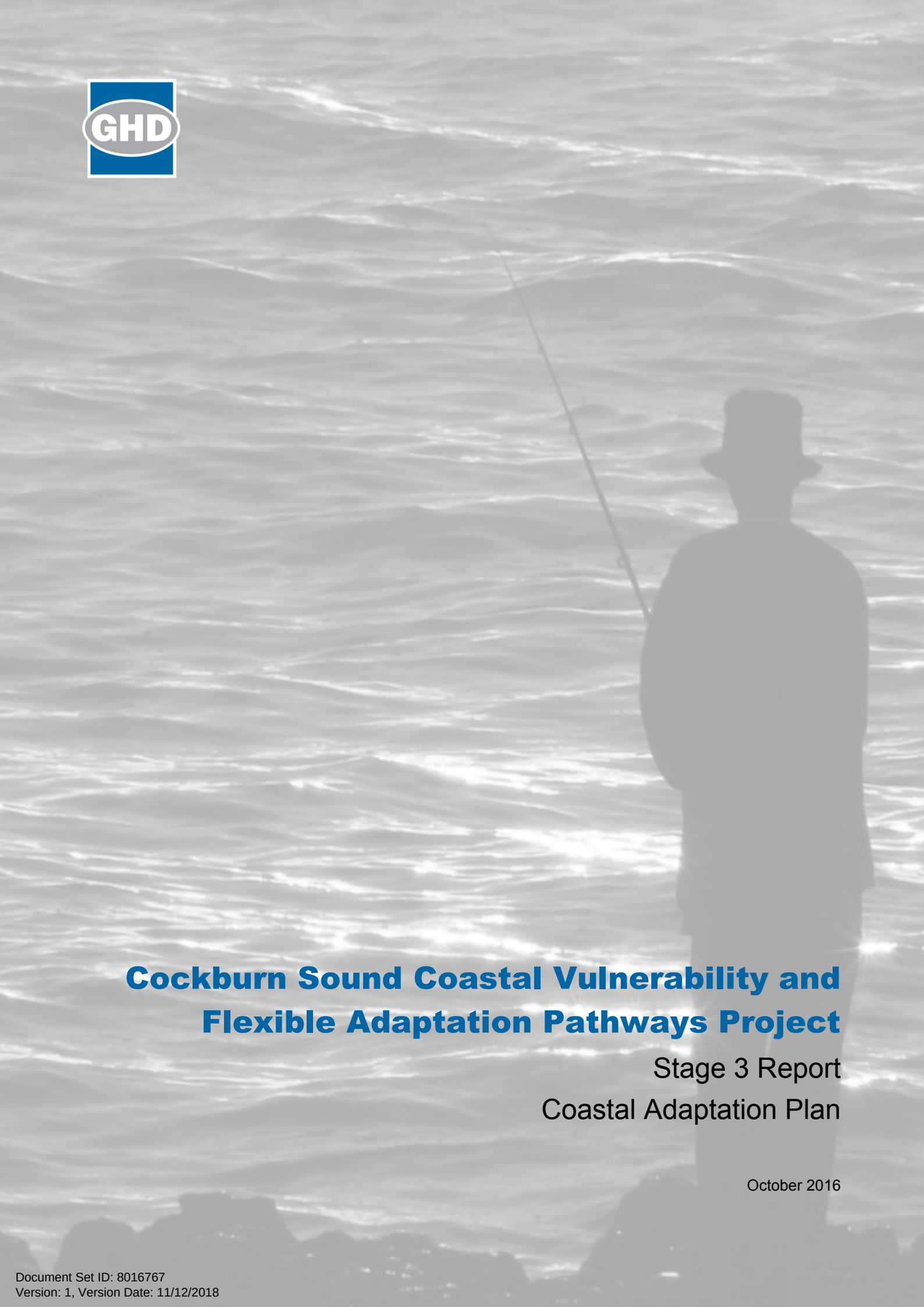

Cockburn Sound Coastal Vulnerability and Flexible Adaptation Pathways Project

Stage 3 Report

Coastal Adaptation Plan

October 2016

Executive summary

The City of Cockburn, on behalf of the Cockburn Sound Coastal Alliance (the Alliance), engaged GHD to prepare the Cockburn Sound Coastal Adaptation Plan. The Cockburn Sound Coastal Alliance is comprised of the City of Fremantle, City of Cockburn, City of Kwinana, City of Rockingham, and Perth Region Natural Resource Management (NRM). The Alliance was established to investigate and plan for coastal hazards along Cockburn Sound and Owen Anchorage.

The Alliance is delivering the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project. The project is being delivered in 4 key stages:

- Stage 1 – Coastal Vulnerability Assessment (completed in February 2013)
- Stage 2 – Values and Risk Assessment (completed in November 2014)
- Stage 3 – Coastal Adaptation Plan (current project stage)
- Stage 4 – Implementation and Monitoring

Stage 3 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. Sections of the Cockburn Sound and Owen Anchorage coastline are particularly exposed and vulnerable to the impacts of sea level rise, storm surge and changes in sediment regimes associated with a changing climate.

Flexible Adaptation Pathway

Informed by community and stakeholder engagement, a series of adaptation principles were developed that provided the benchmark for considering adaptation pathways.

- 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 Cockburn Sound 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.

The proposed flexible adaptation pathway combines decision making 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 retreat) for subsequent triggers over time. With the flexible pathway, the adaptation plans do not bind future communities to the long-term cost of adaptation decisions beyond the design life of the infrastructure or asset that arises from that decision.

The flexible adaptation pathway includes triggers that relate to tolerable and intolerable levels of risk and are directly informed by scenarios of State Planning Policy 2.6 State Coastal Planning Policy. The triggers and the decisions to be made at each trigger are shown in the following table.

Triggers and decisions

Trigger	Decision	Implication/action
Trigger 1: Land at rare risk of inundation or erosion	Risk is tolerable - avoid and monitor	Avoid through strategic planning measures Ongoing monitoring
Trigger 2: Land subject to 100 year ARI acute erosion event and 500 year ARI inundation event	Increasing likelihood of intolerable risk - accommodate and monitor	Accommodate through asset specific activities Ongoing monitoring
Trigger 3: Land subject to 50 year ARI acute erosion event and 100 year ARI inundation event	Intolerable risk – interim protection may viable - retreat or protect	Evaluate whether interim protection is justifiable on social, environmental, and economic grounds. Where interim protection is justifiable, determine the nature of the works based on social, environmental and economic grounds.
Trigger 4: Land subject to 50 year ARI acute erosion or inundation event	Intolerable risk - protection is not viable - retreat	Actively plan for retreat in a coordinated manner. This should be led by state government, as the tier of government with the jurisdiction to change land use.

Analysis of the decisions at each trigger point identified a key limitation in the ability of local governments to effectively undertake coastal adaption planning. Whilst local government is, for the most part, the manager of public land along the coast, they have very little authority to make adaptation decisions that would have implications beyond the coastal reserve. The Western Australian Planning Commission is responsible for much of the relevant planning and decision making on coastal land. Across the Cockburn Sound and Owen Anchorage, much of the strategic infrastructure is state managed (such as the freight rail line), or of state significance (such as the Kwinana Strategic Industrial Area). Because decisions to retreat require land use change and relocation of state significant infrastructure, it is likely that the jurisdiction to make such decisions lies with the state government.

The proposed model for retreat requires the state government to approach the expansion of the coastal foreshore in a manner consistent with the planning and provision of other infrastructure.

Planning Adaptation Measures

State Planning Policy 2.6

A review of State Planning Policy 2.6 is required to provide greater policy guidance for coastal dependent development (listed variations), where the policy supports their location in areas of risk. Additional policy guidance is required to manage the longer term potential costs of protection or decommissioning of these developments following the design life.

Metropolitan Region Scheme

To facilitate avoid and retreat measures the Metropolitan Region Scheme will need to be amended to expand appropriate reservations for parks and recreation (coastal foreshore), public purposes (as required by servicing agencies), and road and rail reservations (as required by transport agencies). Land acquisition and/or compensation may be required as a result of amendments to the Metropolitan Region Scheme.

Regional plans and strategies can identify infrastructure of regional and state significance and plan for new locations outside areas of coastal risk. Key infrastructure along the coast of Cockburn Sound that will require consideration includes:

- Freight rail linking the Fremantle Port with Kwinana Industrial Area and the Kewdale/Forrestfield Marshalling Yards (managed by Public Transport Authority and Brookfield Rail in some parts)
- Water Corporation desalination plant
- Woodman Point and Point Peron wastewater treatment plants and ocean outfalls

Future infrastructure, including the Fremantle Port Outer Harbour and the potential Mangles Bay Marina are also key infrastructure which will need to be considered in regional plans.

Local planning strategies and schemes:

Local planning strategies can clearly identify at what point the scheme will need to incorporate controls on development or redevelopment in vulnerable areas and/or recommend at what stage the Western Australian Planning Commission should progress an amendment to the Metropolitan Region Scheme to expand the Parks and Recreation Reserve along the coastal foreshore.

Local planning schemes, informed by the strategy, can incorporate a special control area to advise land owners and planners that an area is in a vulnerable coastal area for the long-term (100 year) planning horizon. The extent of development controls included can reflect whether or not intolerable risk will be experienced in the immediate (15 year) planning horizon. Over time, as risk increases, more stringent development controls can be included into the special control area in the scheme, moving from a communication tool to a development control mechanism.

Foreshore Management Plans

In addition to influencing development control within foreshore reserves, foreshore management plans can be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities; 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. To be effective, foreshore management plans need to go beyond providing a list of facilities and short term management priorities, they should become an implementation framework for preferred adaptation options.

Coastal protection measures

To inform anticipated decisions in the study area, interim protection measures were identified and assessed using multi-criteria decision analysis. This compared a retreat decision with coastal protection approaches, including hard-passive and hard-active approaches. Hard – passive protection works 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. Examples include groynes and offshore breakwaters. Hard – active works 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). Examples include seawalls and levees.

Across the study area, results tended to highly rank the hard - passive engineering approaches. This occurred because these options provide protection to the landward assets as well as beach retention for the life of the measures. However, results need to be considered carefully by decision makers in the light of other considerations such as materials availability and environmental impact.

Based on the analysis, concept plans were developed for interim coastal protection of those parts of the coastline at risk in the current 15 year planning horizon, and a provisional plan developed for protection works thereafter.

Specific recommendations

The adaptation plans prepared in Stage 3 include the following specific recommendations:

1. The establishment of special control areas (SCA) for land identified as at risk in the period to 2110 (noting that the landward extent will increase over time), which establishes a long-term intention to retreat from this area, where applicable, and provides for special planning instruments.
2. A firm concept plan for interim coastal protection of those parts of the coastline at risk in the current 15 year planning horizon, and a provisional plan for protection works thereafter.
3. Engagement with infrastructure providers to develop long-term plans to retreat from the SCA in the lead up to triggers that require such action, and servicing plans for the interim period.
4. Engagement with the owners of other assets in the SCA (including private landowners) to develop long-term plans to retreat from the SCA in the lead up to triggers that require such action, and any plans for interim protection in the interim period.
5. The updating of hazard mapping as new IPCC assessment reports are released, and implementation of the monitoring recommendations in the Stage 1 report.
6. Ongoing monitoring of shoreline change and risk levels to provide information about imminent triggers.

The success of this approach will be dependent on state and local government implementing necessary strategic planning measures to implement the flexible, trigger based adaptation pathway at all levels. It cannot be achieved by the actions of local governments alone.

A key outcome of Stage 3 is that – at the time of Trigger 3 - interim protection appears justifiable to continue many current land uses along the Cockburn Sound Owen Anchorage coast. However, there are limitations in the extent of the coast that is viable for protection, and it is likely that these values leading to a protection decision will change over time as the cost grows. It is important that state government, supported by local government, undertakes longer term strategic planning to prepare for retreat decisions for when interim protection is no longer justifiable or feasible based on social, environmental, and economic values.

Each of the separate local government adaptation plans provide a series of recommended strategic and capital adaptation options to be considered by decision makers. Alongside this, the project evaluation makes the following recommendations for future adaptation planning in the study area and in Western Australia:

- There is a need for state government to lead coastal adaptation planning in the Perth Metropolitan Region, in particular to consider long-term impacts and retreat strategies in regional planning and schemes so that local governments can update their local planning strategies and schemes in response.
- Adaptation pathways should reflect the cyclical nature of adaptation planning, and maintain the most flexible adaptation options in subsequent adaptation decisions.
- Adaptation pathways should provide opportunity for decisions to be made based on values of the time, rather than pre-empting long-term decision making.
- In developing policy around interim protection, state government should consider supply of basic raw materials, for example sand for beach nourishment, at a regional scale as this will influence feasibility of protection options.

