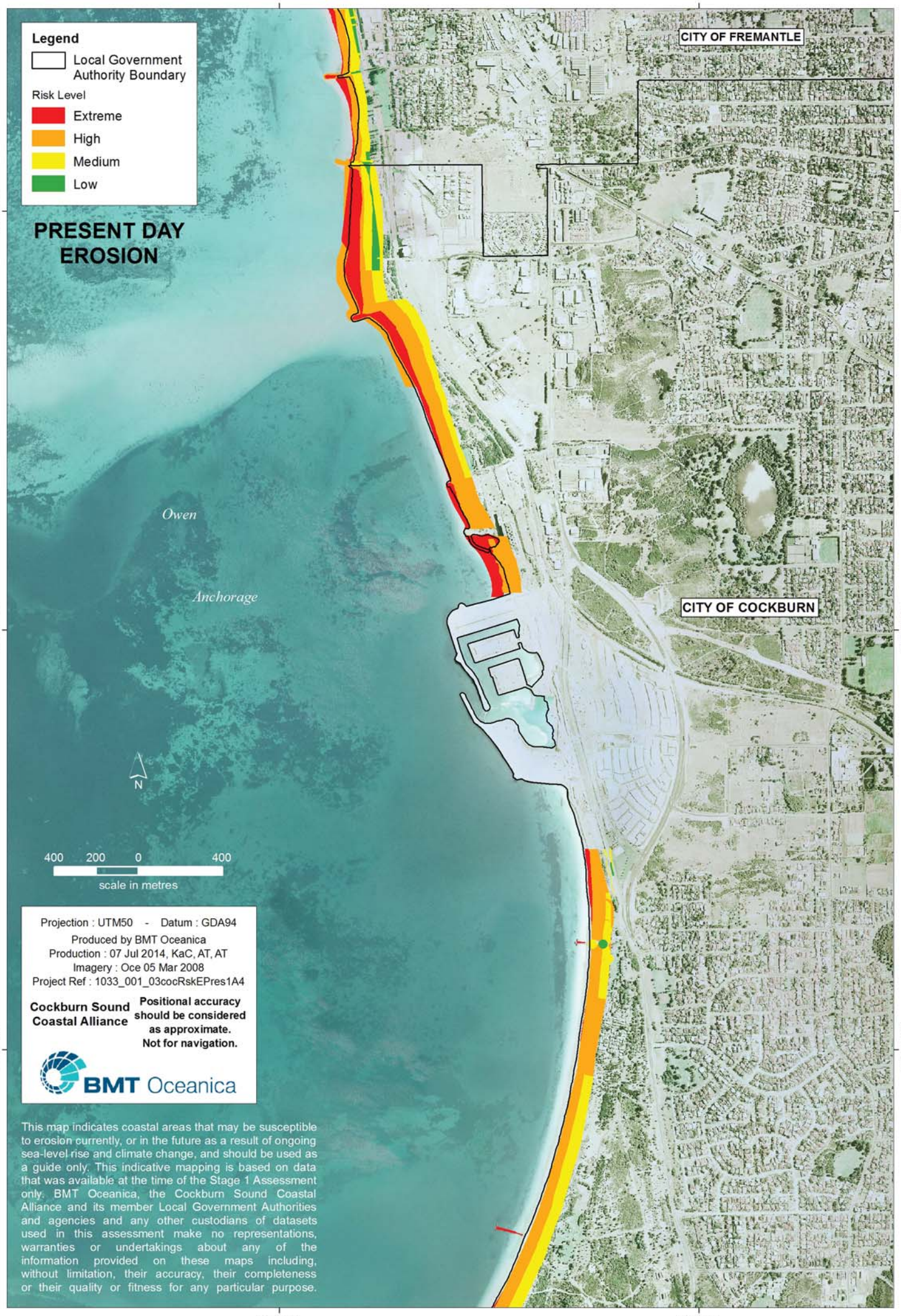
GHD (2016) Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project – Stage 3 Report Coastal Adaptation Plan

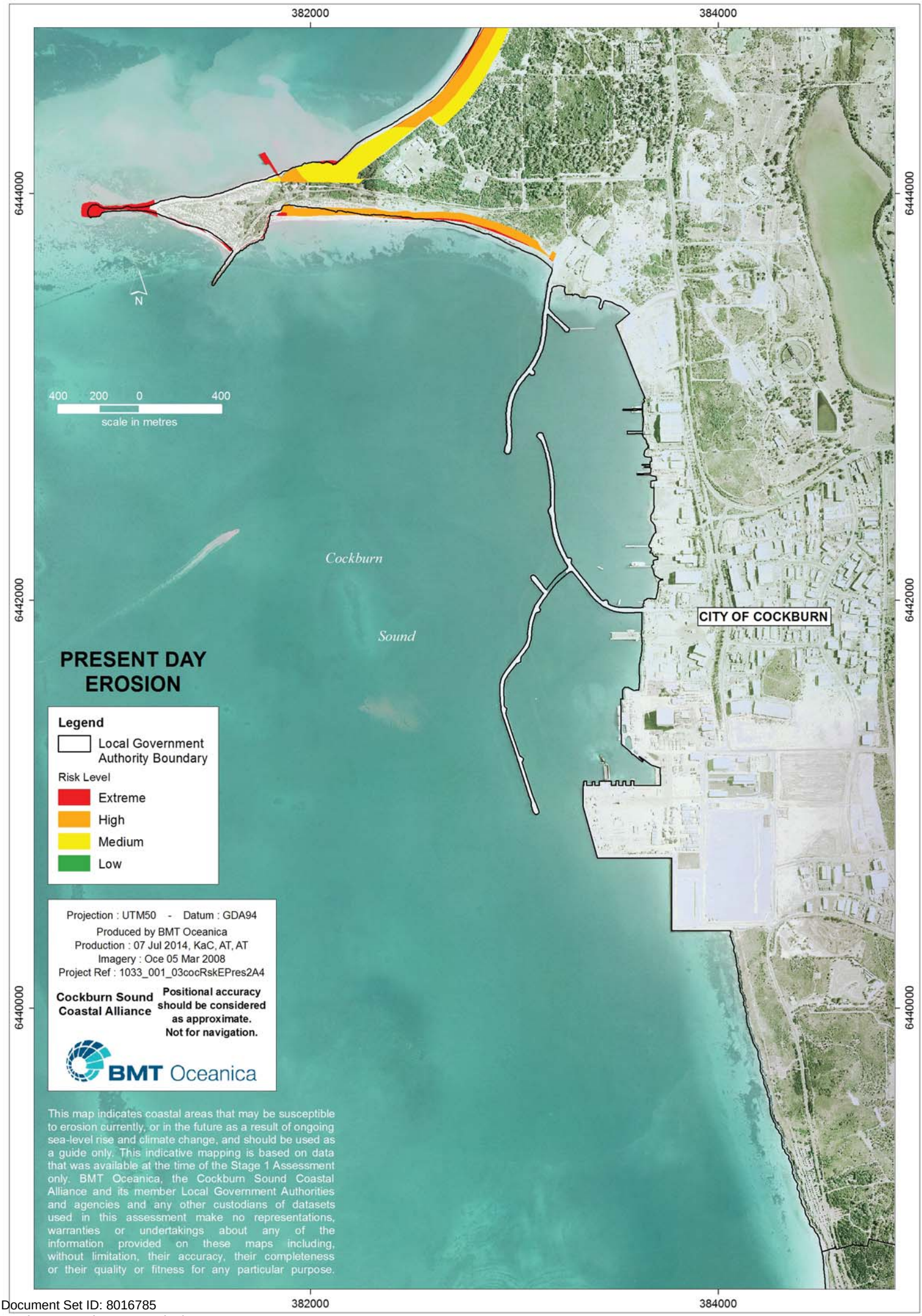
GHD (2016) Cockburn Sound Coastal Adaptation Plan – Adaptation Options Compendium