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Appendices

Appendix A – Stakeholder and Community Engagement Outcomes Report

Appendix B – Options Compendium

Appendix C – Coastal Adaptation Plans

Appendix D – Coastal Management Unit Preliminary Assessment Summary

1. Introduction

1.1 Project background

The City of Cockburn, on behalf of the Cockburn Sound Coastal Alliance (the Alliance), engaged GHD to prepare the Cockburn Sound Coastal Adaptation Plan. The project forms part of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project, which includes:

- 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

The objectives of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project are to:

- improve the understanding of the coastal features, processes and hazards of the study area (coastal landforms, geological features, sediment supplies, sediment distribution and met-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
- facilitate the understanding of climate science, coastal hazards and risk management amongst key stakeholders (including community)
- identify what assets are situated along the coast and what services and functions those assets provide
- identify the social, economic and ecosystem services '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
- in consultation with the key stakeholder groups and community verify the intrinsic current and anticipated economic, socio-economic, community and ecologic values of assets (both physical and environmental) 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
- identify critical data gaps

Stage 3 (the project) supports a number of the above objectives, and 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. Sections of the Cockburn Sound and Owen Anchorage coastline are particularly exposed and vulnerable to the impacts of sea level rise, storm surge and changes in sediment regimes associated with a changing climate.

1.2 Purpose of this report

This report provides a technical presentation of project outcomes and learnings, and provides analysis of the critical thinking behind coastal adaptation plans prepared for the Cities of Fremantle, Cockburn, Rockingham and Kwinana.

Details of specific measures and recommendations are provided in each of the separate Coastal Adaptation Plans prepared for each Local Government member of the Cockburn Sound Coastal Alliance.

1.3 Report structure

This report has been structured to present the methodology, learnings, and recommendations of the key elements that underpin the coastal adaptation planning process, including:

- stakeholder engagement
- adaptation pathways
- planning measures
- coastal adaptation measures

The specific project methodologies and learnings are discussed within chapter for each of these key project elements.

A consolidated list of learnings and conclusions is provided in the final chapter.

1.4 Scope and limitations

This report has been prepared by GHD for the Cockburn Sound Coastal Alliance and may only be used and relied on by the Cockburn Sound Coastal Alliance for the purpose agreed between GHD and the Cockburn Sound Coastal Alliance as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than the Cockburn Sound Coastal Alliance arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer various sections of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by the Cockburn Sound Coastal Alliance and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report.

GHD has prepared the preliminary cost estimates set out in section 6 of this report ("Cost Estimates") using information reasonably available to the GHD employee(s) who prepared this report and based on assumptions and judgments made by GHD. The Cost Estimates have been prepared for the purpose of comparing coastal adaptation options and must not be used for any other purpose. The Cost Estimates are a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimates and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimates. Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

2. Overview of Project Methodology

2.1.1 Project Objectives

The objectives of Stage 3 of the project were to:

- Develop an effective coastal adaptation plan (or plans) to be implemented by the relevant local governments and stakeholders. The adaptation plan(s) will be at the site specific scale for each local government areas. They will include sufficient detail for coastal managers (for e.g. local governments) and local communities (e.g. Coastcare groups) to endorse and implement. The plan(s) may identify where more detailed localised investigation and design treatment is required (e.g. geomorphological and/or detailed coastal engineering) in the process of selecting and refining the retreat, adapt or protect actions proposed for any particular site;
- Effectively engage with key community groups and stakeholders to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone and potential adaptation options; and
- Build capacity in the community, local governments, natural resource management groups, Coastcare groups, industry and other stakeholders by facilitating the understanding of climate science, coastal processes, hazards and risks through the development and dissemination of the adaptation plan(s).

2.1.2 Project Steps

Stage 3 of the project was delivered across six key steps; a number of these were delivered concurrently, and many offered the same enduring themes and outcomes that underpinned the project outcomes.

Step 1 project plan and stakeholder and community engagement strategy

This step involved the preparation of a project plan and stakeholder and community engagement strategy to inform delivery of the project.

In this step, a stakeholder alignment workshop was held, which identified key performance indicators for the project deliverables. These include:

1. The adaptation plan is written so that it clearly confirms the role of Local Governments, State Government and other parties in the identified adaptation responsibilities.
2. The adaptation plan includes actions for Local Government assets and recommended direction for all others. Where actions are identified for Local Government, the adaptation plan will include sufficient detail to define the objective of the action, the expected timing of the action and the delivery process.
3. The adaptation plan and supporting communication channels provide clear, direct and consistent messages which enable informed investment decisions and community confidence.
4. The adaptation plan is developed through a robust and quantifiable assessment methodology which is transparent and provides clear rationale for decision-making. The methodology can be applied at relevant review periods for this project area or can be applied by others seeking to develop adaptation plans.
5. The project has resulted in increased awareness and knowledge of local coastal risks and challenges in adaptation by the community and key stakeholders.

A report on the activities and outcomes of stakeholder and community engagement (including the stakeholder and community engagement strategy) is provided in Appendix A.

Step 2 localised adaptation action option identification

This step involved an initial consideration of adaptation pathways for the study area and determination of the appropriate engineering and planning responses that might be applicable to the Cockburn Sound Owen Anchorage coast. Early stakeholder engagement outcomes, policy analysis, and determination of anticipated trigger points formed the basis for developing appropriate adaptation pathways for the study area. A listing of adaptation options that relate to the developed pathway was then identified. These options were summarised in the Options Compendium, which is provided in Appendix B.

Step 3 liaison with local government officers, external stakeholder representatives and the community to test values and options

The intent of this step was to engage with stakeholders and the community to test the values attributed to coastal assets in Stage 2 of the Cockburn Sound Coastal Vulnerability and Flexible Adaptation Pathways Project, and to consult on adaptation options being contemplated – as set out in the Compendium.

Whilst Stages 1 and 2 reports had been prepared, they had not been released to the community or stakeholders until commencement of Stage 3.

To continue the engagement from Stage 2, this step involved a series of one-on-one meetings with local government representatives, industry and infrastructure stakeholders, and community information sessions and focus groups. Engagement was targeted to community members and asset managers affected by future coastal risks. Early consultation, such as with local government representatives, identified there was very limited knowledge in the community and amongst many stakeholders of the previous project stages, consistent with the intent of Stage 3 being to commence the broader engagement process. The ability of Stage 3 to meaningfully consult with community and stakeholders on values and options was limited given a lack of community interest and awareness of the issue more broadly (not only in relation to the specific outputs of Stages 1 and 2) and in consideration of the project timeframe available to promote awareness raising in the community. The intent of the engagement strategy shifted to informing community and stakeholders of the previous project stages, and gain inputs where possible into the weighted importance of coastal values to inform the adaptation plans.

Step 4 coastal adaptation plan development

This step involved the review of the first-pass adaptation options and pathways from Stage 2 and determination of recommended adaptation measures for coastal management units along the Cockburn Sound Owen Anchorage coast. The determination of coastal adaptation measures included the investigation of the most appropriate adaptation pathway for the study area, and consideration of planning measures that would be required to deliver that pathway. In line with the pathway, coastal adaptation measures were identified and prioritised through a Multi-Criteria Decision Analysis (MCDA) process.

Consideration of adaptation options resulted in recommended adaptation approaches and measures for the trigger points anticipated to be experienced in each coastal management unit in the study area. The following triggers and decisions were analysed for the immediate and long-term planning horizons (these triggers are discussed further in section 1.1:

- 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

This was undertaken in a two-step evaluation process, dependant on the trigger point reached. Firstly, on the basis of learnings from previous project stages – in particular the outcomes of stakeholder engagement – the determination of adaptation measures was undertaken within the context of a long-term, trigger based decision making framework, rather than direct comparison of all possible detailed adaptation measures. Where the first strategic assessment recommended interim protection options to manage short-term risks (i.e. trigger point 3 requires immediate interim protection), a second assessment was undertaken to explore and make more detailed recommendations about appropriate short-term adaptation measures, to manage specific locations within management units experiencing immediate intolerable risk. For those locations where retreat or interim protection was not required in the short-term (i.e. trigger point 3 not reached), a number of short-term management and accommodation measures were identified. Depending on the recommended adaptation measure, a range of planning and/or physical adaptation measures were recommended.

Step 4 then generated recommended coastal adaptation plans for each of the local government areas (included in Appendix C).

Step 5 stakeholder and community engagement on draft adaptation plans

On the basis of the need for more enduring community and stakeholder engagement on coastal adaptation planning on the Cockburn Sound Owen Anchorage coast, rather than including an interim engagement step on draft adaptation plans, the project shifted engagement to the end. In this way, the adaptation plans – which operate as a blueprint for integrating adaptation planning into capital and strategic planning processes rather than making the decision now – become the catalyst for engagement on decision making over time. This step included provision of elected member briefings to each Alliance Council.

Step 6 final report and evaluation

The final step in the project is an evaluation of the project. This report provides the evaluation of the project and recommendations for future work.

3. Stakeholder engagement

3.1 Engagement Strategy

Stakeholder engagement was delivered in line with a stakeholder engagement strategy for the project. The objectives of the strategy were to:

- consult with government agencies to ensure relevant issues are captured in the adaptation plans
- ensure all interested stakeholders have the opportunity to participate in the adaptation planning project phase
- effectively engage with key community groups and stakeholders to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone and potential adaptation options
- inform the community and other stakeholders on opportunities to participate in the delivery of an effective adaptation plans
- encourage informed comment on the adaptation plans
- progress engagement about impacts, issues and benefits
- assist the project team in developing appropriate risk management measures in response to key issues raised as part of the engagement process

A report on the activities and outcomes of stakeholder and community engagement are provided in Appendix A.

3.2 Key Learnings

3.2.1 Previous engagement of key stakeholders

The preparation of adaptation plans required that the key, impacted stakeholders be engaged in the planning process. Whilst issues of coastal management and climate change draw interest from a range of interests and groups, key stakeholders are those that are either directly impacted (asset and land owners/managers) and those that are required to make decisions in line with adaptation plans (decision-makers).

For the Cockburn Sound Owen Anchorage coast, asset and land owners/managers were identified to be:

- Local governments and other foreshore managers
- Coastal industries and LandCorp
- Infrastructure and utility providers
- Community (property owners)

Decision-makers were considered to be:

- Local government
- State government (in particular Department of Planning)

Coastal users, an important consultee to inform values and adaptation actions on the coast, were considered to be:

- Broader community (broader than property owners)
- Community groups

Decision-makers are generally represented on the Cockburn Sound Coastal Alliance, and have been well engaged in the project during Stages 1 and 2. Outside direct membership of the alliance, even within local governments, there has been less engagement in the project through Stages 1 and 2. This was observed through:

- One on one meetings with local government representatives, beyond those representatives on the alliance;
- Meetings with servicing authorities, infrastructure providers, and industry representatives.

No community engagement had been carried out prior to Stage 3, with the public release of the Stage 1 and 2 reports occurring during implementation of Stage 3. This is consistent with the overall project objectives, which identify community and wider stakeholder engagement being a key task for Stage 3.

3.2.2 Awareness and engagement of stakeholders

Beyond specific key asset managers and decision-makers that had been engaged in previous stages, there was limited knowledge of the project. The level of understanding of local government representatives, for example, varied across the four local governments in the Alliance. Where officers had been directly engaged in the previous project consultation and delivery, there was an understanding of the project objectives and outcomes. Beyond those officers, there appeared to be limited dissemination of the project learnings throughout decision making organisations. There had been no targeted or active consultation with the community, which was therefore a key task for Stage 3.

The level of community interest in the project and the issue of coastal hazards and adaptation more broadly was extremely low and suggests a significant effort is required to communicate project outcomes to the community. In total, 26 people were engaged through information open day opportunities at the Fremantle Woolstores and the Rockingham Shopping Centre, and a total of 17 people attended focus group sessions. The low level of participation impacted the ability of the project to test values and options from Stage 2 in a reliable way. Therefore engagement focussed on promoting awareness of the Stage 1 and 2 outcomes, and obtaining input into weighting the relative importance of criteria used in the options evaluation process which effectively enabled participants to influence the preference of adaptation options based on the relative importance of values. In this way, values (or the importance thereof) were refined into the options evaluation process through engagement outcomes rather than tested.

Participants of the focus groups were noted as more likely to have had some previous information about the project or were generally interested in climate change and adaptation. However, whilst participants at open day opportunities (in the form of stands at community shopping centres) did note their concern for the future, few considered the issue substantial, and no participants subsequently attended the focus groups.

Industry and infrastructure stakeholders had considerably more awareness of coastal issues, although had limited awareness of the project. The limited awareness of the project may have resulted in low levels of engagement of industries and infrastructure providers in workshops. Those that attended, appreciated the opportunity for the adaptation plans to inform their own

decision making. A key observation is that all industry and infrastructure attendees considered that the State Government was the key decision-maker.

In relation to community and stakeholder views in relation to adaptation options, some stakeholders – particular infrastructure providers – were comfortable with concepts of retreat once assets required renewal. However, the majority of stakeholders and community tended to focus on protection of current assets and values in the near term. For some, longer term strategic responses, such as retreat, seemed too complex a response to consider.

3.2.3 Community values

One of the core aims of the stakeholder engagement component of the project was to consider and test the core and/or dominant values of the community in relation to the coast, and the implications of the impacts of sea level rise. These values were intended to be used as part of the methodology for testing the various coastal management options.

As is quite typical, different community members responded based on their different interests. This was expressed through those who potentially had at-risk property being inclined to expect hard infrastructure protection (groynes, seawalls etc.), and those with no direct property impact, i.e. beachgoers, being inclined to expect the retention of their beach and adjacent parking areas and parklands.

Regardless of their interests, the immediate general reaction was to assume that existing property including parks, parking areas and private property would all be protected. However, through the course of further discussion and/or the presentation on the impacts of various coastal management options, the majority of stakeholder participants changed their position. The reality of the cost of protecting the whole coastline and the inevitable loss of beach was subsequently considered by participants to be undesirable, except in the cases of individuals with directly at-risk property.

The process of engaging with the community thus illustrated that the community is not sufficiently aware of, or informed about, the potential impacts of sea level rise and erosion to articulate their values in a way that was constructive for assessing the various options for coastal management. This was further conveyed in the generally low level of interest in being engaged.

In response to this, it is recommended that the Alliance continue with awareness raising via a number of methods, including specific information on the website, fact sheets, via a longitudinal survey, within projects (e.g. during preparation of individual foreshore management plans) and through an ongoing interaction with the broader community. Due to low participation, this was not achieved in Stage 3. However, ongoing engagement is important to inform future iterations of adaptation planning and more detailed planning and implementation of adaptation actions. The ongoing engagement strategy needs to be a process of regular and repeated opportunities to inform and engage with the community so that the values of the community can be properly assessed. This will be important for long-term decision making, which will need to test the values of the community in relation to the coast at each decision making point.

3.2.4 Timeframe for engagement and delivery

An important learning is that preparation of adaptation plans – if they are to be prepared as a detailed, confirmed list of actions for implementation – require significant time and planning for meaningful engagement. In particular, engaging the community (as an important influence of decision-makers) requires substantial investment in education and awareness as a precursor to engagement.

A key lesson learned from the delivery of the Cockburn Sound Owen Anchorage coastal adaptation plans is that greater investment – in particular in relation to time to engage the community through awareness campaigns using media, social media, and other forms of advertising – prior to commencing the adaptation planning project phase may more effectively generate sufficient levels of awareness and knowledge to consult on adaptation. This was an objective of Stage 3, however was not achieved within the project timeframes available.

A longer term awareness drive and community dialogue – engaging with media – would be a better way in which to engage the community to engage them in testing values. There may also be benefit in future projects engaging with the community at project commencement as part of the values identification process. By commencing with an awareness drive, future projects will be able to then tap into community and stakeholders with a greater awareness and appreciation of coastal risk and impacts of various adaptation measures. Greater levels of awareness will bring together broader views on the issue, and enable a more informed discourse of the, often competing, values of the coast and coastal land.

3.3 Implications

The original objective of stakeholder and community consultation was to test values and options for coastal adaptation planning. “Values” for the purposes of preparing the adaptation plan related to weighting of social, environmental, and economic criteria that were used in the Multi-Criteria Decision Analysis (described in Section 6). Due to limited engagement of community and stakeholders, a reliable sense of the values of the coast could not be ascertained, as only a very small sample size was available. Nor was the sample representative of the community as a whole, as community members involved tended to be attracted to the project through local environmental networks. Therefore, whilst the project could consider stakeholder inputs to the comparison of options, they were limited and required assumptions to be made on current values. Furthermore, there was limited capacity to imagine and engage beyond the immediate planning horizon, beyond the temporal scale of personal impact.

These outcomes were not considered to preclude the preparation of adaptation plans in Stage 3, however informed their focus and role. Engagement outcomes encourage the development of plans as a tool for ongoing communication and engagement over time, rather than preparing plans that provide a listing of recommended adaptation measures. Due to very limited community awareness and engagement, it would be inappropriate to prepare and adopt resolved action plans. Stakeholder engagement outcomes require development of tools for engagement and decision making. In most areas of the Cockburn Sound Owen Anchorage coast, significant decisions on valuable assets are not required immediately, which makes adaptation plans an effective tool to achieve engagement in future decision-making, rather than preparing them as a resolved product of current engagement.

4. Adaptation pathways

4.1 Adaptation principles

The consideration and determination of adaptation pathways needs to be informed by clear, agreed adaptation principles. These provide a clear policy framework against which values and costs of adaptation options can be considered and evaluated. To inform the Cockburn Sound Owen Anchorage coastal adaptation plans, adaptation principles were developed, based on current coastal policy and outcomes of stakeholder engagement. These were important to provide the key rationale behind the adaptation pathway and strategic recommendations presented in the plans, and to link the adaptation plans to prevailing policy. Confirmed adaptation principles also provided a key policy tool against which to review and refine the first-pass adaptation pathways and options generated in the Stage 2 report.

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 Cockburn Sound 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*".

4.2 The evolving risk

In applying the adaptation principles to the study area, broader consideration of the Stage 2 risk assessment, and risk assessment approaches for coastal adaptation more broadly, was a key element of considering and reviewing appropriate adaptation pathways for the study area.

Risk assessments of the hazards arising from coastal processes rely on the conventional risk analysis technique:

- evaluate the likelihood of the occurrence; then
- evaluate the consequence of the occurrence.

In this case the occurrence is the erosion and/or inundation of coastal land. The likelihood was evaluated in Stage 1 and Stage 2 of the project at different points in time: now, 2070 and 2110. As the coastal processes are dominated by sea level rise, the area of land affected by storm events increases at each of these dates. In these circumstances the risk 'likelihood' will steadily increase over time, and this needs to be the basis for planning for the long-term.

As the world is in an inter-glacial period, the sea level has been slowly rising for many thousands of years. At Fremantle, some 150mm of sea level rise has been measured over the last 100 years (Figure 1), net of seasonal and inter-annual variation.

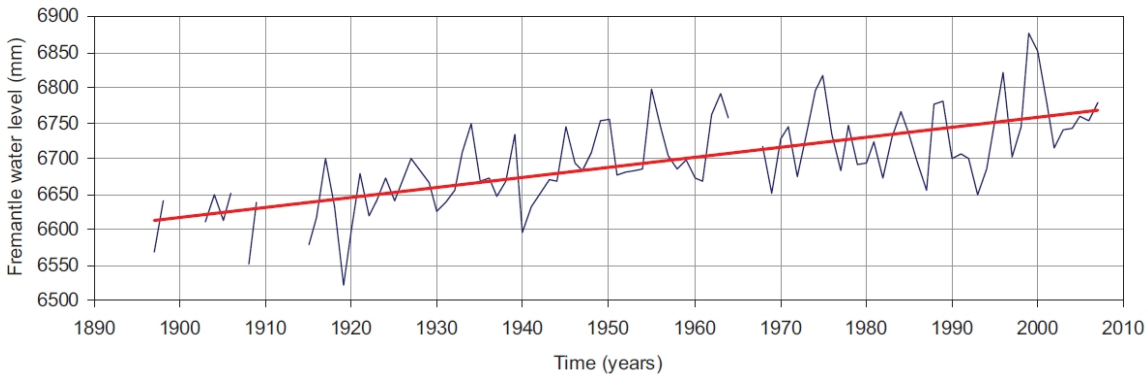
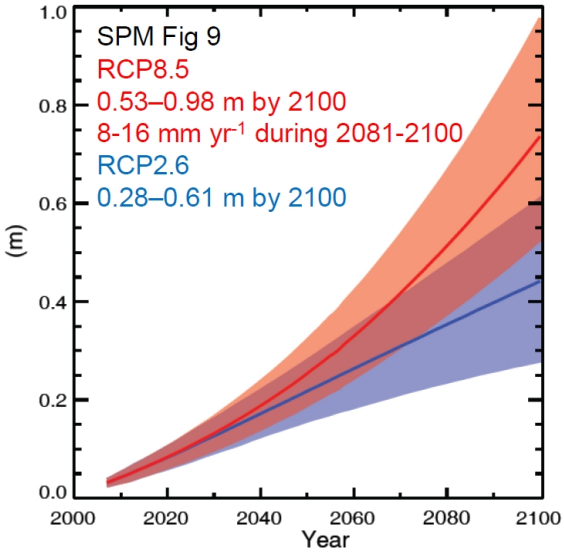


Figure 1 Annual mean tide gauge recordings at Fremantle

Source: Sea Level Change in Western Australia, Application to Coastal Planning, Department of Transport Coastal Infrastructure, Coastal Engineering Group (2010)

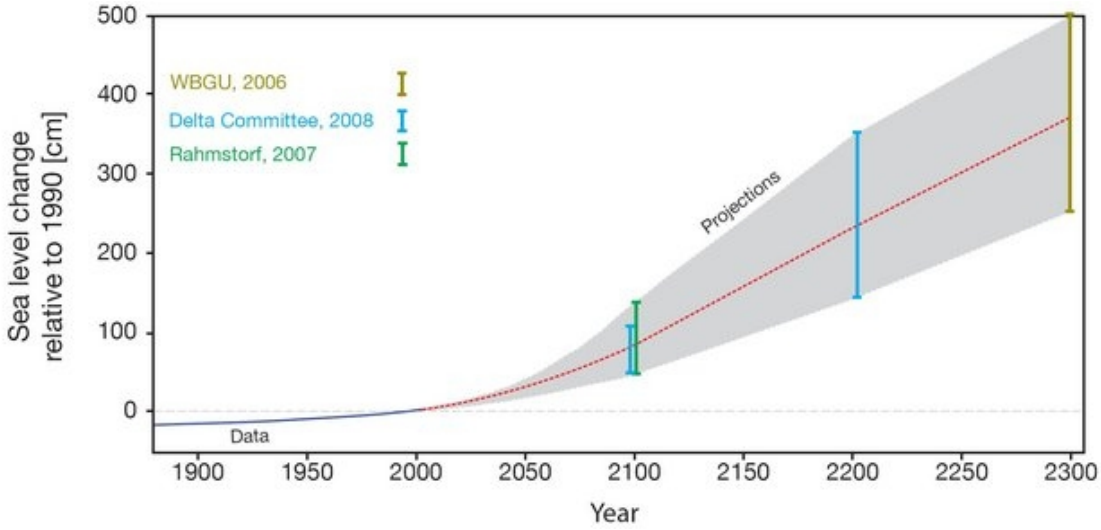
The projections for further rises in sea level over the next 100 years vary considerably but all represent increases due to global warming (Figure 2). It is clear from this chart that the sea will continue to rise well beyond the end of this century.



Source: IPCC (2013)

Figure 2 Projection of sea level rise to 2100

Indeed, projections indicate that sea levels will still be rising in hundreds of years from now (Figure 3).



Source: Rahmstorf, S. (2012) Modelling sea level rise. Nature Education Knowledge 3(10):4

Figure 3 Future sea level rise

According to the document 'Sea Level Change in Western Australia, Application to Coastal Planning', Department of Transport Coastal Infrastructure, Coastal Engineering Group (2010):

> *"The lag between atmospheric and ocean warming, and the time required for ice sheets to melt, means that sea level is likely to continue to rise for many centuries to come. The estimates suggest that the rate of global sea level rise due to thermal expansion over the 22nd century will be similar to that in the 21st century, with only a slight reduction in the following centuries. (DCC, 2009)"*

Figure 4 sets out the distance from the coastline to lines representing the combined erosion and inundation likelihood i.e. the worst case (most landward) line identified by inundation and erosion risk for Coastal Management Unit 2 (South Beach). This figure is derived from the hazard mapping prepared in Stage 1 and interpreted in Stage 2 (Table 8.1 and 8.2, p.53 of Stage 2 Report).