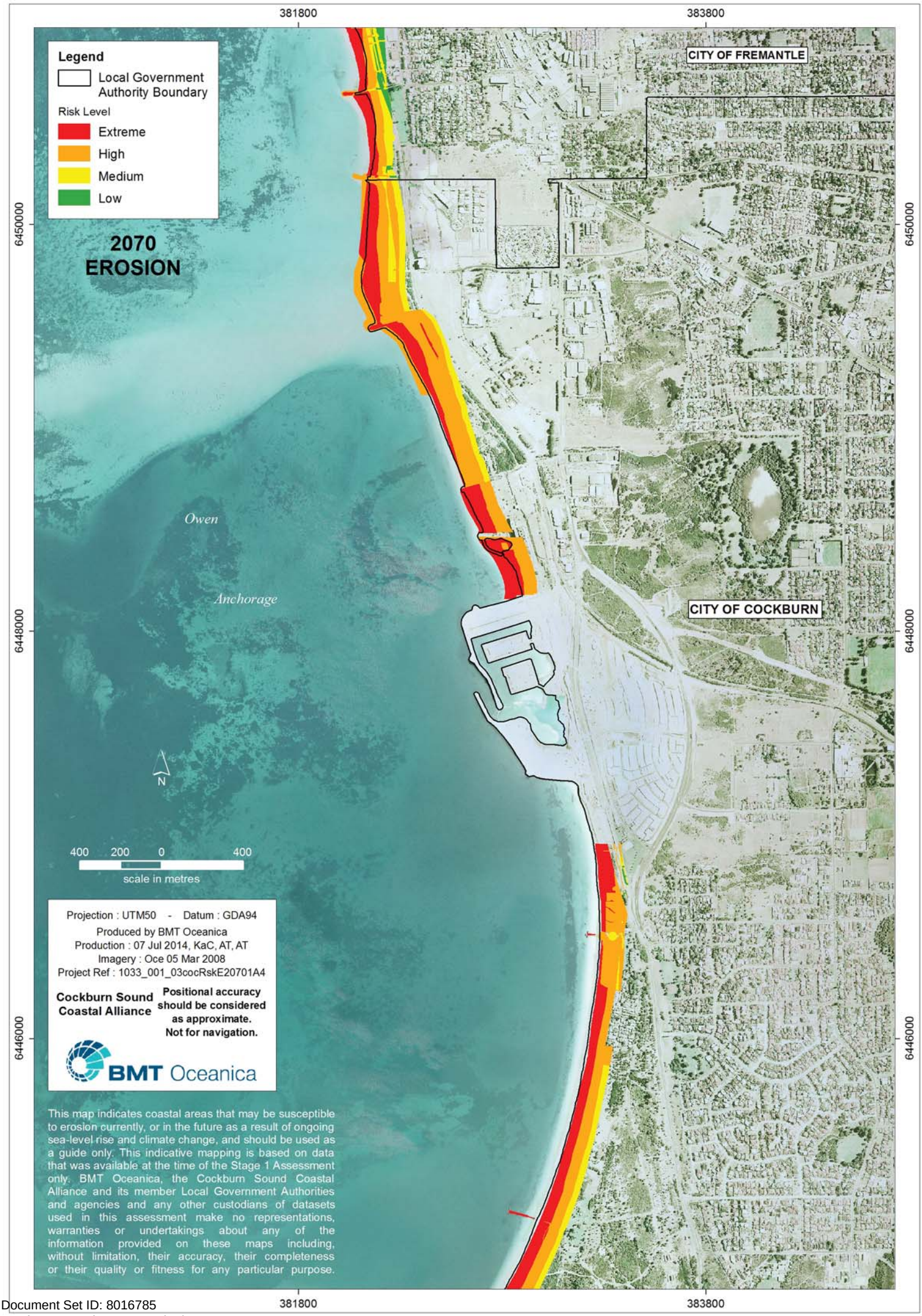
Appendices

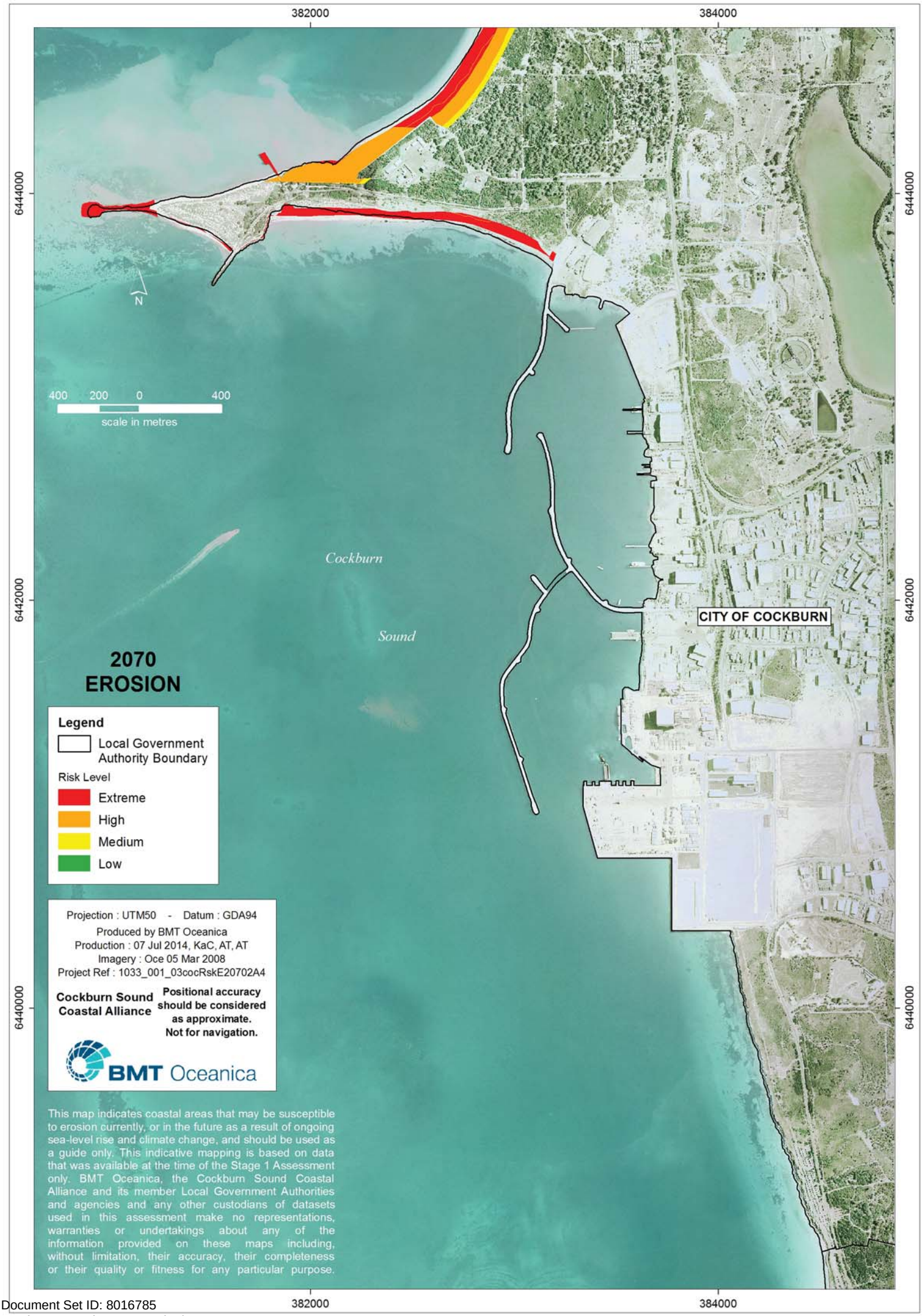
Appendix A – Coastal Risk Mapping

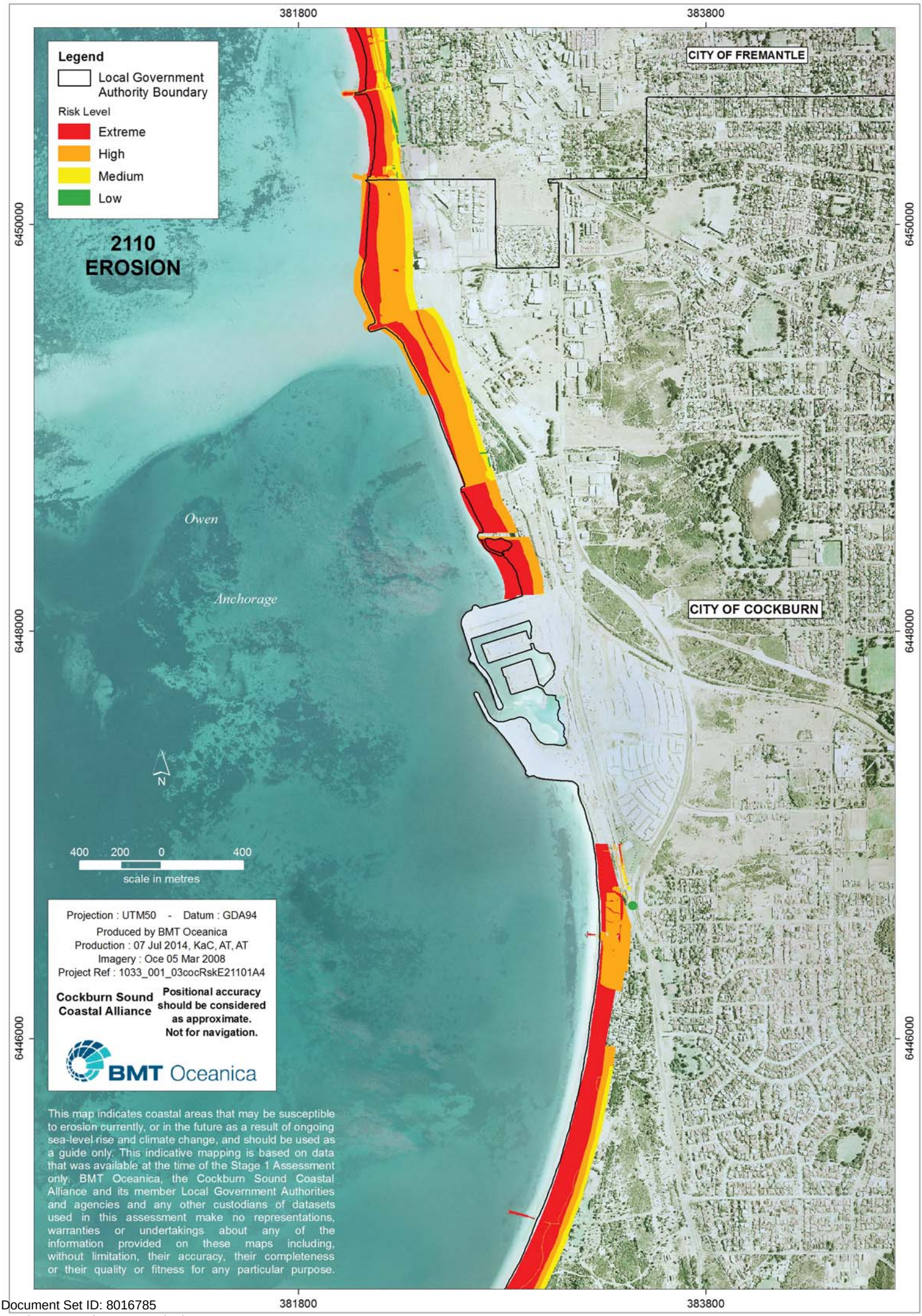
Prepared by BMT Oceanica for the Cockburn Sound Vulnerability Values and Risk Assessment Study