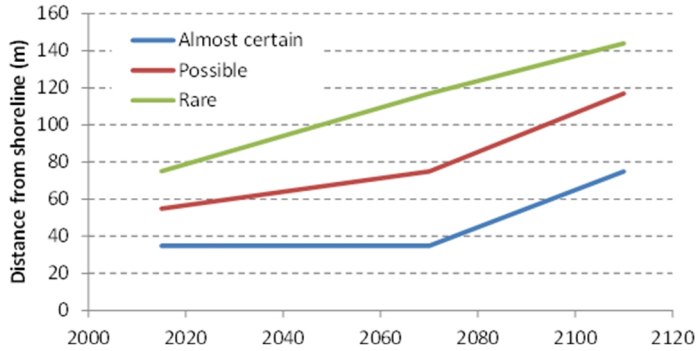


Figure 4 CMU2 combined erosion and inundation likelihood

This shows that at a distance of 80 metres from the shoreline, likelihood of erosion and inundation is currently 'rare' (meaning a 500 year ARI), becomes 'possible' (100 year ARI) by 2070 and 'almost certain' (1 year ARI) by 2110. Analysing these curves demonstrates that at 70 metres from the shoreline, erosion and inundation is 'rare' in 2020, but will be 'almost certain' by 2110, depending on the rate of sea level rise. This same relationship applies generally throughout the project area[1]. Stage 1 identifies the zone that is vulnerable to 2110, but it is important to convey the message that this zone may continue to extend landwards well into the future due to ongoing sea level rise (Figure 3), with the 2110 'rare' line moving toward 'almost certain' in the very long-term.

4.3 Decision making framework

The *Coastal Hazard Risk Management and Adaptation Planning Guidelines* (WAPC) set out coastal adaptation options available when making decisions about managing coastal risk (Figure 5). The options shown in Figure 5 should be considered in decision making 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 community to make when deciding on the future of coastal assets and land.

[1] Table 8.2 indicates that the present day 'rare' line is represented by the more landward of the 500 year ARI inundation line (1.48m AHD) and 2070 acute erosion line. The 2110 'almost certain' line' is described similarly as the more landward of 1 year ARI inundation line (1.5m AHD) or 2070 acute erosion line.

Figure 5 Hierarchy of adaptation options (WAPC, 2014)

Stage 2 of the project devised first pass adaptation pathways for each coastal management unit of the Cockburn Sound Owen Anchorage coast. These were reviewed and tested against the adaptation principles developed from policy review and learnings from community and stakeholder engagement. Pathways from Stage 2 did not include timeframes and, when tested against the adaptation principles, were not considered to clearly communicate the ongoing, cyclical nature of adaptation planning. The need to articulate adaptation pathways in a way that confirms the cyclical nature of adaptation planning (i.e. that decisions and adaptation actions do not exist in perpetuity) was a key result of community engagement in Stage 3. Community members engaged assumed that protection would simply happen, and that would be the long-term solution. Whereas local government representatives and many elected members were very concerned about the impacts of locking themselves into a decision that would have considerable long-term financial impacts. A pathway that communicates the long-term, continual application of the options hierarchy was considered more appropriate to be consistent with the hierarchy of adaptation options and communicate the cyclical nature of adaptation planning to the community.

To develop an appropriate long-term pathway, the hierarchy of adaptation options was considered against the adaptation principles to determine a pathway that would apply the hierarchy to the study area over time. The key learning of this was that:

- decisions to implement particular adaptation measures should be made at the time that risk becomes intolerable (the trigger point) to avoid pre-empting decisions on incorrect community values, which change over time
- accommodation and interim protection measures have a design life, after which risk will again rise to intolerable, and a new trigger point will be reached
- decisions to implement a particular adaptation measure must maintain all adaptation options at future trigger points, including opportunity to retreat
- over time, into the long-term planning horizon and beyond, increasing risk associated with increasing sea level rise may make interim protection options unviable on the basis of environmental, economic, and social cost, leaving retreat as the only viable adaptation option. The cost and impact of retreat increases if it has not been adequately prepared for in earlier planning horizons and at earlier trigger points.

Adaptation involves a very long-term strategic retreat plan for vulnerable coastal land, while taking responsible interim measures to continue land uses where those measures can be justified on social, economic and environmental grounds. These measures and decisions are taken at various trigger points over the immediate and long-term planning horizon. This represents a 'no regrets' approach to adaptation that can be applied into the foreseeable future. If the rate of sea level rise is slower than presently estimated, retreat can be delayed, and if it is faster, brought forward.

The adaptation plans present a recommended flexible adaptation pathway, which combines decision making 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 retreat) for subsequent trigger points over time. In this way, by choosing to accommodate or protect in early horizons, the adaptation plans do not bind 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 6. A more detailed description of the trigger points is provided in section 1.1.

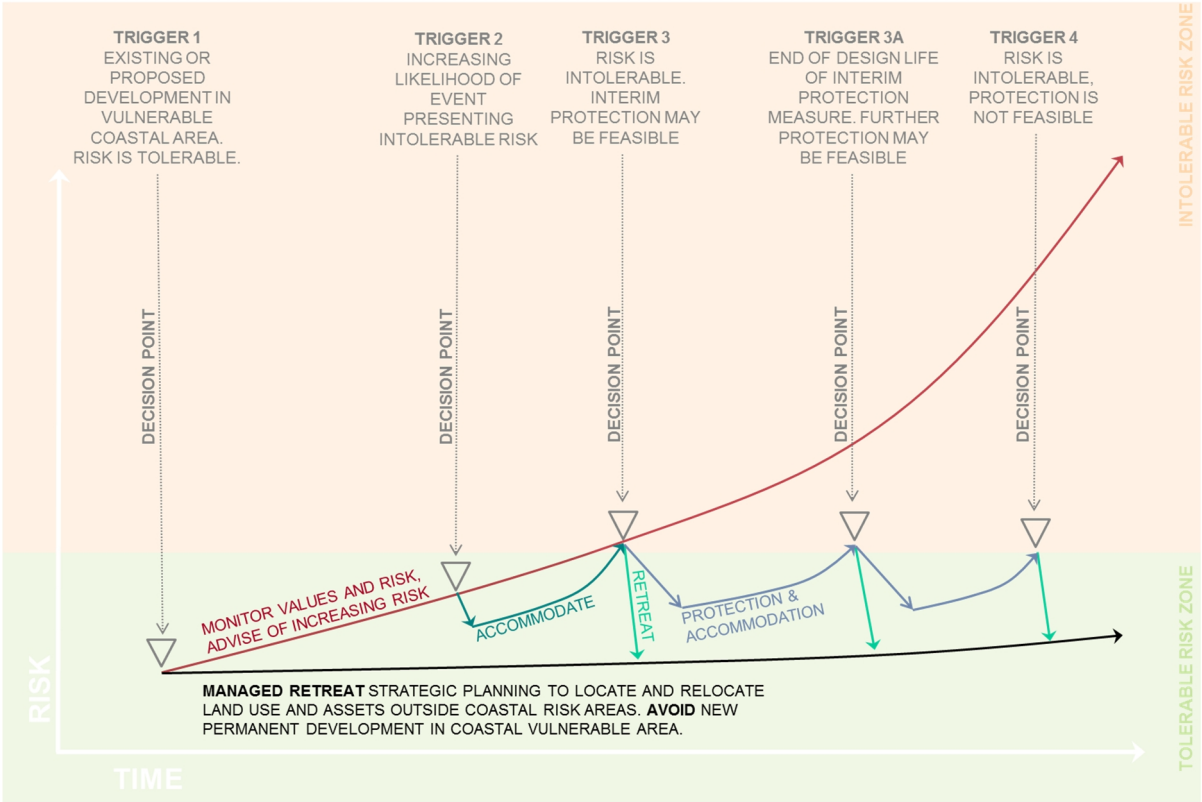


Figure 6 Flexible adaptation pathway

Alongside trigger-based decisions for appropriate accommodation and interim protection works, the adaptation plans recommend that the WAPC and local governments undertake strategic planning to avoid putting new development at risk, and facilitate changed settlement patterns over time to maintain viability (manage the cost and impacts) of a subsequent retreat decision as other adaptation measures become less feasible and more restrictive over time.

It is recommended that the area identified in the Stage 1 and 2 studies as potentially vulnerable to coastal risks be established as a special control area (SCA). The establishment of this SCA would trigger a separate process for approval of new development, redevelopment and ongoing use of existing land, outside the foreshore reserve.

The establishment of the SCA effectively signifies the long-term coastal risk that applies to this land. It can also be a tool to manage intensification of land use to manage the cost impacts of retreating from the SCA over the very long-term through progressive re-zoning of areas with unacceptable near term risk to foreshore reserve (Parks and Recreation Reserve in the Metropolitan Region Scheme), after which existing land uses could continue as non-conforming uses. Interim protection of coastline would defer this re-zoning but would only occur where it can be justified on the grounds of overall community cost – benefit.

A detailed explanation of the planning response is set out in section 5, and the coastal adaptation plans provide recommendations for local governments to consider in determining the spatial extent of and setting up the SCA, and engaging with the WAPC regarding expansion of the foreshore reserve.

4.4 Decision making

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

- the consequences and likelihood of the hazard
- the feasibility and costs associated with accommodation / protection compared to the residual value and useful life of the asset
- the disruption and costs involved with relocation.

It is not feasible for government (either local or State) to make judgements or decisions about individual private assets. Accordingly, government decisions should reflect a consideration of these factors (and others) in respect of assets collectively in a particular coastal unit, noting that individual assets of high enough importance can influence unit wide decisions. This approach will enable private asset owners to establish their own pathway and make decisions in the light of government action and advice.

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,
- any such measures are designed for a finite life or specified sea level rise and are constructed on coastal reserves, and
- advice is provided to private asset owners about government decisions to protect or otherwise, and about the likely residual risk associated with those decisions

Further discussion of the consequences of government decisions on private asset owners/managers is set out in Section 4.8.

4.5

4.5 Decision triggers

As the sea level rises, the risk of erosion and/or inundation increases. Accordingly, the process for government decision making should reflect that increasing risk.

In order to make appropriate decisions it is important to identify the trigger points that separate the options available to decision-makers. 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 these decisions, using the combination of factors giving rise to erosion and/or inundation likelihood developed in the Stage 2 report (Table 8.1 and 8.2, p.53 – i.e. the worst case (most landward) line identified by inundation and erosion risk). The determination of triggers was informed by the Stage 2 report (Section 9.5.3, p.85) which in turn is based on Fisk & Kay (2010).

The triggers are reached when, within the immediate planning horizon (i.e. 15 years which is the anticipated/effective life of most strategic land use plans), the most seaward asset (i.e. parks, road / rail reserve or urban / industrial land) in a management unit meets the risk criteria set out in . Guidance for the timing of this decision is provided by the approach taken in SPP 2.6 in respect of new development. This policy requires the determination of a coastal processes setback (CPS) line, behind which all new development must occur. The timeframe set for the analysis is 100 years.

These triggers will require endorsement and incorporation into management plan, planning controls, and adaptation plans.

Trigger 1 would be reached when land is identified at 'rare' risk of inundation / erosion. The role of local and state government during this phase is to:

- alert landowners and managers of the increasing risk, and
- to consider any measures appropriate in such an event (e.g. emergency evacuations).

Private landowners/asset managers can then take action appropriate to their own circumstances.

Trigger 2 occurs when the risk escalates such that the land is subject to a 100 year ARI event/acute erosion line. The role of local and state government during this phase is to

- alert landowners and managers of the increasing risk, and
- take appropriate accommodation actions for extreme events at the urban scale.

This would include requiring landowners / asset managers to take action sufficient for their premises to accommodate a more extreme 500 year ARI event, which is the equivalent of the SPP 2.6 requirement to set finished floor levels for this eventuality.

Trigger 3 would occur when the land is subject to a 50 ARI event / acute erosion. This would trigger a decision by local and state government to either retreat or provide interim protection to a coastal unit. The approach taken in this report to evaluate these options (see Section 6.4) is recommended to apply.

A local and state government decision to protect a coastal unit should be accompanied by appropriate accommodation measures to be taken at both the urban and premises scale. 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 selected measure does not perform to expectations. Accordingly accommodate is also part of the protect options although the nature of the measures may differ from earlier phases.

Under these circumstances private landowners/asset managers can again determine their actions in light of local and state government decisions.

It is recommended that if a protect measure is implemented, it is clearly intended to last only for the design life of the protection measure, and does not infer that ongoing protection will be afforded to that coastal unit. At the end of the design life of the measure, this trigger is again invoked and a decision is made to either extend protection, or retreat.

A decision to retreat from a coastal unit would lead to the planning actions set out in Section 5.

Trigger 4 would be reached when the land is:

- seaward of the 50 year ARI event/acute erosion line; and
- interim protection measures are no longer feasible.

At this point, retreat is the only alternative.

The proposed approach is shown graphically in Figure 7.

Table 1 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 and 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

The Western Australian Planning Commission is responsible for much of the relevant planning and decision making on coastal land. In addition to administering the application of and development within the coastal foreshore reserve (which is the 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 local governments outside that coastal reserve. Across the Cockburn Sound and Owen Anchorage, much of the strategic infrastructure is state managed (such as the Kwinana-Fremantle Port freight rail line), or of state significance (such as the Kwinana Strategic Industrial Area). Because decisions to retreat require land use change and relocation of state significant infrastructure, it is likely that the decision will be made by the State Government. Therefore, a key learning of Stage 3 of the project is that, whilst local government and the Alliance can support government options identified in , local government is not the responsible authority for those decisions and will have a role more related to a landowner or asset manager in coastal adaptation planning.

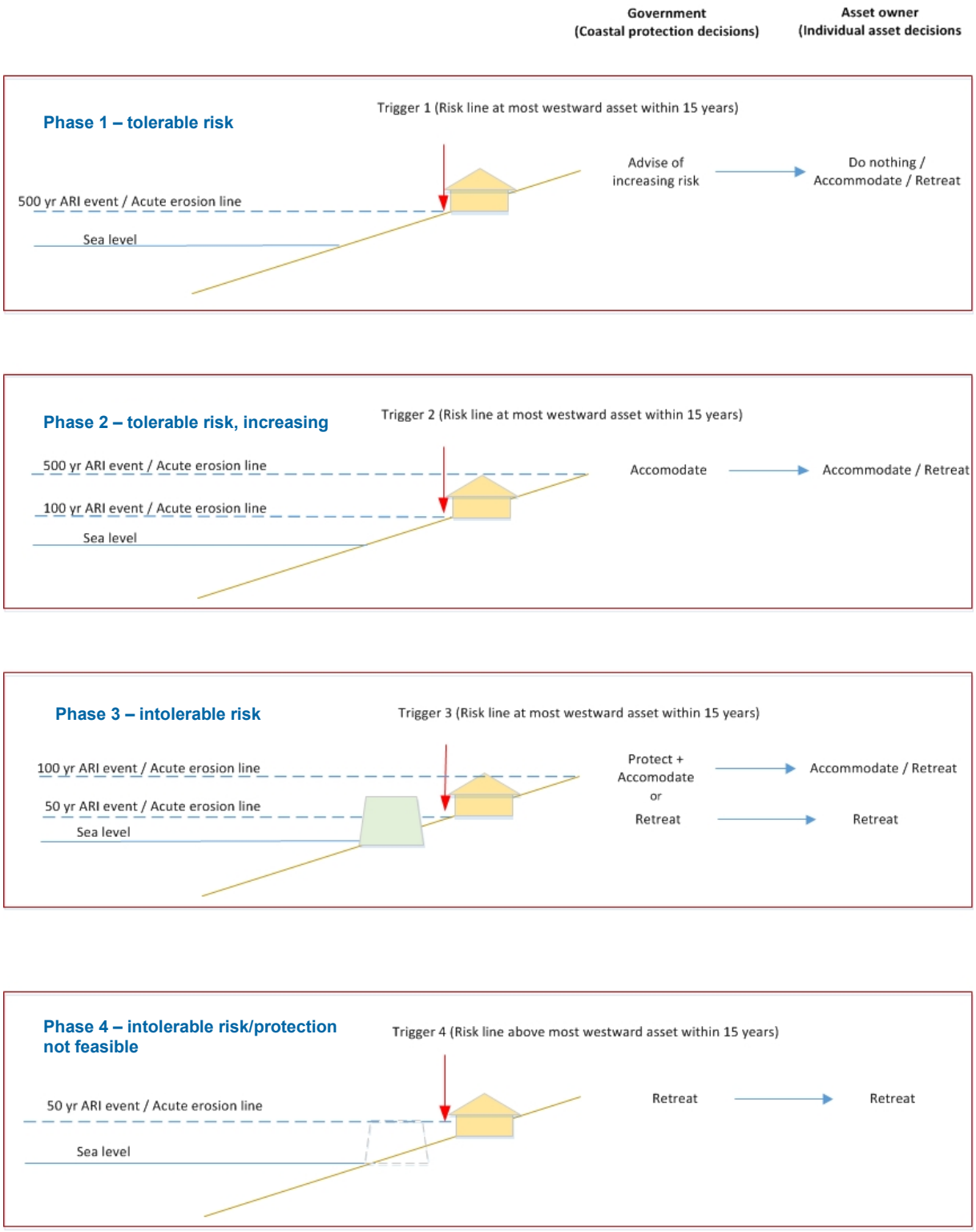


Figure 7 Decision Triggers (at any point in time)

4.6 Trigger 1 and 2 Decisions – Avoid and Accommodate

Avoid options involve avoiding 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 coastal risk, for the life of that development. SPP2.6 already provides a generally effective policy framework to avoid new development in areas of coastal risk. The adaptation plans include a range of planning recommendations (also described in section 5) to provide greater policy guidance and application of avoid principles to existing urban areas.

Accommodation options 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.

The adaptation plans include specific accommodation measures for all locations, and recommend immediate implementation to manage immediate risk (where trigger point 3 has not been reached requiring interim protection).

4.7 Trigger 3 Decisions - Retreat or Protect

Trigger point 3 is the decision point for local and state government to determine whether to retreat or implement interim coastal protection works. In order for such works to be justifiable, there needs to be sufficient benefit to offset the cost and other consequences of the works. As noted above, the financial equation is the comparison between:

- the capital and ongoing costs (including decommissioning) of these measures, and
- the benefits obtained by delaying the losses and costs of eventual retreat.

Since there are non-financial costs and benefits, multi-criteria analysis (MCDA) has been used to rank the retreat and one or more interim coastal protection options, with costs as one criteria (derived from a discounted cash flow calculation). These alternatives have been evaluated for each coastal management unit in turn to identify:

- whether interim protection measures are justifiable; and
- where they are justifiable, the nature of the works.

The MCDA process (fully described in Section 6.4) has been applied at the point where trigger 3 has occurred, or when it is estimated to occur in future. Where the present risk is deemed intolerable within the current 15 year planning horizon and an interim protection measure is deemed preferable over retreat, it is envisaged that the soft-passive, hard-passive or hard-active engineering approaches identified will form the basis of a program of concept and detailed design development with the implementation to shortly follow the completion of this Stage 3 Study. Until trigger 3 occurs in other units, the concepts will remain provisional until they fall within the 15 year planning horizon whereupon they will be re-evaluated. The proposed near and long-term measures will together inform the development of a funding strategy for the works.

Any coastal protection works (e.g. sea walls, groynes, beach nourishment) which are additional to existing structures will influence coastal processes, particularly sediment transport, on adjacent parts of the coast. The preliminary set of interim protection works derived from the MCDA process described above (i.e. consideration of individual coastal units) has therefore been reviewed in light of potential cumulative effect, the likely availability of materials and the

potential environmental impact of the measures. This iteration has led to a preliminary conceptual plan for:

- the protection of certain areas of the coastline, including measures such as beach nourishment and dune stabilisation as well as hard measures including groynes, breakwaters and seawalls; and
- strategic retreat from other areas.

The generic options available are set out in the Adaptation Options Compendium (a companion document) and those considered specifically for each coastal unit are described in section 6 and in the adaptation plans.

4.8 Trigger 3 and 4 – Delivering Retreat

Investigations undertaken during this study have not identified examples elsewhere in Australia of successful retreat policies or models at a locality scale, particularly when retreat affects private land and assets. While an implementation model is proposed in this report, further exploration of the issues with a wide range of stakeholders will be necessary to ensure such decisions to be viable and achievable at the local level. When considering models for delivering retreat, there are two key, separate roles for coordinated action by government:

1. Coordinating land use zoning and policy changes, and coordination between multiple infrastructure owners and managers to cooperate in relocating and retreating assets; and
2. Establishing funding arrangements, including the responsibilities of government, public and private land and asset owners to finance the necessary collective action.

Retreat decisions, where they affect private and state government land and assets, cannot be delivered by local government alone, and cooperation between various levels of government will be necessary. It is not within the scope of this commission to recommend funding arrangements and there are currently no commitments from governments at any level to provide funding for private land and asset owners for acquisition or compensation associated with implementing retreat (or even to implement coastal protection options). However such arrangements will ultimately need to developed by government and consistently applied to avoid ad-hoc decisions that create unsatisfactory precedents.

An important consideration in retreat models is to manage the implications and delivery on private land. Where retreat on private land is not adequately planned for, and there are no clear provisions for private landowners to relocate their assets in a timely fashion, there can be considerable pressure to modify retreat policies and put in place protection measures to protect private land and assets. This can result in the loss of a public foreshore reserve to the point of its interface with private land, with consequent loss of social amenity and values. Retreat models should consider and plan for retreat of both public and private land and assets in a coordinated way, to maintain a public foreshore reserve, and associated social values and public benefit, over time.

The coastal foreshore is a vital piece of infrastructure. It provides an important coastal protection measure that protects public and private land and associated assets from coastal risk as well as serving important social functions as outlined in SPP2.6. It is vital that the public foreshore is retained and managed. Examples across Australia – from Byron Bay in New South Wales and Seabird in Western Australia – show the significant impact and stress that occurs when erosion risk directly affects private property. In such scenarios, the need for immediate action and the high value placed by residents on their land and assets can drive reactive

adaptation approaches, which may not consider the broader and long-term environmental, social, and economic cost.

Where retreat is a preferred decision (or trigger 4 is reached) a model for delivery might be one that is similar to how the State Government delivers traditional infrastructure. For example, planning and delivering the coastal foreshore reserve in a manner similar to other vital infrastructure in Western Australia, such as highways. This includes planning for and acquisition of the land necessary for public reserve, then budgeting/obtaining funding for a major capital project that delivers the on-ground infrastructure. In the case of managed retreat, that capital project would include relocation of remaining infrastructure and assets, and remediation of the public foreshore reserve. This model is shown in Figure 8.

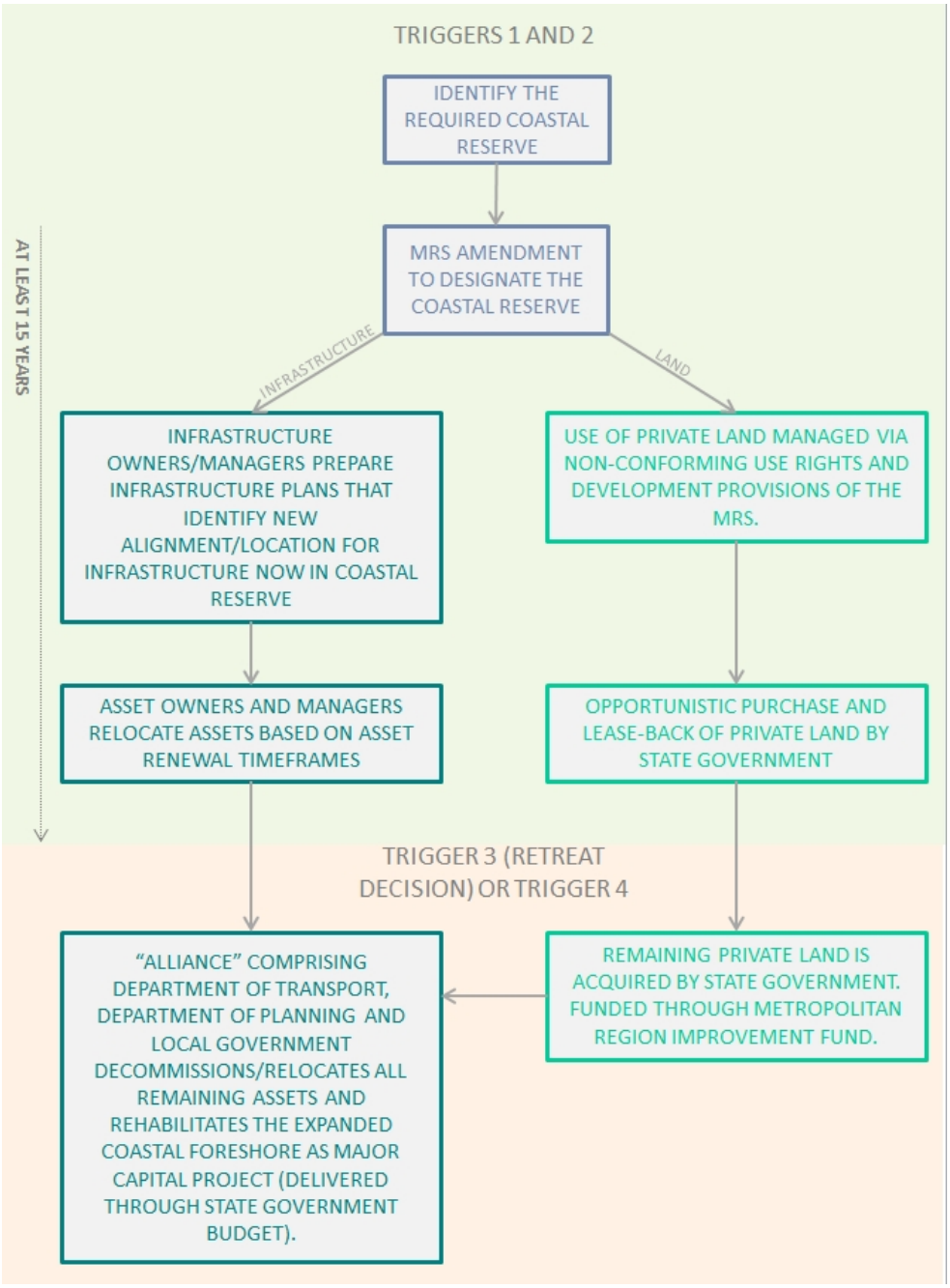


Figure 8 Model for strategic retreat delivery

4.8.1 Strategic planning

The strategic retreat model would commence with key strategic planning tasks, to identify and put in place the necessary public reserve. In the Cockburn Sound and Owen Anchorage, this would effectively require an expansion of the existing MRS Parks and Recreation Reserve. The strategic planning tasks would be delivered by the Western Australian Planning Commission.