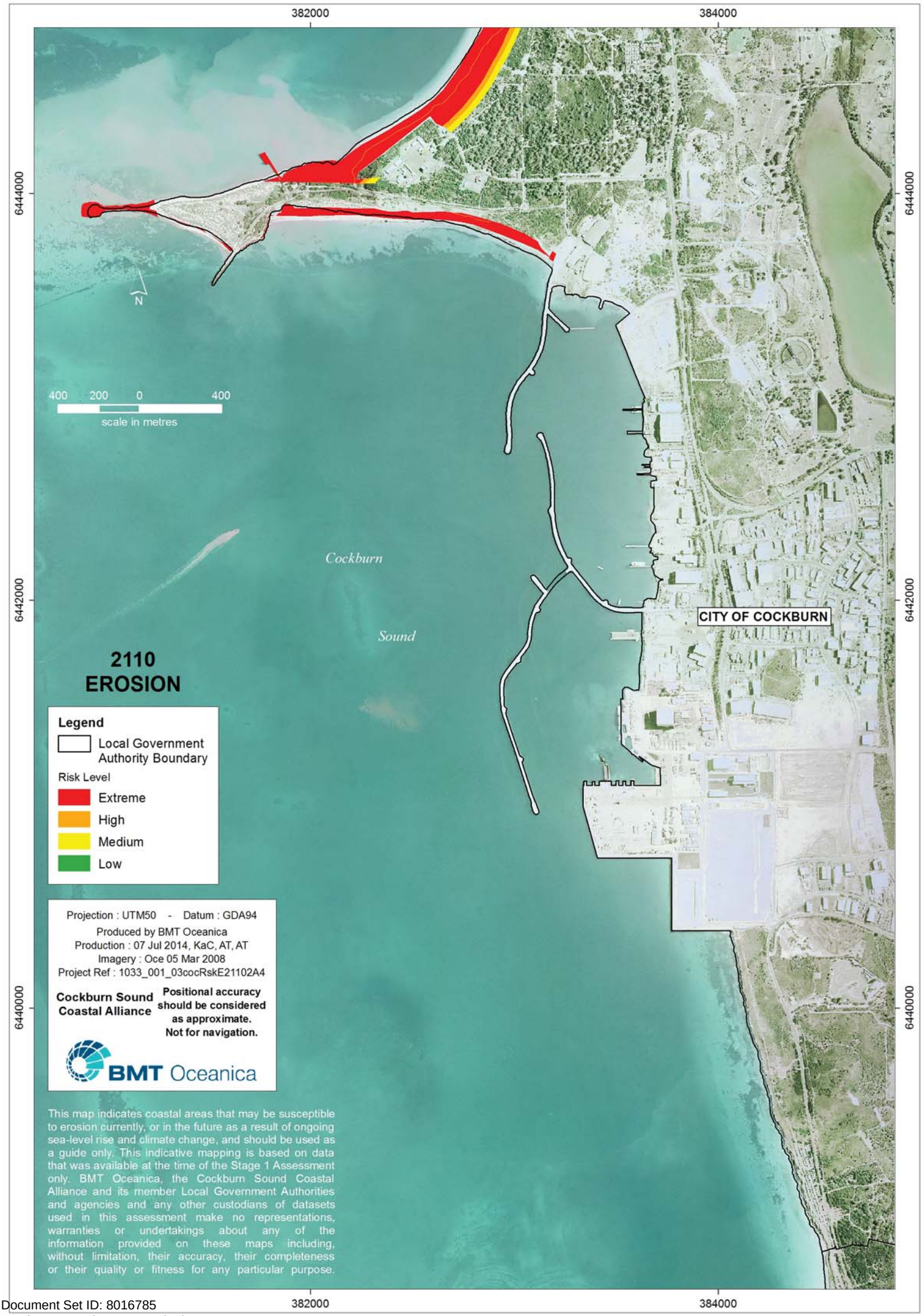


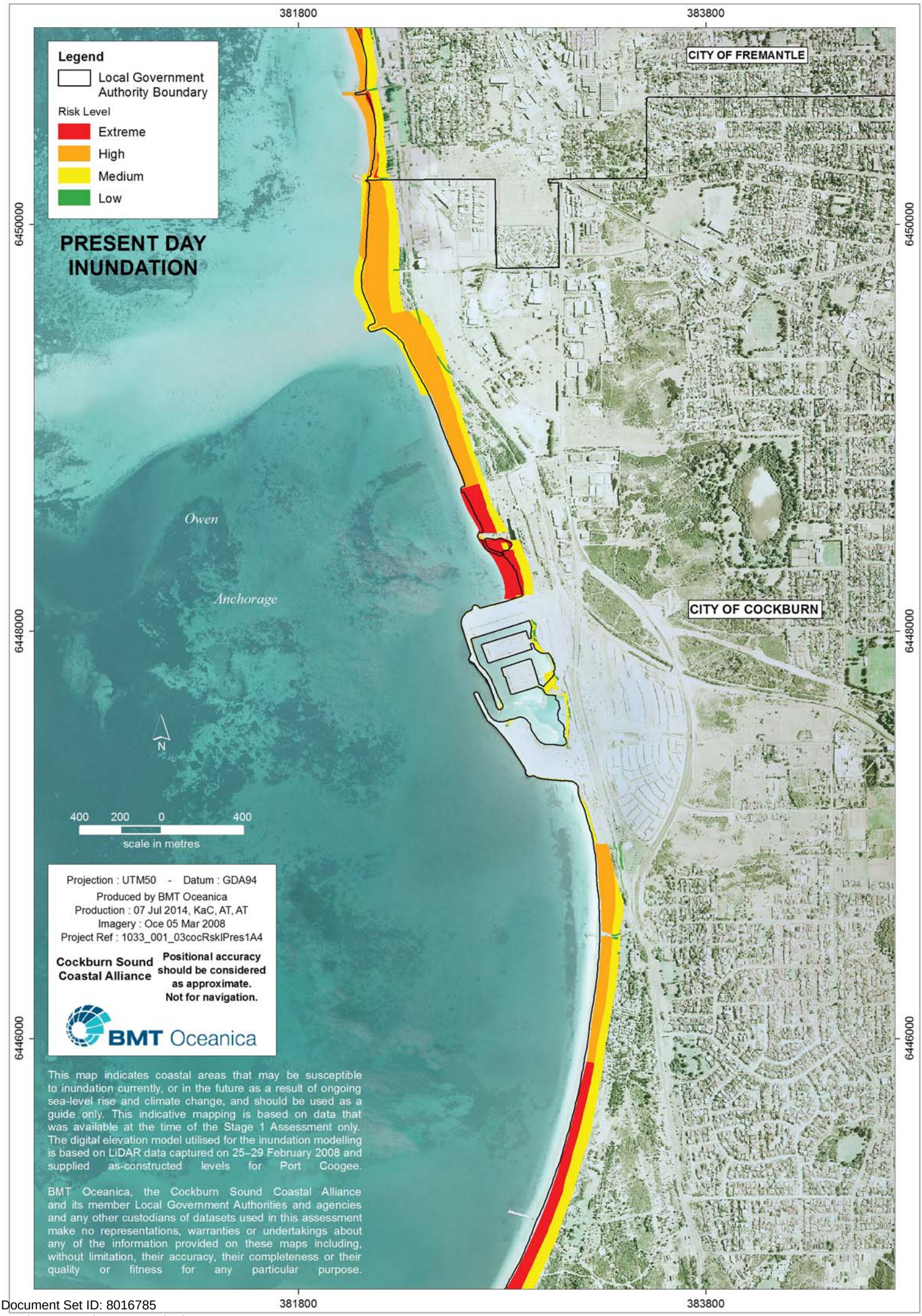


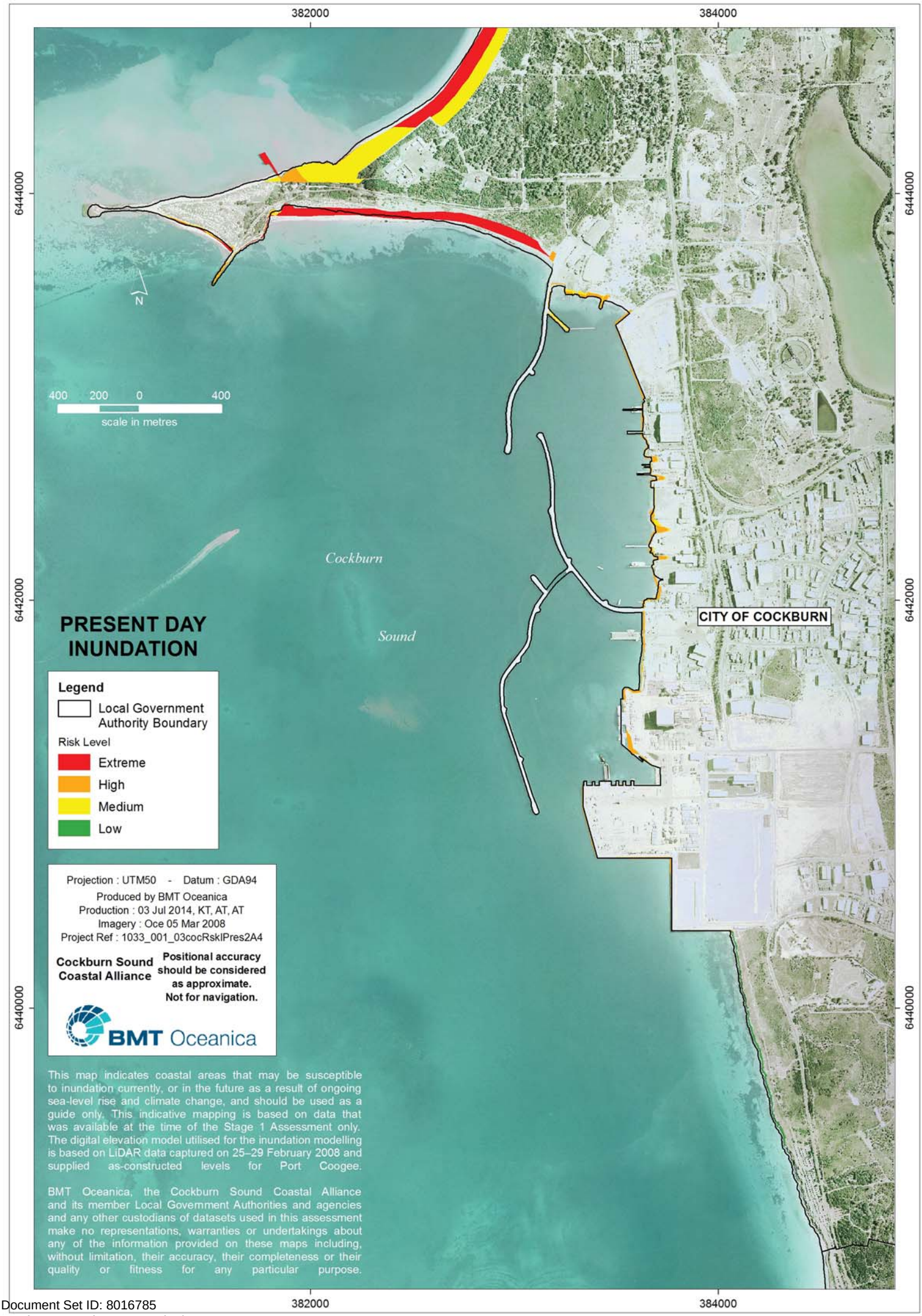




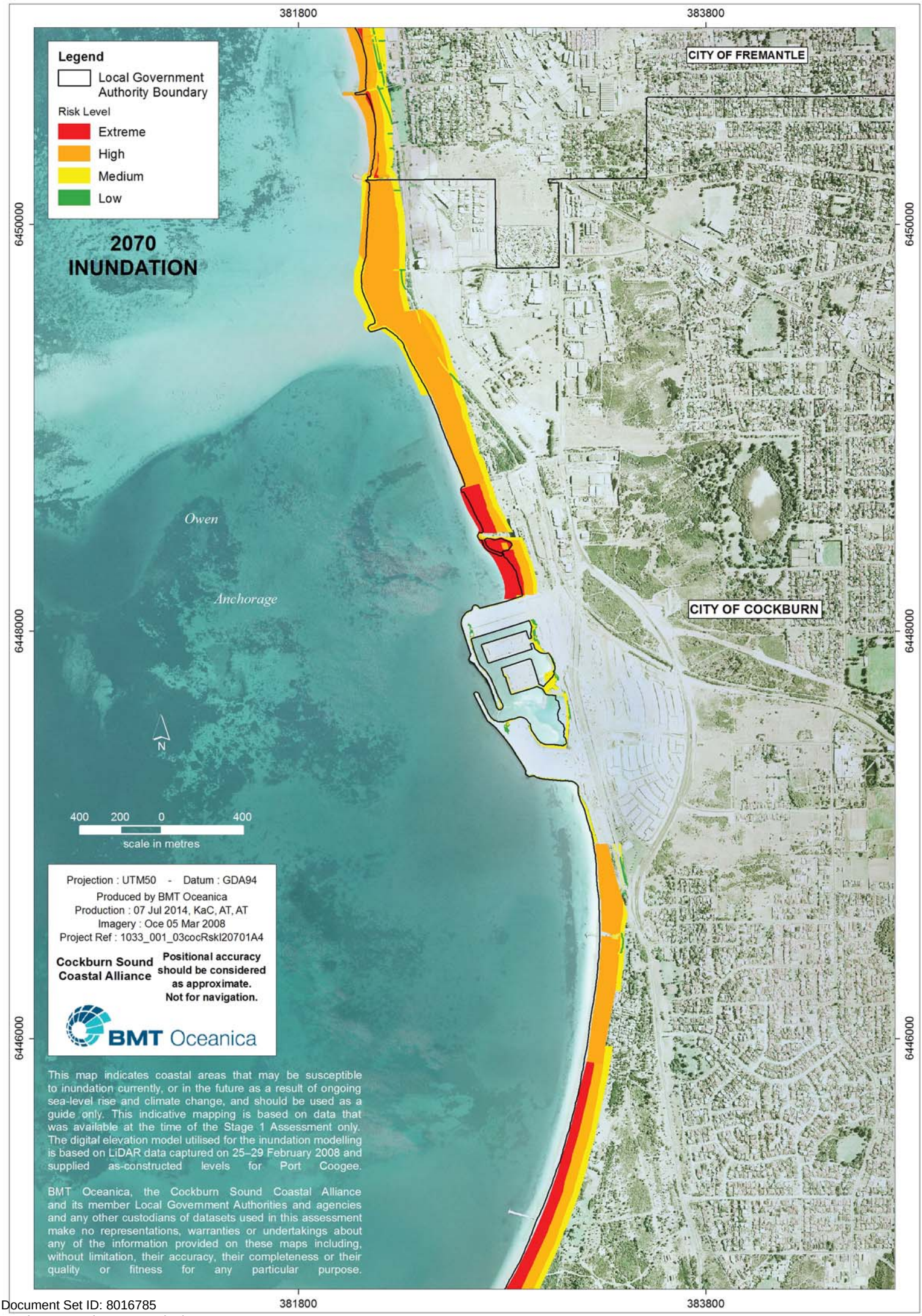


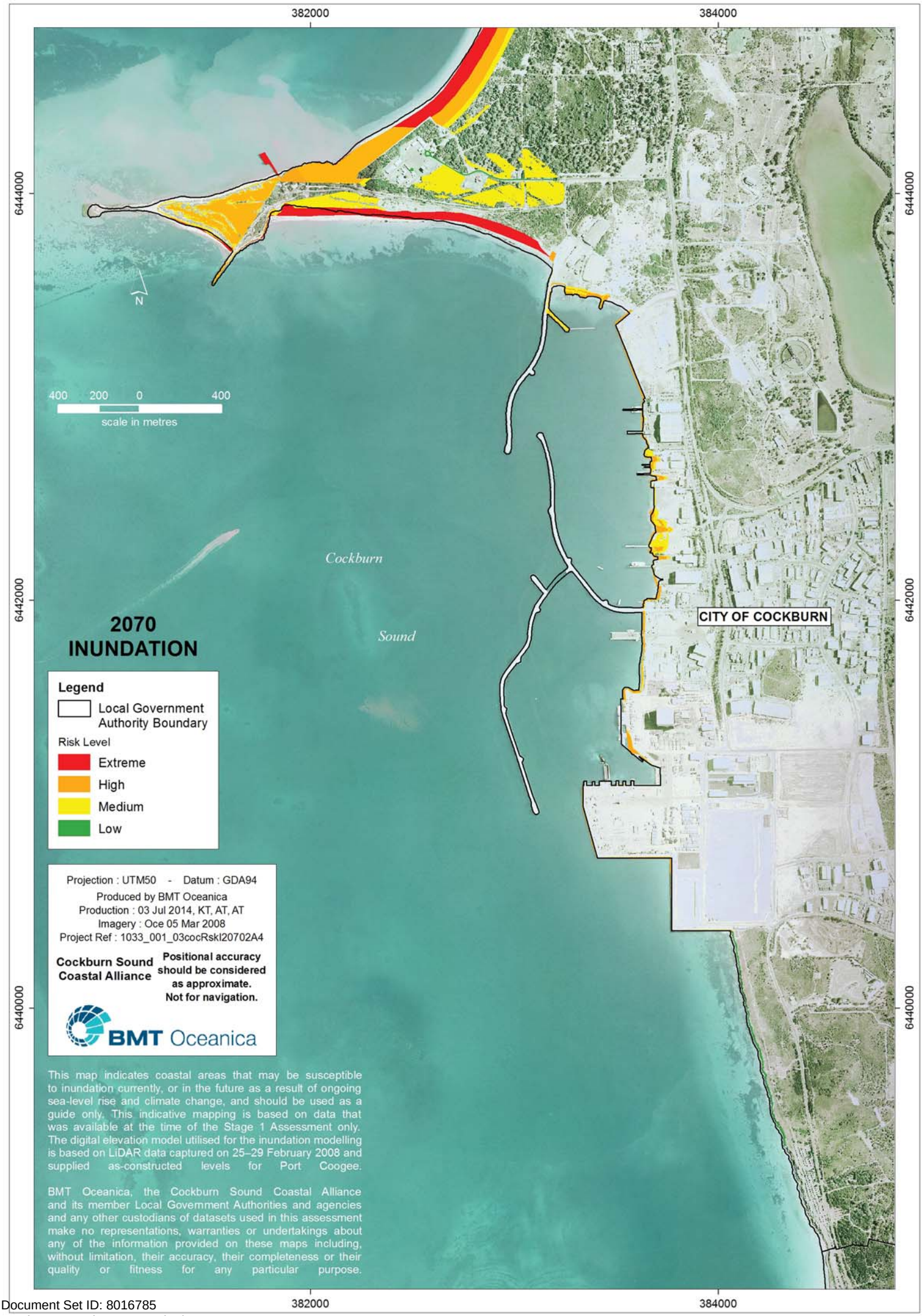


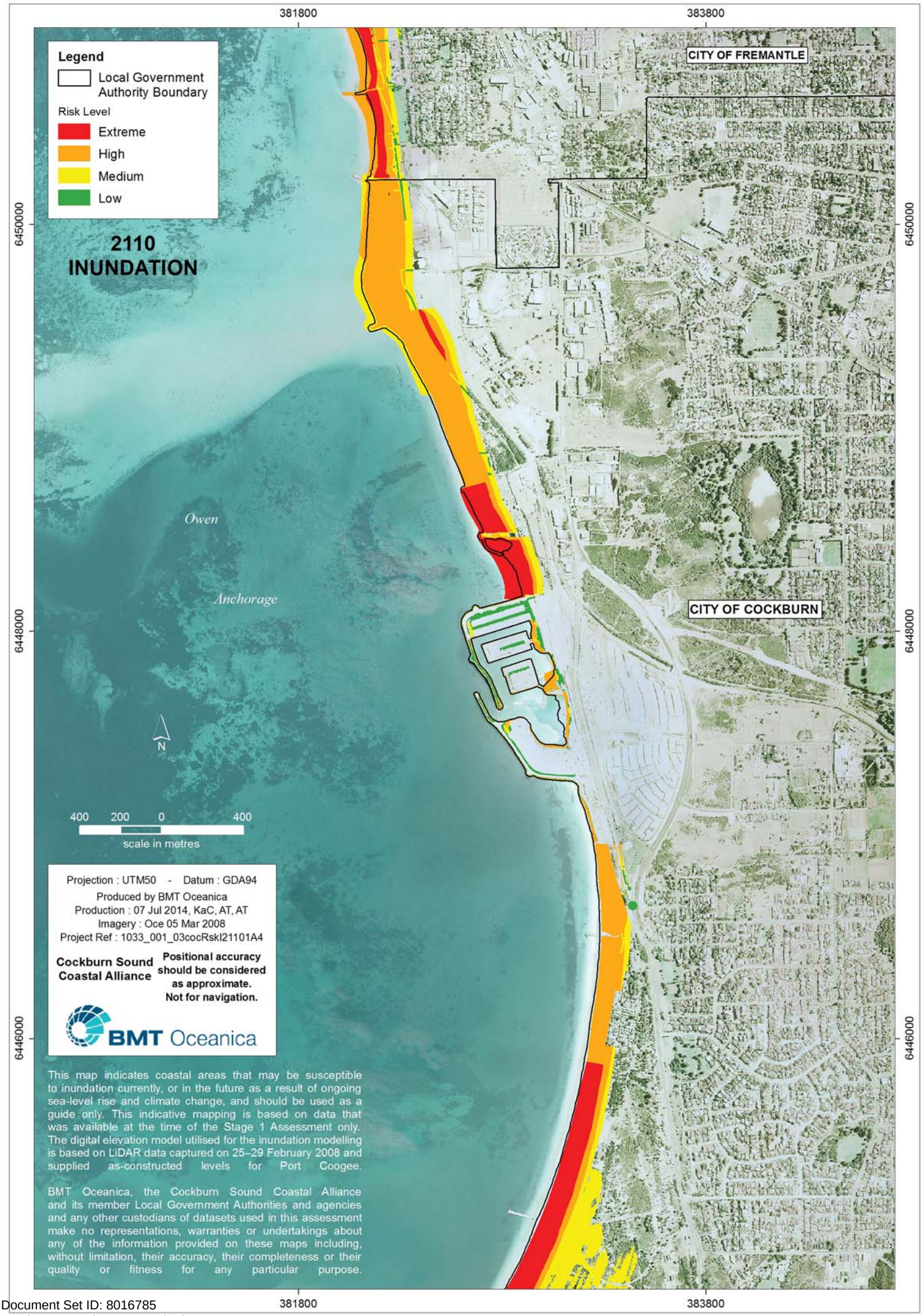


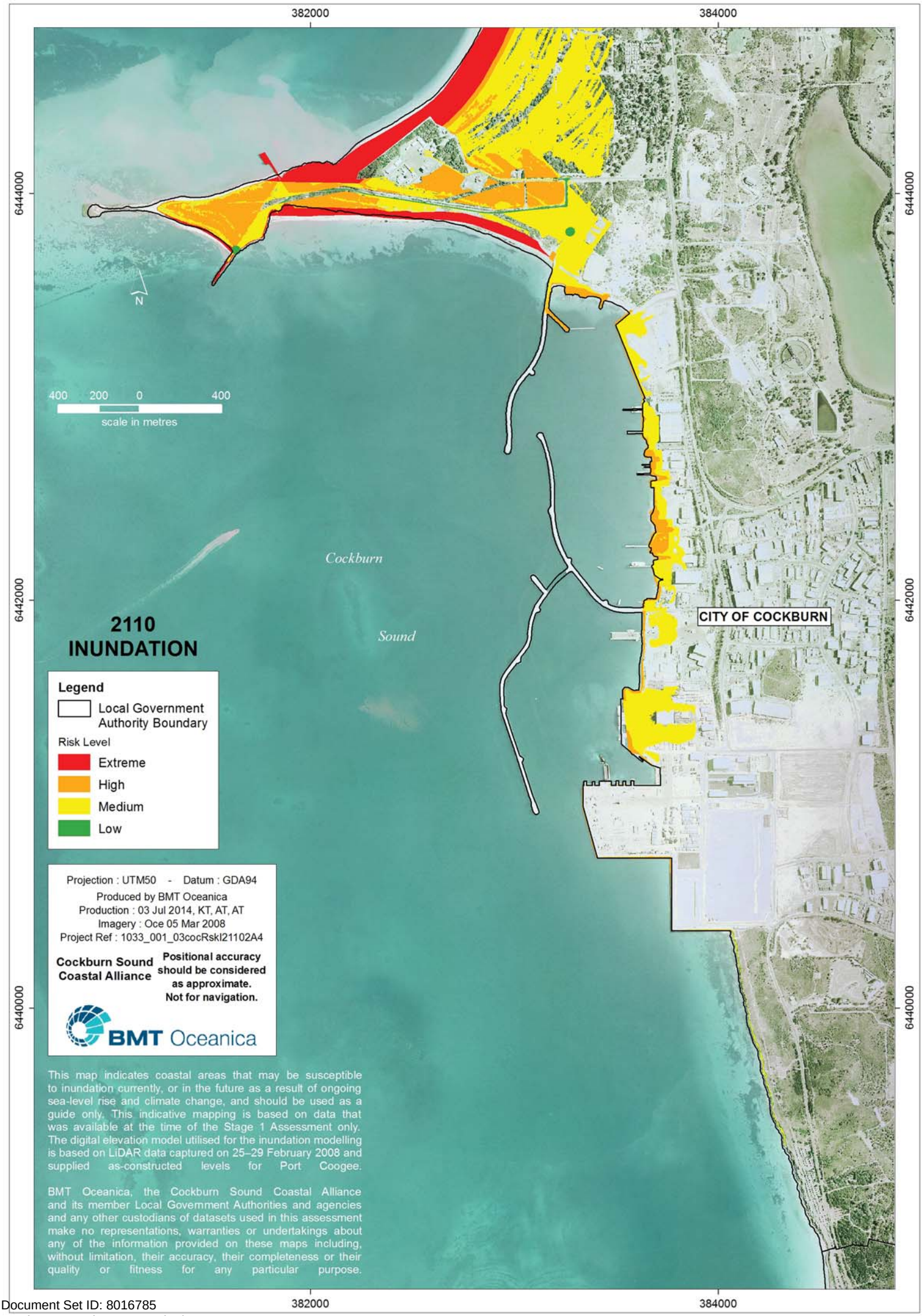


This map indicates coastal areas that may be susceptible to inundation currently, or in the future as a result of ongoing sea-level rise and climate change, and should be used as a guide only. This indicative mapping is based on data that was available at the time of the Stage 1 Assessment only. The digital elevation model utilised for the inundation modelling is based on LiDAR data captured on 25–29 February 2008 and supplied as-constructed levels for Port Coogee.









Appendix B – MCDA Results and Sensitivity Analysis

MCA results and sensitivity analysis

The results of the MCDA and associated sensitivity analysis plots are set out below.

The tables indicate the unweighted and weighted scores for each option.

The sensitivity analysis was carried out using HiView's inbuilt analysis plots.

Sensitivity down plots

The sensitivity down window calculates which criteria weights are sensitive. The criteria are listed down the middle of the screen. Where a change to the cumulative weight of a criterion can result in a new most preferred option, a bar is drawn on the graph. The bars are colour coded. A red bar is very sensitive, a yellow bar is less sensitive and a green bar would require a large weight change to change the most preferred option. The thresholds for colour coding are as follows:

Red - cumulative weight would have to change by 5 points or less in order to change the most preferred option.

Yellow - cumulative weight would have to change by between > 5 to 15 points in order to change the most preferred option.

Green - cumulative weight would have to change by more than 15 points in order to change the most preferred option.

The bars drawn to the left of the criteria list represent a decrease in cumulative weight, whilst the bars drawn to the right represent an increase. For each instance of a bar being drawn, the new most preferred option is displayed at the end of the bar. Where there is no bar, no amount of weight change will change the most preferred option. The sensitivity down window is used to direct further analysis of the model. Where criteria have a red bar, further analysis is a high priority.