State Planning Policy No. 2.6 State Coastal Planning Policy (SPP 2.6) sets effective guidance for the minimum requirements for a public foreshore reserve in Western Australia. Whilst this is only applied, in practice, to greenfield development, the policy model is relevant to determining the extent of the reserve in existing urban areas. In line with SPP 2.6, the required foreshore reserve should be determined by the physical processes setback (vulnerable area) plus additional land required to provide a suitable public reserve for the long-term planning horizon. The additional reserve required in addition to the physical processes setback will be dependent on the function of the reserve, environmental values of the area, and the facilities required to provide an effective public reserve.

Once the necessary foreshore reserve has been identified, it can then be incorporated into the Metropolitan Region Scheme (MRS) through a scheme amendment. This puts in place the planning framework and development control necessary to manage retreat of development and infrastructure from the shoreline. A trigger for the reservation process would be a retreat decision made for land that would be influenced by trigger point 3 or 4 in the 15 year planning horizon.

It is important that a public coastal foreshore is maintained ahead of the shoreline to meet SPP 2.6 objectives, and also to protect private land from coastal erosion.

Existing development on newly reserved land can be continued through non-conforming use rights. The reservation of land will impact on property values, recognising the intention of the land for a public purpose. Similarly to land reserved for other purposes (including regional roads), compensation would be payable for injurious affection when the land is first sold following the reservation, or if an application for approval to commence development of the land is refused as it is not consistent with the public purpose of the reserve.

4.8.2 Acquisition of Coastal Land

Where the foreshore reserve is applied in the MRS prior to the need to physically retreat, it may not be needed to be acquired immediately by State Government. Over time, lots within the newly expanded MRS reserve can be opportunistically purchased by State Government, and then leased back until such time as physical retreat is required. The Metropolitan Region Improvement Fund may be a suitable source for opportunistic land acquisition to support an expanded, public coastal reserve.

4.8.3 Coastal Infrastructure

Once the MRS reserve has been expanded, this will be a clear direction for infrastructure and asset owners/managers to prepare infrastructure plans that will identify new locations and alignments for infrastructure, outside the new foreshore reserve. Prior to the retreat trigger, asset owners and manager should relocate assets to outside the new foreshore reserve as assets are renewed. This may require additional acquisition of land and/or easements in new infrastructure locations.

4.8.4 Trigger 3 or 4 reached

Once trigger 3 is reached with a decision to retreat, or trigger 4 is reached then physical retreat will be required.

Under the strategic infrastructure retreat model, the physical relocation of any remaining infrastructure/assets and remediation of the land as public foreshore reserve can be funded as a major capital project through the state government budget (not operational funds), including any contributions from other sources (as discussed in Section 4.8). The project could be delivered as a collaborative construction project - involving the key agencies of the Department of Transport and the Department of Planning in consultation with the relevant local government – incorporating all necessary engineering, design, and construction skills required to deliver the retreat in a consolidated manner.

At this time, any remaining private land would be acquired for the purposes of public works.

The planning of strategic retreat should be coordinated in discrete projects and study areas. If this model is effective, it would be appropriate for delivery across the Perth Metropolitan Region. The WAPC Infrastructure Coordinating Committee should have a role in planning for strategic retreat projects where they impact on regional infrastructure to ensure all relevant agencies are aligned in delivery.

There may be some locations where the above model, based on maintaining a coastal foreshore reserve is not essential for retreat. Models that allow the public reserve to erode and require individual, staged retreat by landowners over time may be appropriate in locations where there is limited value of retaining public access to the coast. However, this is unlikely to be effective in many areas. In particular, similar retreat models have not succeeded in other Australia jurisdictions where private residential land is at risk, and political pressure has resulted in an abandonment of retreat strategies and installation of temporary protection to protect private residences. Furthermore, the Western Australian government has maintained a policy position of ensuring coastal reserves and public ownership, access to and enjoyment of the coast. This is a key policy principle of State Planning Policy 2.6. In some limited locations, for example along the Kwinana Industrial Area where public access to the foreshore may not be safe, appropriate, or of high amenity, retreat models that require individual retreat of private assets may be considered by government in consultation with landowners and the community.

4.9 Private Assets

On those parts of the coast where coastal protection measures cannot be justified, it is recommended that the responsibility for considering interim accommodation / protection falls to the owner of the assets. Any decision to protect will require approval of state government, and may not be supported if it is inconsistent with a government decision to retreat or if protection would impact on adjacent properties or areas. It is not the role of government to engage in evaluating the cost – benefit of interim measures for assets owned by other entities, nor facilitate their implementation. Therefore the adaptation plan for these assets should focus on communication and engagement with the asset owners.

4.9.1 Infrastructure and services

Residential, commercial and industrial facilities are all dependent on service infrastructure, namely transport, water, wastewater, power, telecommunications and gas. Ongoing occupation of their premises is dependent on the continuation of these services. Accordingly engagement with the service providers is a critical task. It is proposed that each of the service providers is presented with the key findings from the previous stages of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project and the proposed coastal protection works identified in each of the adaptation plans. Service providers should be encouraged (preferably required) to devise a long-term plan to retreat from the coastal vulnerable zone, consistent with the adaptation plans, including the proposed interim coastal protection works. Where assets are deemed to be at risk in the current 15 year planning horizon, service providers should be encouraged or required to advise local government and their customers of any changes to service arrangements arising from their decision to retreat or implement interim protection measures. Major regional infrastructure will require significant strategic planning to plan for relocation where required by decisions to retreat. This is described in section 5.

4.9.2 Other landowners

Informed by the proposed interim coastal protection works and advice from service providers, other landowners are in a position to devise their own long-term strategy to either retreat or temporarily protect their assets when the risk becomes intolerable. Any temporary protection by landowners will be subject to consistency with government decisions and approval of development applications submitted to the Western Australian Planning Commission or local government for this purpose. Applications are unlikely to be supported where interim protection would cause adverse impacts on adjacent properties or areas.

Where intolerable risks to the assets are deemed to arise within the 15 year planning horizon, asset owners will be encouraged (preferably required) to advise an intention to retreat or prepare a plan for interim measures to protect their assets . Knowledge of these plans will be important for monitoring the adaptation plan's implementation, including informing the ongoing planning of service providers. The owners of assets that are not at risk within the 15 year planning horizon would be advised about the increasing risk to their assets over time.

It is recommended that landowners are restricted from implementing coastal protection measures (save for existing structures). Such measures may have consequent effects on adjacent coastline. As foreshore reserves exist along most of the coast, this is potentially an issue only in the Kwinana industrial area (where many lots extend to the coastline) and a small strip of urban land south of Port Coogee. If interim coastline protection measures are implemented in the Kwinana industrial strip, this should be implemented through a process controlled by state government with costs determined in consultation between industry and government.

Further detail on appropriate measures for owners/managers of private assets is set out in Section 6.6.

4.10 Future hazard assessment and monitoring

It is recommended that the erosion and inundation hazard assessment is reviewed and updated as necessary following the release of the next Intergovernmental Panel for Climate Change (IPCC) assessment report which is expected in 2020 / 21. In the meantime the Stage 1 report should continue to be the basis for assessing risk, but reflect the evolving research on climate change in general and sea level rise in particular. Since the last IPCC report there has been a great deal of research focus on the impact of ice sheet collapse and melting on sea levels. It is likely that this research will lead to revisions to the most recent IPCC sea level rise scenarios (Golledge et al 2015), although most of the impact will be after the 21st century.

The Stage 1 report set out a series of recommendations for coastal monitoring (Section 7.2, p.146). Building on the previous recommendations the following list of monitoring and data acquisition/analysis is also recommended:

- The Department of Transport and other state agencies currently undertake monitoring and data collection regimes within the Owen Anchorage and 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 this data by each local government is recommended to allow for trends to be identified that may be affecting their coastline 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 for better calibration and validation of any modelling required.
- Photo monitoring should be undertaken biannually (winter/summer) and during/post significant storm events, as per the methodology recommended by Department of Transport (2012). Visual comparison of site photos provides context for interpretation of the measured profile, vegetation line and bathymetric changes.
- 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 tracked to record storm event water levels and monthly mean sea level, to help interpret coastal management pressures, along with annual means (and exceedance levels) to help track requirements for adaptation. 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 within the Cockburn Sound Coastal Alliance would allow for resources to be pooled and trends across local government boundaries to be identified. Implementing these recommendations is critical to ensuring future decision making is based on the best evidence.

5. Planning Measures

Delivering the adaptation approach described in Section 3 requires considerable early strategic planning by local and State government. Using land use planning as a tool to facilitate decision making and strategic retreat planning is necessary, and allows for new locations of strategic infrastructure for the next planning horizon.

There are two key roles of the planning framework in strategic adaptation planning:

1. Provide a robust policy tool to avoid new, incompatible land use and permanent/long-term assets in areas of risk, whilst facilitating appropriate, short-term coastal development; and
2. Provide a framework for retreat through identifying low-risk land for new and relocated development and infrastructure relocation, and placing controls on land in areas of increasing risk to require the relocation of assets.

The delivery of these planning roles requires both State and local government planning tools to proactively incorporate coastal adaptation planning, as shown in Figure 9 below.

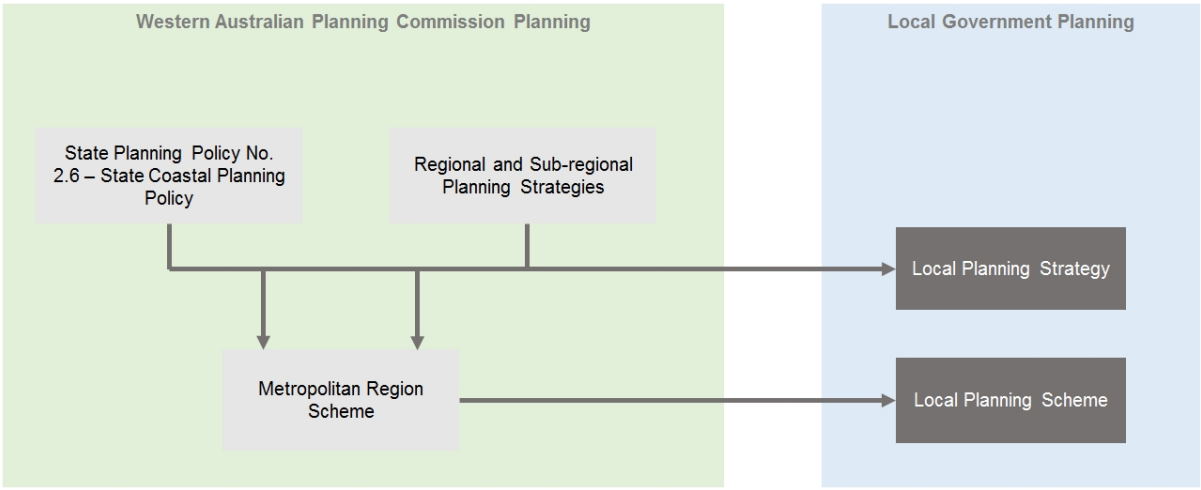


Figure 9 Key land use planning tools to deliver coastal adaptation planning

The Western Australian planning framework centralises much planning authority at the State Government level. Local Planning Strategies and Schemes, whilst prepared and administered by local governments, require the approval of the Minister for Planning, on advice of the Department of Planning. Local government strategies and schemes are also required to be consistent with regional and sub-regional planning strategies and structure plans, and the Metropolitan Region Scheme. Whilst much coastal hazard risk management and adaptation planning is undertaken at the local government level, its delivery requires implementation by the State Government and Western Australian Planning Commission through strategic land use planning processes and the Metropolitan Region Scheme. In effect, local government does not have planning jurisdiction to deliver retreat strategies, as zoning of land and reservation of land for key infrastructure in the Perth Metropolitan Region is a State responsibility through the Western Australian Planning Commission.

Whilst the ultimate responsibility for planning lies with the State Government, a range of projects at both state and local level are necessary to develop the strategic planning framework for implementation of the measures set out in the coastal adaptation plans, and to maintain flexibility in adaptation over time.

5.1 Local Government Strategic Plans

The coastal adaptation plans recognise the opportunity for local government strategic and community plans to operate as a trigger for community consultation on values related to coastal development. Using community consultation through these plans provides an opportunity for local government to revise values and determine what new learnings exist in relation to coastal adaptation. The outcomes of consultation and strategic visioning by local governments can be used to test recommendations of adaptation plans, revise recommendations based on community values and new learnings, and identify any immediate term actions for delivery.

5.2 Local Planning Strategy and Scheme

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" (WAPC Local Planning Manual). The strategy is therefore the appropriate 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 local government'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 schemes over time.

These planning documents are scheduled for review, in accordance with the Western Australian Planning Commission (WAPC) Planning and Development Regulations, on a five yearly basis. The review of these documents can plan to incorporate, over time, the requisite planning framework to adapt to coastal risks in the immediate (15 year) and longer (100 year) term.

5.2.1 Special Control Area for Vulnerable Coastal Area

The local planning strategy provides the first planning step to identify a special control area for vulnerable coastal area. The review of the local planning strategies should include extensive community and stakeholder engagement to determine the recommended extent and operation of the special control area, based on the recommendations of the coastal adaptation plans.

The local planning strategy can clearly identify at what point the scheme will need to incorporate controls on development or redevelopment in vulnerable areas and/or recommend at what stage the Western Australian Planning Commission should progress an amendment to the Metropolitan Region Scheme to expand the Parks and Recreation Reserve along the coastal foreshore.

The local planning scheme, informed by the strategy, can 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 can reflect whether or not intolerable risk will be experienced in the immediate (15 year) planning horizon. Over time, as risk increases, more stringent development controls can be included into the special control area in the scheme, moving from a communication tool to a development control mechanism.

5.2.2 Coastal Settlement Planning

The amenity of the coastal foreshore environment provides a strong attraction for settlement at higher densities. In many areas, this is leading to increased pressure for higher density along the coast. Within existing built up areas, increased density located within or adjacent to the vulnerable coastal area can increase the future cost of retreat – both in terms of loss of land values, land acquisition costs, and the social cost of the number of dwellings or businesses impacted by being located in areas of risk. This can create pressure to protect land at the expense of public foreshore, with the loss of community amenity and facilities as the foreshore reserve is eroded, but not extended into high density development. It is important that local governments consider the most appropriate location of density and infrastructure and avoid density increases within and adjacent to coastal risk areas.

The coastal adaptation plans do not recommend decreasing density on existing private land along the coast, although in some locations (such as along the Rockingham coast) higher density development occurs and has been planned for in existing planning schemes. Any decreasing of land use intensity will draw potential claims for injurious affection of land values, for which the local government may be liable. Over time, as private land will be required to be incorporated into the foreshore reserve, reserving land within the Parks and Recreation Reserve will provide triggers for compensation (at the time of sale or a refused development application) or land can be acquired by state government. This is the appropriate trigger and mechanism to compensate loss of property values where private land is required to expand the foreshore reserve. To ensure that acquisition or compensation costs are not increased over time due to increased development potential, the adaptation plans recommend maintaining and not increasing density within the coastal risk zone.

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

In particular, local planning strategies can incorporate:

- policy measures that require infill development to be assessed against SPP2.6 as if it were new development
- density recommendations to locate increased densities outside both the physical processes setback and the associated long-term foreshore reserve
- 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

5.3 Regional Planning Strategies and Metropolitan Region Scheme

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, which zones and reserves land for development and public purposes. The Metropolitan Region Scheme includes the Parks and Recreation Reserve, which is the most effective planning tool to facilitate avoid and retreat decisions.

To facilitate avoid and retreat measures the Metropolitan Region Scheme will need to be amended to expand appropriate reservations for parks and recreation (coastal foreshore), public purposes (as required by servicing agencies), and road and rail reservations (as required by transport agencies). Land acquisition and/or compensation may be required as a result of amendments to the Metropolitan Region Scheme.

The importance of regional plans and strategies relates in particular to the ability for strategic infrastructure to retreat. This includes opportunistic relocation of assets – through relocation of assets as they are renewed – and planned relocation of assets through strategic planning and capital works. Infrastructure of regional and state significance cannot be easily relocated – either planned or opportunistic – unless regional plans and strategies identify and plans for new locations outside areas of coastal risk. Key infrastructure that will require consideration includes:

- Freight rail linking the Fremantle Port with Kwinana Industrial Area and the Kewdale/Forrestfield Marshalling Yards (managed by Public Transport Authority and Brookfield Rail in some parts)
- Water Corporation desalination plant
- Woodman Point and Point Peron wastewater treatment plants and ocean outfalls

Future infrastructure, including the Fremantle Port Outer Harbour and the potential Mangles Bay Marina are also key infrastructure which will need to be considered in regional plans.

Future iterations of regional plans and strategies should incorporate consultation with local governments to understand where infrastructure assets are located in areas that are not appropriate for interim protection based on the values of the time. Consultation should then occur with infrastructure providers 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.

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

SPP 2.6 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 risk areas can 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 the 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 guidance is required to manage the longer term potential costs of protection or decommissioning of these developments following the design life. This can 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
- Consideration of the need for special area rates to support decommissioning or longer term interim protection costs

5.5 Foreshore Management Plans

Foreshore management plans can be adopted by the WAPC as management plans under the MRS for the parks and recreation reserves. The plans can then form the statutory planning framework for all development within the foreshore reserve, as well as provide a tool to prioritise the efforts of reserve managers on various adaptation and management activities.

Foreshore management plans can also be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities. In this way, they are a more tangible project for community members to engage in, compared to broader adaptation planning processes. 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.

To be effective, foreshore management plans need to go beyond providing a list of facilities and short-term management priorities. Key elements that can be considered in foreshore management plans to deliver adaptation planning include:

- Soft engineering approaches and management – such as beach nourishment and natural dune management to provide a natural buffer from coastal processes;
- Sea level rise and coastal risk, with trigger points for the relocation or decommissioning of existing assets;
- Policy requirements for development in the foreshore, 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 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 also consider funding responsibilities and partnerships for coastal infrastructure, including community facilities and any identified coastal protection works.

6. Coastal Adaptation Measures

6.1 Review of previous project stages

6.1.1 Stage 1 Hazard assessment

Stage 1 of this project produced a coastal vulnerability assessment focused on potential impacts on the Cockburn Sound, Owen Anchorage and the east of Garden Island coast from climate change and associated sea level rise. The work undertaken included study and mapping of inundation and erosion hazards for various scenarios. Climate change scenarios and projection time frames were reviewed and identified with the timeframes selected being present day, 2070 and 2110, referring to the West Australian State Planning Policy (SPP 2.6).

To facilitate the modelling and spatial interpretation, the sediment cells framework mapped by Stul et al. (2012) was adopted to separate the coast into sections that exhibit similar processes and morphology, giving eight mainland and three Garden Island segments.

The study assessed the inundation hazard based on the review of existing topography, analysis of existing water level data sets for 1, 10,100 and 500 annual return interval (ARI) extreme scenarios[2] and adding the projected sea levels for the specified climate change scenarios of 0.5 metres by year 2070, 0.9 metres by year 2110 and 1.5 metres by year 2110 as shown in Table 2 below.

Table 2 Sea level rise scenarios

Scenario	Present day	+0.5 m SLR	+0.9 m SLR	+1.5 m SLR
1 year ARI (63% AEP)	1.00 m AHD	1.50 m AHD	1.90 m AHD	2.50 m AHD
10 year ARI (10% AEP)	1.16 m AHD	1.66 m AHD	2.06 m AHD	2.66 m AHD
100 year ARI (1% AEP)	1.34 m AHD	1.84 m AHD	2.24 m AHD	2.84 m AHD
500 year ARI (0.2% AEP)	1.48 m AHD	1.98 m AHD	2.38 m AHD	2.98 m AHD

Assessment of erosion hazards included the review of short-term erosion associated with normal coastal processes and various intensity potential storm events, gradual changes in the shoreline position and short-term and long-term availability of sediment and concluded with a projection of the landward retreat of the shoreline (erosion) within each section of the coast.

The study report stated that changes to the areas experiencing recession are likely to occur through several different mechanisms, including sea level rise contributing to decrease or cessation of onshore sediment supply, geometric response of the coast (due to shifting the hydraulic zone), and increased exposure of rock. The study has concluded that the onshore feed of sediment may be insufficient to keep up with these changes by the year 2070.

The report summary reiterated that modelling of beach profile is highly variable, determined by the relative ease with which sand can be transferred between and within the resulting coastal segments. It also adds that evidence used to estimate projected future change is not compelling, and there is uncertainty associated with estimates of sand supply, alongshore

[2] ARI is related to the annual exceedance probability (AEP) which is the probability that a given event will be exceeded in any one year

transport and the pathways of coastal response to sea level rise. It finally concludes that potential changes to sediment transport caused by sea-level change are further complicated by the unknown future modification of the coast by engineering works and that it is important that a holistic approach to coastal management be developed, with suitable triggers set to indicate a need to change management approaches.

6.1.2 Stage 2 Values and Risk Assessment

Stage 2 comprising of Coastal Vulnerability Values and Risk Assessment was completed in November 2014. This stage identified the coastal assets affected by coastal processes including from climate change and estimated the 'value at risk' of these assets. It included a risk assessment of likelihood and consequence of the identified hazards and a first pass assessment of potential adaptation options for the coastal assets at risk.

The Stage 2 approach to assessment of risk was to identify the 'cost of risk' of coastal assets for present day, 2070 and 2110. It was assumed that an erosion hazard would result in total loss of an asset but (occasional) inundation may only mean a partial loss or a reduction in value of an asset.

The quantitative values of these assets were assessed according to their value as market goods and services, social and cultural non-market goods and services and ecosystem services.

The study concluded that the total cost of risk to the land and assets (considering both erosion and inundation over 100 years) is greater than $325 million. The majority of this value is in the beaches ($130 million) and parks ($122 million), which signifies the high economic, social and environmental values held in these assets. The study did not include for the cost associated with loss of land or industry. The risks were evaluated on an individual asset based level.

Stage 2 study identified first pass adaptation options with three adaptations pathways including retreat, maintain and intensify. The retreat pathway would lead to progressive retreat in response to climate change. Maintain would allow protection of existing developments (the report does not identify how or for how long). The intensify pathway would allow protection works to support the intensification of land used at isolated coastal nodes and infill areas. Accordingly, the study concluded that:

- the City of Fremantle coastline covering South Beach and Bathers Beach is suited to the maintain pathway or the intensify pathway.
- the City of Cockburn coastline is suited to the maintain pathway or the intensify pathway. The preferred direction may differ by location and on preferences from the community and other stakeholders.
- the City of Kwinana coastline would be suited mostly for the intensify pathway. The coastline is already heavily modified and the industrial uses are of regional and possibly state significance.
- the City of Rockingham coastline would be suited for the maintain pathway, but this will depend on whether the community and other stakeholders aspire for significant intensification in the area or prefer the community and amenity values to be largely maintained as they currently are.
- small pockets of coastline (mostly within existing conservation areas) would be suited for the retreat pathway.
- eastern shoreline of Garden Island would be suited for the retreat pathway (subject to further discussions with Department of Defence).