Sensitivity up plots

The sensitivity up graph displays the sensitivity of the selected tree item with regard to the most preferred option at the top of the tree.

This graph demonstrates how the most preferred option at the top of the tree varies with the cumulative weight on node selected. The x-axis represents the cumulative weight on the criterion. The y-axis shows the total weighted values, at the root node, of each of the options. The vertical red line shows the current cumulative weight of the selected node. Reading the y-values for each option, these are the same as the total weighted scores in the node data window for the root node. The line for each option shows how this total weighted score will change as the cumulative weight on the criterion changes. The most preferred option at any cumulative weight has the highest y-value. At the vertical red line, whichever line has the highest y-value is currently the most preferred option.

Coastal Management Unit 3

Northern boundary:	North boundary Pickled Fig Café
Southern boundary	South extent of Robb Road
Key assets	Power Station Redevelopment Site (Cockburn Coast), C. Y. O'Connor Reserve
Interim protection options	

Option 1: Initial stage (Present)
- Investigate modifications to Catherine Point Groyne (~80m)
- Install a seawall between the northern groynes (~550m)

Later stage (2070)
- Install a seawall between the southern groynes (~1,700m)

Option 2: Initial stage (Present)
- Investigate modifications to Catherine Point Groyne (~80m)
- Undertake beach nourishment
- Undertake dune redevelopment

Later stage (2070)
- Install a seawall along full length (~2,250m)

Option 3: Initial stage (Present)
- Investigate modifications to Catherine Point Groyne (~80m)
- Undertake beach nourishment
- Undertake dune redevelopment
- Install initial offshore breakwaters or groynes

Later stage (2070)
- Install additional offshore breakwaters or groynes
- Undertake beach nourishment
- Undertake dune redevelopment

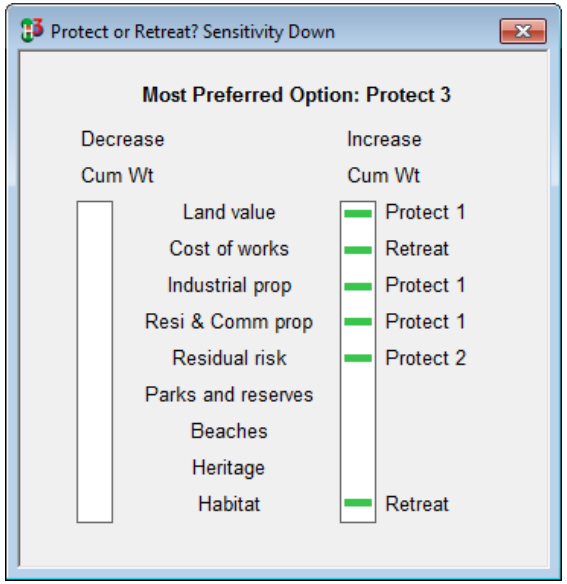
			Raw data						Normalised score				Weight	
			Retreat	Protect 1	Protect 2	Protect 3			Retreat	Protect 1	Protect 2	Protect 3	Nominal	Adjusted
Coastal Management Unit														
3	Loss of land value	Discounted cost ($m)	126	25	25	25	201%	R/A	0	100	100	100	0.11	0.15
	Interim protection costs	Discounted cost ($m)	0	18	30	12	201%	R/A	100	41	0	60	0.11	0.15
	Industrial property impact	No. potential lots affected		0			0%	Ttl lots	0	100	100	100	0.19	0.15
	Residential & commercial property impact	No. potential lots affected		59			2%	Ttl lots	0	100	100	100	0.11	0.15
	Residual risk to property	Scale of 1-5	1	2	2	3			100	50	50	0	0.07	0.05
	Parks and reserves impact	Area (ha)		31			7%	Ttl area	0	100	100	100	0.11	0.00
	Beach recreation / amenity impact	m of beach		2030			9%	Ttl beach	100	0	60	100	0.15	0.25
	Heritage impact	No. of heritage properties affected		3			6%	Ttl props	0	100	100	100	0.04	0.05
	Habitat loss	Area (ha)		17.9			9%	Ttl area	100	0	50	50	0.11	0.05
									400	591	660	710	1.00	1.00
						Weighted score			50	59	70	86		
						Rank			4	3	2	1		

Notes:

1. Industrial property impact derived from the rail reserve rather than the number of industrial lots

2. Weighting of zero for Parks and reserves assumes that the equivalent area can be retained in the Retreat option.

Sensitivity Analysis



Coastal Management Unit 4

Northern boundary:	South extent of Robb Road
Southern boundary	Socrates Road/Pelinte View intersection
Key assets	Port Coogee

Interim protection options

Option 1: Initial stage (2110)

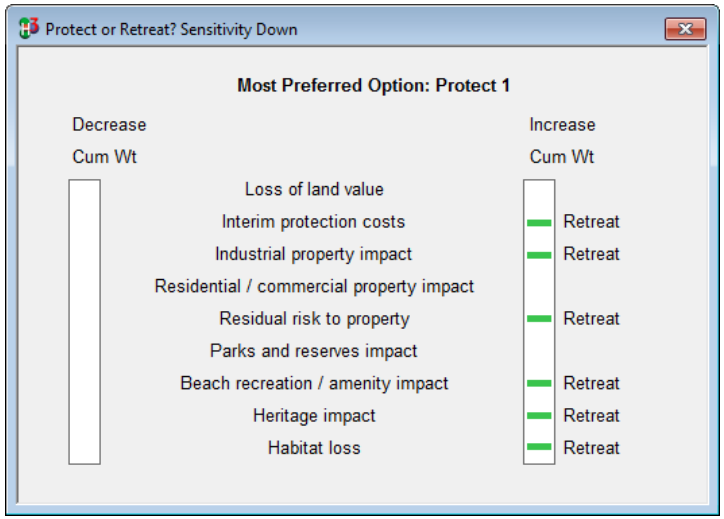
- Adjust reclamation levels
- Build additional seawalls

		Raw data						Normalised score					Weight	
		Retreat	Protect 1	Protect 2	Protect 3			Retreat	Protect 1	Protect 2	Protect 3		Nominal	Adjusted
Loss of land value	Discounted cost ($m)	241	133				R/A	0	100				0.11	0.55
Interim protection costs	Discounted cost ($m)	0	13				R/A	100	0				0.11	0.15
Industrial property impact	No. potential lots affected	0				0%	Ttl lots	0	0				0.19	0.00
Residential & commercial property impact	No. potential lots affected	321				12%	Ttl lots	0	100				0.11	0.15
Residual risk to property	Scale of 1-5	1	2					100	0				0.07	0.05
Parks and reserves impact	Area (ha)	0.04				0.01%	Ttl area	0	100				0.11	0.10
Beach recreation / amenity impact	m of beach	0				0%	Ttl beach	100	0				0.15	0.00
Heritage impact	No. of heritage properties affected	0				0%	Ttl props	0	100				0.04	0.00
Habitat loss	Area (ha)	0.0				0%	Ttl area	100	0				0.11	0.00
								400	400				1.00	1.00
					Weighted score			20	80					
					Rank			2	1					

Notes:

1. Weighting for Parks and reserves assumes that the equivalent area cannot be retained in the Retreat option.

Sensitivity Analysis



Coastal Management Unit 5

Northern boundary:	Socrates Road/Pelinte View intersection
Southern boundary	South boundary of Coogee Beach Surf Life Saving Club
Key assets	Coogee beach reserve

Interim protection options

Option 1: Initial stage (2040)

- Build seawall along the shore

Later stage (2070)

- Extend the seawall

Option 2 Initial stage (2040)

- Build two new groyne structures
- Beach nourishment to establish artificial beach

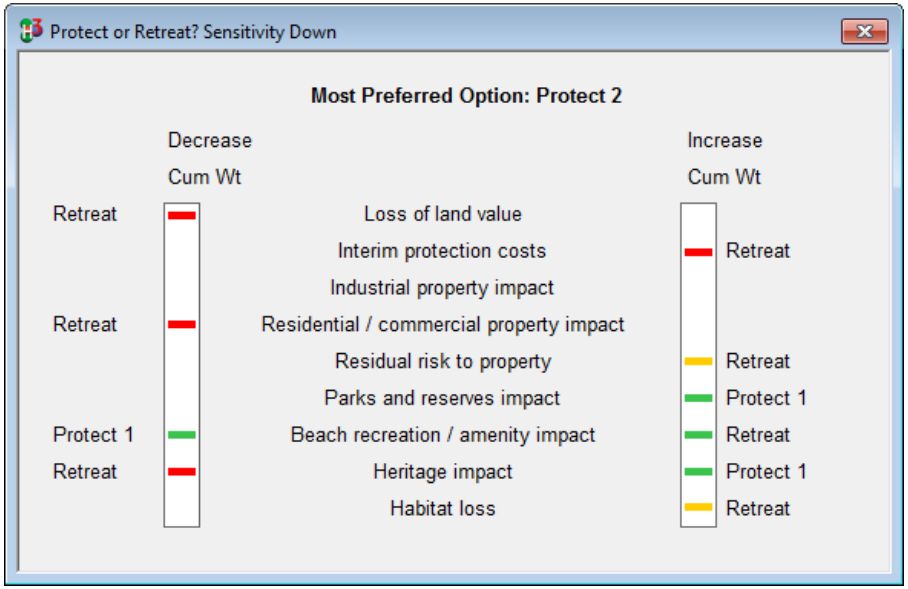
Later stage (2070)

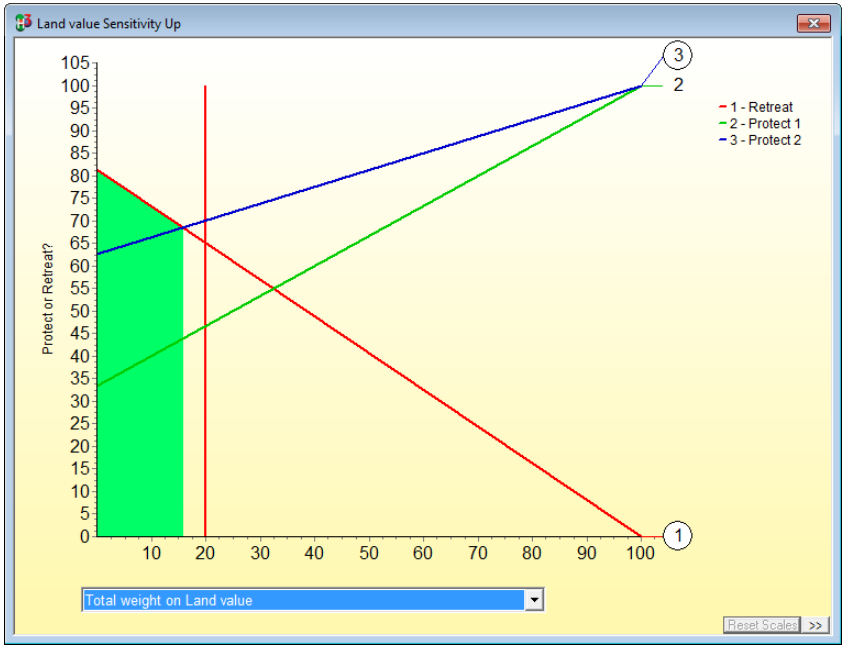
- Add the third groyne on the northern side

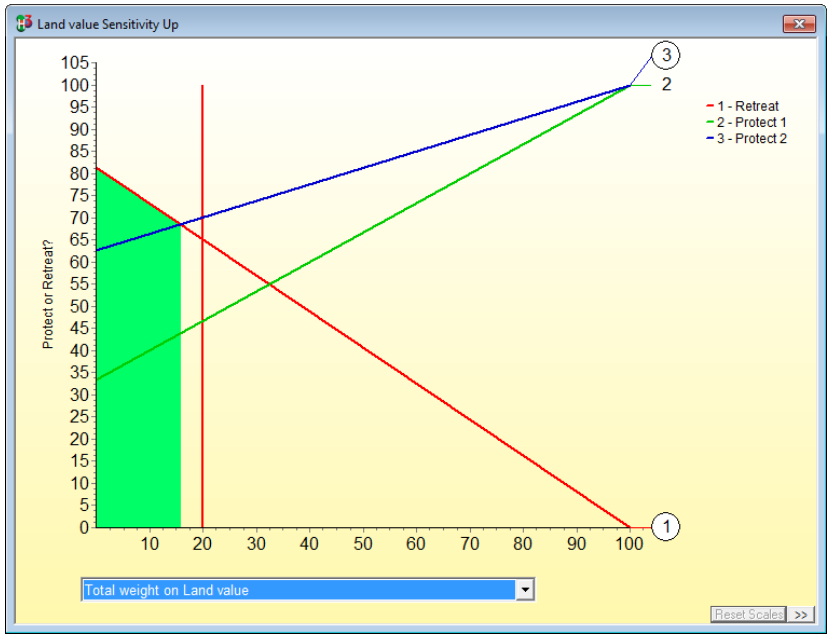
		Raw data						Normalised score				Weight	
		Retreat	Protect 1	Protect 2	Protect 3			Retreat	Protect 1	Protect 2	Protect 3	Nominal	Adjusted
Loss of land value	Discounted cost ($m)	18	4	4		172%	R/A	0	100	100		0.11	0.20
Interim protection costs	Discounted cost ($m)	0	11	27		212%	R/A	100	58	0		0.11	0.20
Industrial property impact	No. potential lots affected	0				0%	Ttl lots	0	0	0		0.19	0.00
Residential & commercial property impact	No. potential lots affected	83				3%	Ttl lots	0	100	100		0.11	0.10
Residual risk to property	Scale of 1-5	1	3	2				100	0	50		0.07	0.05
Parks and reserves impact	Area (ha)	19.39				4.32%	Ttl area	0	100	100		0.11	0.00
Beach recreation / amenity impact	m of beach	1150				5%	Ttl beach	100	0	100		0.15	0.25
Heritage impact	No. of heritage properties affected	1				2%	Ttl props	0	100	100		0.04	0.05
Habitat loss	Area (ha)	13.2				7%	Ttl area	100	0	50		0.11	0.15
								400	458	600		1.00	1.00
					Weighted score			65	47	70			
					Rank			2	3	1			

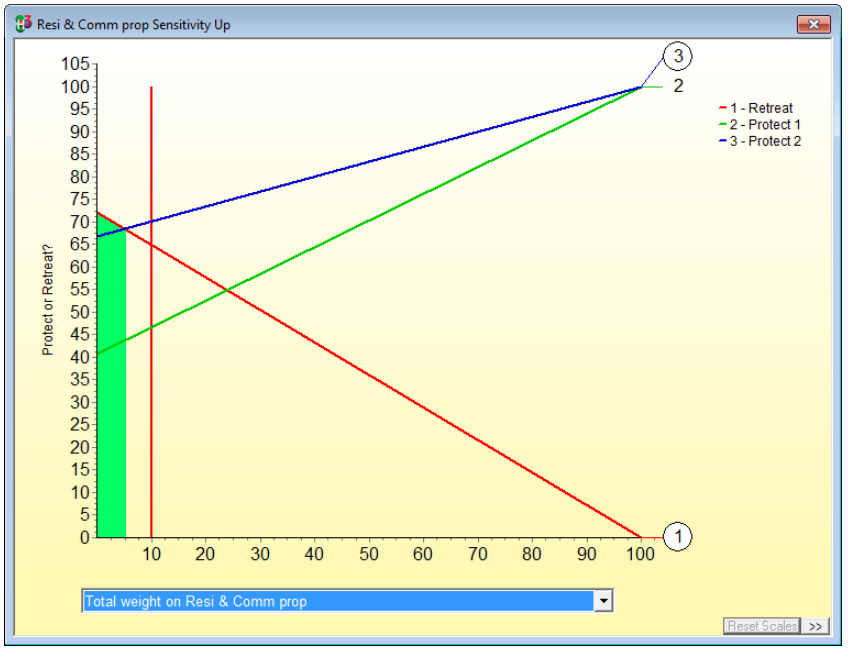
Notes:

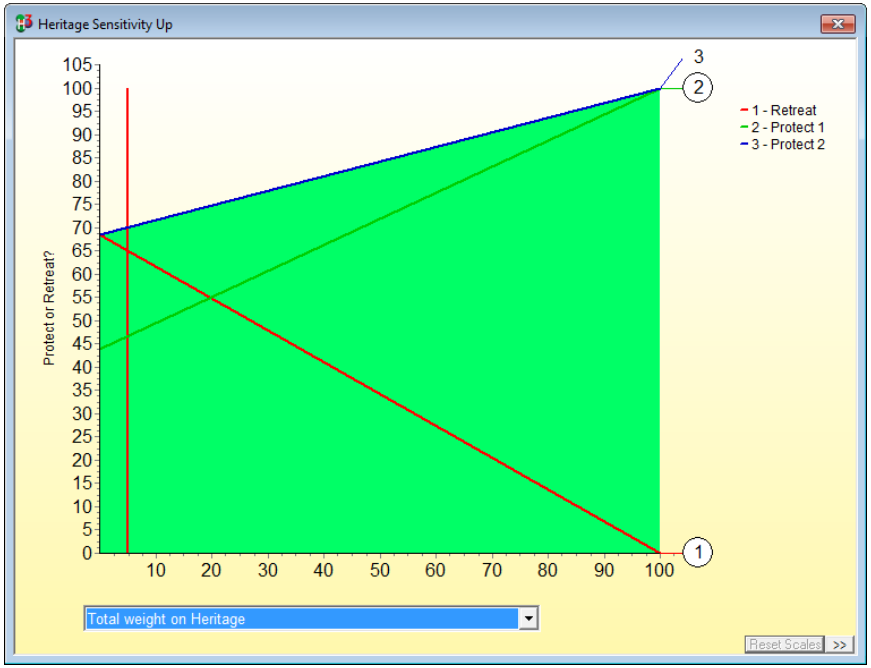
1. Weighting for Parks and reserves assumes that the equivalent area cannot be retained in the Retreat option.

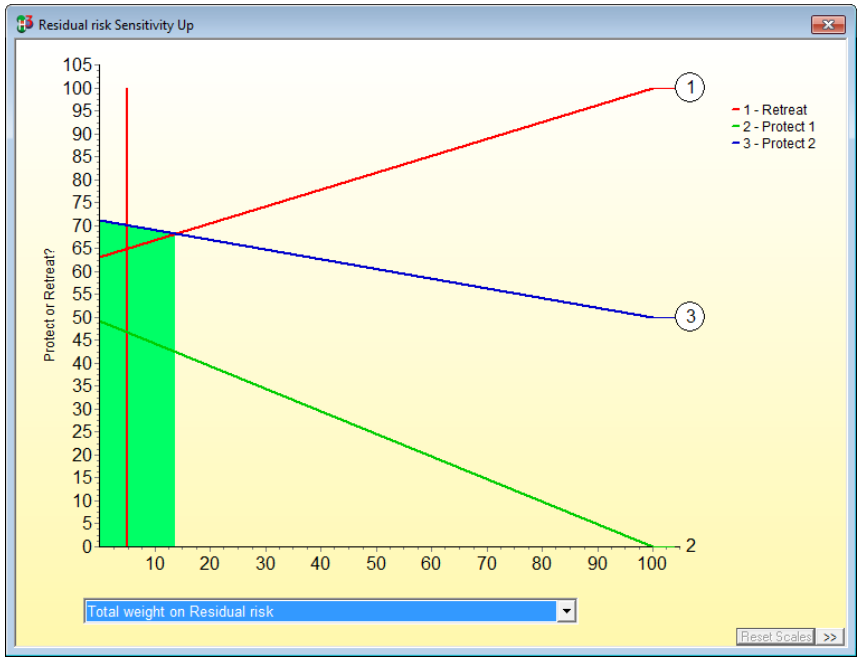


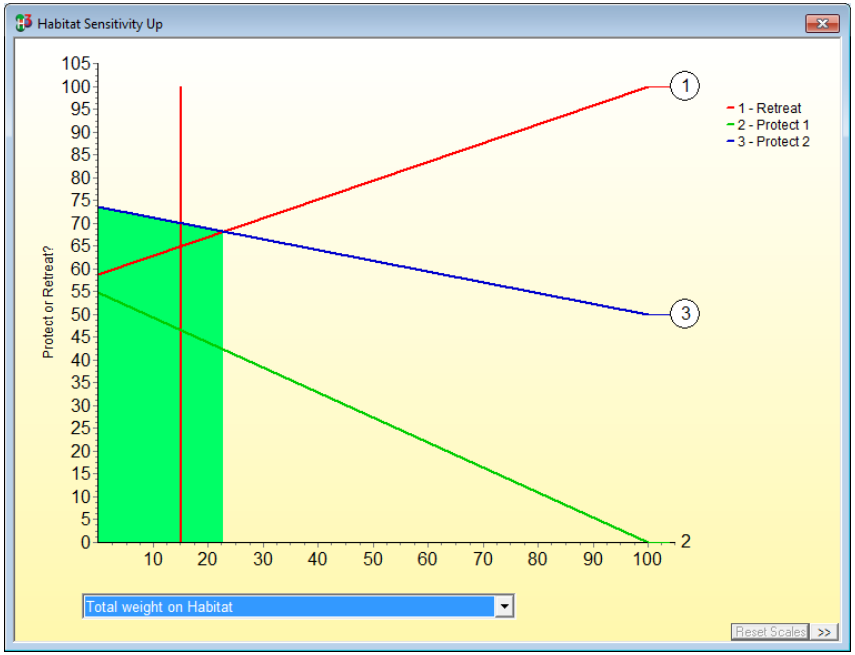












Appendix C – Provisional Adaptation Measure Maps

LEGEND

- Indicative Management Unit Boundary
- **Protection Works**
- Dune Stabilisation
- Breakwater or Groyne (5m high)
- Offshore Breakwater
- Revetment or Seawall (6m High)
- 1.5m Levee - 15m Wide with Road on Top
- Investigate Groyne Modifications
- Beach Nourishment
- Dune Stabilisation
- Raise Ground Levels, Reclaim Land and Upgrade Wharf Structures
- Local Government Area Boundary
- Retreat

Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number 61-32106
Revision 1
Date 05 Feb 2016

Management Unit 3

Provisional Adaptation Measures

Figure 1

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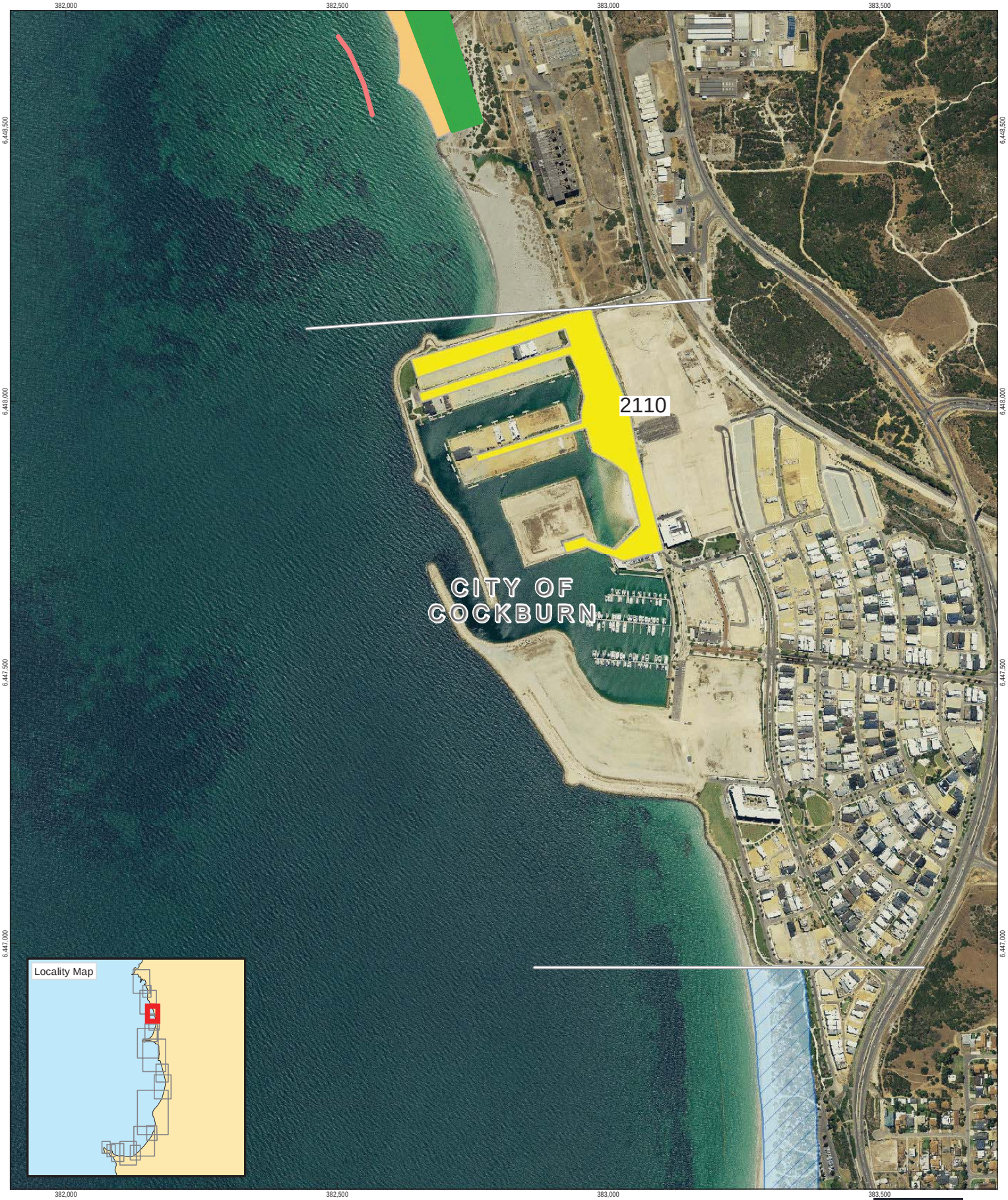
Data source: Landgate: Imagery (Metro Central Feb 2015); GHD: Indicative Management Unit Boundaries - 20160204, Protection Works - 20151027; ABS: Local government area boundary - 20150416. Created by: mczekaj

999 Hay Street Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



LEGEND

- Indicative Management Unit Boundary
- **Protection Works**
  - Dune Stabilisation
  - Breakwater or Groyne (5m high)
  - Offshore Breakwater
  - Revetment or Seawall (6m High)
  - 1.5m Levee - 15m Wide with Road on Top
  - Investigate Groyne Modifications
  - Beach Nourishment
  - Dune Stabilisation
  - Raise Ground Levels, Reclaim Land and Upgrade Wharf Structures
- Local Government Area Boundary
- Retreat

Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

0 30 60 120 180 240 300
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number 61-32106
Revision 1
Date 15 Feb 2016

Management Unit 4

Provisional Adaptation Measures

Figure 1

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999 Hay Street Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

LEGEND

- Indicative Management Unit Boundary
- **Protection Works**
  - Dune Stabilisation
  - Breakwater or Groyne (5m high)
  - Offshore Breakwater
  - Revetment or Seawall (6m High)
  - 1.5m Levee - 15m Wide with Road on Top
  - Investigate Groyne Modifications
  - Beach Nourishment
  - Dune Stabilisation
  - Raise Ground Levels, Reclaim Land and Upgrade Wharf Structures
- Local Government Area Boundary
- Retreat

Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

0 30 60 120 180 240 300
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number 61-32106
Revision 1
Date 15 Feb 2016

Management Unit 5

Provisional Adaptation Measures

Figure 1

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Data source: Landgate: Imagery (Metro Central Feb 2015); GHD: Indicative Management Unit Boundaries - 20160204, Protection Works - 20151027; ABS: Local government area boundary - 20150416. Created by: mczekaj

999 Hay Street Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

LEGEND

- Indicative Management Unit Boundary

Protection Works

- Dune Stabilisation
- Breakwater or Groyne (5m high)
- Offshore Breakwater
- Revetment or Seawall (6m High)
- 1.5m Levee - 15m Wide with Road on Top
- Investigate Groyne Modifications
- Beach Nourishment
- Dune Stabilisation
- Raise Ground Levels, Reclaim Land and Upgrade Wharf Structures
- Local Government Area Boundary
- Retreat

Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number 61-32106
Revision 1
Date 15 Feb 2016

Provisional Adaptation Measures

Management Unit 6
Figure 1

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LEGEND

- Indicative Management Unit Boundary

Protection Works

- Dune Stabilisation
- Breakwater or Groyne (5m high)
- Offshore Breakwater
- Revetment or Seawall (6m High)
- 1.5m Levee - 15m Wide with Road on Top
- Investigate Groyne Modifications
- Beach Nourishment
- Dune Stabilisation
- Raise Ground Levels, Reclaim Land and Upgrade Wharf Structures
- Local Government Area Boundary
- Retreat

Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number	61-32106
Revision	1
Date	05 Feb 2016

Management Unit 7

Provisional Adaptation Measures

Figure 1

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Data source: Landgate Imagery (Metro Central Feb 2015); GHD: Indicative Management Unit Boundaries - 20160204, Protection Works - 20151027; ABS: Local government area boundary - 20150416. Created by: mczekaj

LEGEND

- Indicative Management Unit Boundary
- **Protection Works**
- Dune Stabilisation
- Breakwater or Groyne (5m high)
- Offshore Breakwater
- Revetment or Seawall (6m High)
- 1.5m Levee - 15m Wide with Road on Top
- Investigate Groyne Modifications
- Beach Nourishment
- Dune Stabilisation
- Raise Ground Levels, Reclaim Land and Upgrade Wharf Structures
- Local Government Area Boundary
- Retreat

Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

0 65 130 260 390 520 650

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

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Provisional Adaptation Measures

Management Unit 8
Figure 1

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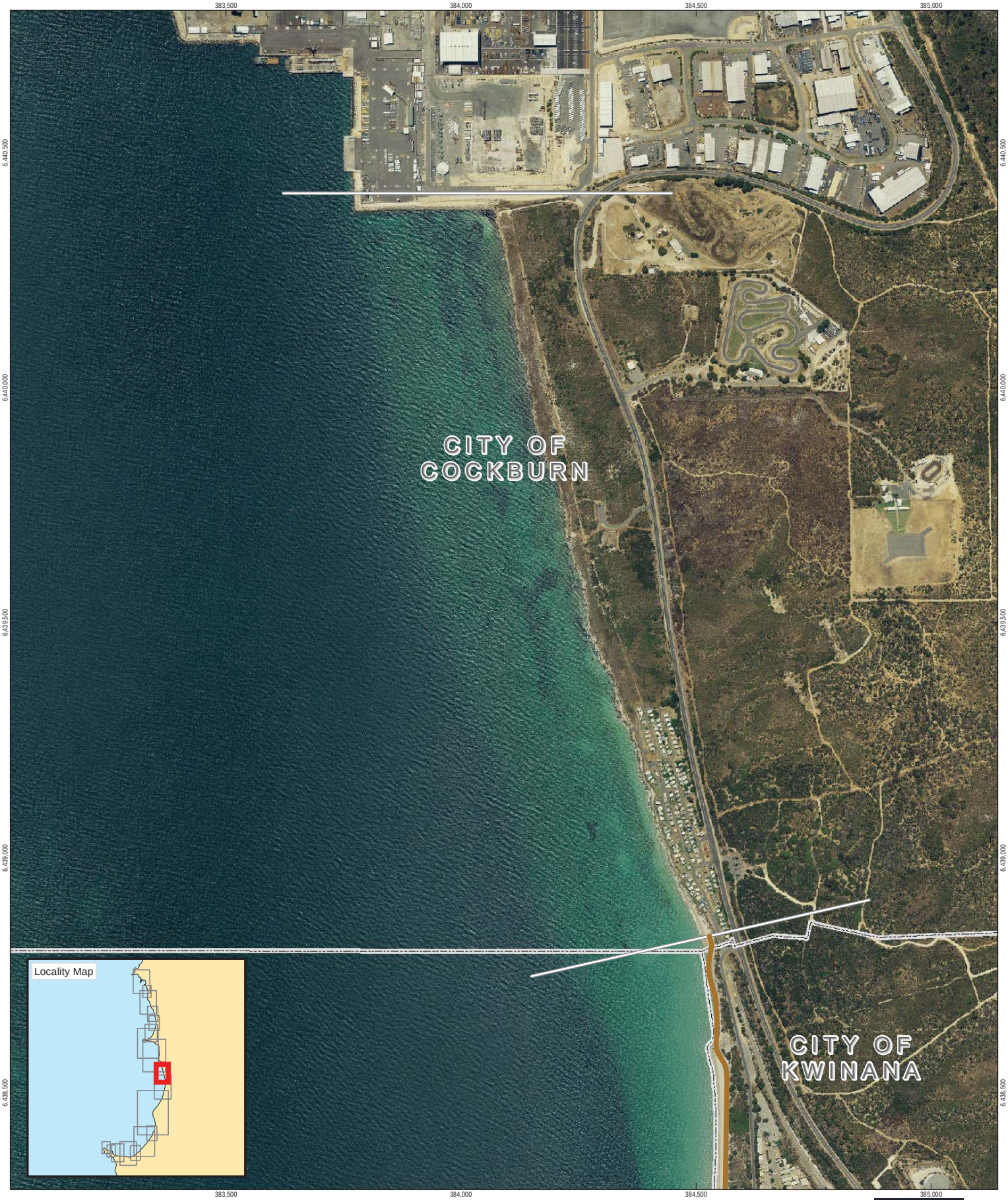

LEGEND

- Indicative Management Unit Boundary

Protection Works

- Dune Stabilisation
- Breakwater or Groyne (5m high)
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Breakwater or Groyne (5m high)
Offshore Breakwater
Revetment or Seawall (6m High)
1.5m Levee - 15m Wide with Road on Top

Cross Section

Paper Size A3

0 35 70 140 210 280 350

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number 61-32106
Revision 1
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Provisional Adaptation Measures

Management Unit 9
Figure 1

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Appendix D – Comparison of interim protection options for Coastal Management Unit 3 – North Coogee

Context

The coastline was modified with groynes, seawalls and breakwaters during the mid-1940s to the mid-1960s and more recently in 2006 with the Coogee Marina construction, which have altered the natural coastal processes. The beaches in this area are fed by the Success Bank offshore of Catherine Point, which leads to long-term accretion due to sediment being trapped by these various coastal structures. In more recent years, erosion has occurred north and south of Catherine Point Groyne due to a movement in the crest of the Success Bank and a reduction in the rate of sand feed (MPR, 2014). Erosion north of the groyne appears to have stabilised while south of the groyne continues to be eroded which resulted in a coastal path needing relocation in 2013.

Setback studies undertaken by MP Rogers in 2014, predicted that immediately south of the groyne may continue to erode 10 to 20 metres over the next two decades while further south may also experience some erosion before the coastline returns to dynamic stability. However, the coastline will continue to be at risk of erosion due to future sea level rise and erosion from severe storm events as indicated in the hazard mapping undertaken in Stage 1 and 2.

Comparison

A comparison of each criterion for each option listed in is detailed in the following sections.

Criterion: Performance

Based on the sediment transport regime in CMU 3, it is believed that both options could be effective at altering longshore currents and sediment transport and, as a result reduce longshore erosion and increase the beach width. The following points provide a comparison between the options:

- It is likely that due to the offshore location of the sand feed, groynes are likely to offer the best capture of sand without interfering with transport to shore from the sand feed.

- While accretion is expected up drift of the proposed first two groynes, erosion would be expected on the down-drift. This erosion is likely to be offset by the presence of a larger buffer to south due to long-term accretion to the southern end of CMU 3. Although offshore breakwaters may offer erosion protection in its immediate shadow area, there is the potential for erosion either side of the structure due to the interruption to longshore drift. Therefore placement of the breakwaters and selection of distance, spacing and length of the structures should ensure that they do not aggravate the existing erosion issue while not restricting the onshore sand feed. Achieving both objectives may prove difficult.

- Offshore breakwaters do have the capability to reduce wave energy transmission which groynes do not. Therefore the beach response behind the offshore breakwaters is likely to be less than for open coasts or where groynes are placed. The direction of littoral drift is also less critical for offshore breakwaters than groynes as sand does not have to saturate an up-drift side before it can bypass the structure. Although the sand feed from

Success Bank directs sand north and south from Catherine point, during seasonal conditions it is expected that there will be bi-directional drift.

– With offshore breakwaters, an uninterrupted access to the beach is provided, while groynes would compartmentalise the foreshore.

– In the long-term, the performance of all structures will be susceptible to sea level rise and will need to be designed accordingly.

Further morphological modelling is recommended to confirm the performance of these structures. Based on this preliminary assessment, GHD would rank both arrangements equally.

Criterion: Costs

The capital costs, annual operating, and decommissioning costs for each option would ultimately depend on the final design developed for construction. Cost estimates should be developed during a concept design stage with an understanding of available funding to ensure feasibility. All options propose the inclusion of beach nourishment, dune redevelopment and groyne modification investigations which will have relatively consistent requirements across all options so the defining cost differentiator between options will be the capital, maintenance and adaptation costs of the interim protection structures.

The cost of design development and modelling of the effectiveness of groynes and breakwaters is considered comparable, as is the development of detailed design documentation. Construction requirements do vary between the two options, as the construction of groynes can be undertaken from land with standard equipment while offshore breakwaters, depending on depth, can be built through use of a temporary causeway or by sea, which can add significant time and difficulty to the works.

Western Australian groynes and breakwaters are typically constructed with a rock armour outer layer with a core of smaller rock materials, and this is the assumption of this assessment. Although suitable rock sources can be found locally throughout most of the state, the availability of materials will become scarcer in the future. Some alternative construction materials for these structures are precast concrete units and geotextile sand filled containers, which should be considered during design development. The volume of materials required is likely to be higher for offshore breakwaters due to the deeper water.

The availability of suitable sand nourishment sources from a financially viable source is a key consideration for ongoing maintenance requirements in the Cockburn Sound. CMU 3 does receive a natural sand feed from Success Bank but all options are likely to require ongoing sand nourishment in response to extreme events, with the more effective structures requiring less in the long-term.

The preliminary high level costs are presented in Table 11 which indicates lower capital and life cycle costs for the groyne option.

Table 11 Preliminary Capital Cost Estimates

	Option 3a			Option 3b		
Timing	Capital ($k)	Annual ($k)	Decom ($k)	Capital ($k)	Annual ($k)	Decom ($k)
Present	$ 5,772,000	$ 101,400		$ 4,472,000	$ 94,900	
2070	$ 9,360,000	$ 288,600		$ 4,940,000	$ 165,100	
2110			$ 7,800,000			$ 3,760,000

Limitations

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Our services are based on GHD undertaking these services in accordance with the following industry standards, codes and guidelines:

– Bicknell C 2010, Sea Level Change in Western Australia: Application to Coastal Planning, prepared by the Department of Transport,

– WAPC 2013, State Coastal Planning Policy Guideline, prepared by the Western Australian Planning Commission, Perth, WA.

These standards, codes and guidelines take into account potential sea level rise impacts only to the extent indicated by these policies and guidelines.

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