The Stage 2 report recommends that the proposed adaption pathways are further developed for each management unit based on the targeted stakeholder/community discussions and further in depth shoreline studies and monitoring.

6.1.3 Current and future erosion and accretion patterns

The dynamic nature of the coast brings risks of inundation and erosion, and the realisation of these risks over time changes the nature, shape, and location of our coast. The coastline of Cockburn Sound and Owen Anchorage has changed throughout history, particularly over the last 50 to 100 years. The risks of coastal erosion and inundation for the coastline have been modelled, looking at current risk, 2070 risk, and 2110 risk. The realisation of erosion and inundation risks will change the coast, the way we use the coast, and the nature (and location) of development along and in the vicinity of the coast.

The physical processes along the Owen Anchorage and Cockburn Sound coastline were assessed during the Stage 1 Assessment and reviewed in the Stage 2 Assessment. These analyses provide details about the existing and potential future coastal systems in this area including the geology and geomorphology, existing engineering controls, water levels, wind and waves, coastal change and coastal dynamics. Understanding these processes is important in determining the most suitable adaptation pathways (including protection options) to be implemented along this stretch of coastline.

Stage 1 report describes the Cockburn Sound and Owen Anchorage as exhibiting a change of morphodynamics from the south to the north, shifting from characteristic low energy behaviour toward swell dominated conditions near Fremantle. Along the east coast of Garden Island, southward transport is dominant under swell, with apparently limited influence of wind waves, which are mainly from the east.

The shoreline supply of sediment is categorised by discrete onshore and alongshore feeds through four major pathways. Two through the gaps in Garden Island Causeway at Careening Bay (1) and Cape Peron (2). Onshore sediment feeds occur to the north of Garden Island across Parmelia (3) and Success (4) banks.

Figure 10, depicts the indicative sediment pathways identified in the Stage 1 report. Overall, the sediment pathways identified within the coast are unlikely to change significantly as a result of elevated water levels (in the order of 1 metre change). However, dramatic changes are likely to occur with respect to the rates at which sediment is supplied to discrete areas Sensitive locations are likely to occur where the sand presently feeds onshore (Catherine Point, Woodman Point), and towards the downdrift end of a compartmentalised beach sequence (James Point, Coogee Beach). There is some potential for erosion to shift to updrift areas in zones of high transport (e.g. south of Catherine Point).

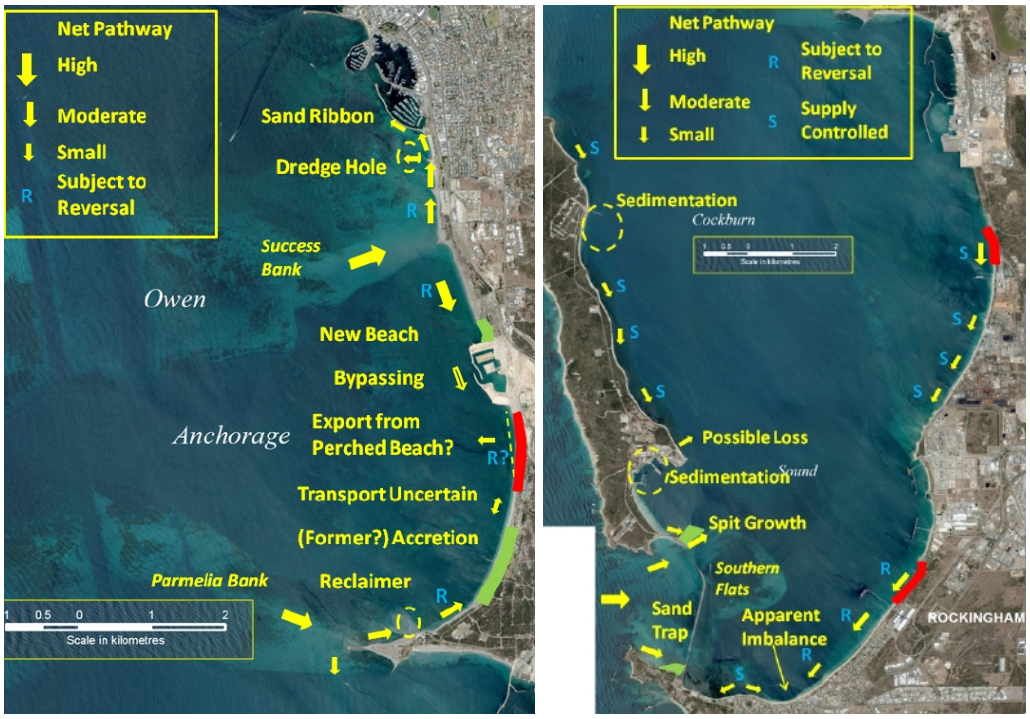


Figure 10 Indicative Sediment Pathways for Study Area (Source: CMZ et al. 2013)

6.1.4 Summary of current local government issues

The Stage 1 Assessment stated that, net coastal accretion is occurring along the Owen Anchorage and Cockburn Sound. Despite this, there have been historic and active erosion pressures along most of the coastline. This has largely been related to the difficulty of distributing the available sediment supply via structures that partition the coastline, whilst accommodating variability caused by storm erosion and longer-term variations in prevailing conditions.

The following existing coastal management pressures were identified in the Stage 1 Assessment:

- Recent erosion along the South Fremantle foreshore and Kwinana Beach which are isolated from sediment supply and have previously been supported by renourishment works. Without amended management, these stresses are likely to worsen progressively;
- Coastal response to construction of Port Coogee is still underway and it is likely to take a number of years before a relatively 'stable' configuration, including the effects of bypassing, to be established;
- The coastal response to the lengthening of the Catherine Point groyne was anticipated to be increased stability to the north and greater coastal variability to the south[3]; and
- Steepening of the sub-tidal parts of the profiles from Coogee Beach to Woodman Point represents a 'priming' of the coast for potential rapid erosion under stormy conditions with reduced capacity for recovery.

Through the Stage 1 and 2 Assessments and in the preparation of this Stage 3 study, the following additional concerns, coastal management pressures and active measures being undertaken were also identified for each local government area:

[3] It should be noted that the City did not proceed with lengthening of the groyne

City of Fremantle

- There are existing stormwater drainage issues within the west end and high groundwater has been identified.
- There are concerns on being able to maintain Bathers Beach in the long-term due to sea level rise.
- The reclaimed land and three harbour areas are presently an area with inundation concerns.

City of Cockburn

- Sand bypassing from the northern side to the south of Port Coogee has been undertaken multiple times since construction with responsibility falling on the Waterway Manager of Port Coogee to perform ongoing beach monitoring and management to mitigate the impacts of the development on coastal processes and maintain Coogee Beach. However, the volume of sand required to maintain the beaches to the south requires less sand to be moved than the quantity arriving to the north of Port Coogee resulting in accretion (MP Rogers, 2014).
- There has been significant erosion south of Catherine Point in recent years, which is expected to continue for a period before stabilisation is reached if the coastline is not modified (MP Rogers, 2014).
- There are some concerns over the surf club reaching its 50 year design life due to the predicted vulnerability in this area.
- North of Catherine Point and Woodman Point are anticipated to experience severe long-term erosion if no additional measures are implemented.
- Woodman Point and small areas of the Australian Maritime Complex are presently an area with inundation concerns.

City of Kwinana

- There is an existing acute erosion risk for areas around the Kwinana Bulk Terminal and the industrial area in general is anticipated to experience severe long-term erosion if no additional measures are implemented and increasing inundation risks with sea level rise.
- Kwinana Beach Jetty was lost due to storm events along the coast and there has been public interest in re-construction
- Several industrial land holders have already implemented coastal protection measures along their properties.

City of Rockingham

- There is an existing acute erosion risk for Palm Beach and large areas of Rockingham are presently at an inundation risk.
- Because the coastline in this local government is exposed to the ocean from multiple directions, it is likely to be affected by a greater number of storm events and experience damage at a greater number of locations.
- The City has an ongoing reactive sand nourishment programme that is a regular component included in budgeting.

6.2 Interim coastal adaptation measures

6.2.1 Option Development

As the coast changes through erosion and inundation, there is a range of planning strategies and interim protection options available to manage how the changes impact how we use and experience the coast. Options range from interim protection measures that will delay coastal processes for short-term protection of assets, through to the retention of natural coastal environments (retreating) that respond to the natural course of coastal processes. The latter approach may include strategic planning interventions and decommissioning of assets at risk.

The Cockburn Sound – Adaptation Options Compendium was prepared to provide a listing of local adaptation options relevant to each coastal management unit of the study area based on the Stage 1 and Stage 2 reports. The compendium provides a localised listing of interim protection and planning options, and a summary description of all adaptation options. The options defined in the Compendium represent a range of interim protection methods including beach nourishment, revetments, breakwaters, stabilisation and related management approaches.

Determining the most appropriate option for a certain location along the coastline requires consideration against social, economic, and environmental values. This was undertaken through a multi criteria assessment (MCA) which is detailed in Section 6.4.

The role of coastal protection is to reduce the risks associated with the coastal hazards of erosion and inundation to land and assets. The options 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 defined in Table 3.

Table 3 Coastal Protection Approaches

Approach	Description	Examples
Soft – Passive	Foreshore protection works that offer benefits to 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 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 Adaptation Options Compendium for the definition of foreshore protection examples

Appropriate coastal protection measures were defined for each of the coastal management units based on those presented in the Compendium. The options prepared were for a whole coastal management unit (CMU) solution rather than asset specific, staged to reflect timing of triggers affecting portions of the CMU. The options proposed were based on preliminary coastal engineering judgement of feasibility/practicability. Detailed studies would be required to confirm suitability, specific locations, extents, materials and design characteristics. Additionally, only up to a maximum of three interim coastal solutions per CMU were investigated. The options presented were developed to provide a high level comparison of hard or soft and passive or active engineering approaches against retreat to determine the preferred approach to be implemented at the time of trigger 3 within each coastal management unit. There may be multiple types of protection required in one CMU for a given approach. Therefore the approaches presented should be considered as recommendations that would require further consideration and development before implementation is undertaken.

Options prepared for management units where triggers are anticipated over several planning horizons included staging, with individual stages of work to manage intolerable risks for specific locations within management units in the immediate (current day) and longer term planning horizons (2070 and 2110). Protection has only been proposed for implementation at the point where coastal assets are deemed to be reaching intolerable risk (i.e. at Trigger Point 3, refer Section 1.1) during the near term planning horizon. Refer to Appendix D, for a summary table of the preliminary assessment and compendium interim protection options for each CMU. 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).

Irrespective of the preferred option presented, it should be noted that proactive coastal management (including dune management and revegetation) will be important so that natural erosion processes are not accelerated by lacking coastal management. 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 down the loss of land from erosion processes. These management techniques are less of a response to the changing coast and more a management tool to delay interim protection and planning responses.

The protection measures considered for each CMU are described in detail in the adaptation plans and summarised below.

6.3 Costing basis

Protection Staging

In order to provide a cost component to the MCA the interim options were costed based on typical designs of protection structures; refer Table 4 and Table 5.

Conceptual solutions presented are a whole of coastal management unit solution. Solutions have only been proposed where based on coastal engineering judgement they are likely to be feasible/practical. Only two or three interim coastal solutions per CMU were investigated and the definition of protections is to consider a range of protection strategies including active or passive protection of the coast. Multiple types of protection may be required in one CMU. For example, additional groynes with beach nourishment and a new seawall may suitable.

Protection has only been implemented in areas considered to be at intolerable risk during the relevant planning horizon (immediate, 2070 or 2110). This is based on the present land use, its consequence category and whether the relevant intolerable likelihood event crosses the land use area. This is in line with the risk assessment approach where the tolerability of erosion and inundation events is different.

The assessment of the protection option included in the MCDA, where it included staging over the immediate and long-term (2070 and 2110) risk scenarios, included only the extent of the infrastructure required to manage the extent of the risk at the time. Effectively, the cost of a protection option was calculated for the section of the coastline that was likely to require the treatment within a particular timeframe.

Maintenance

Maintenance was costed over the lifetime of foreshore structures assuming that this will leave them in a serviceable condition at the end of their design life to allow for upgrade if required.

Hazards

This assessment only assesses coastal hazards of inundation and erosion. For areas where there are protective structures in the foreshore, or natural structure like protection (for example CMU 9's rocky shoreline) an overtopping assessment should be undertaken for individual assets to see if the risk of overtopping is allowable for the land use.

Sand nourishment and artificial beach

Construction of an artificial beach and sand nourishment is based on the assumption that suitable sediment sources (quantity and sand grain size) are available. It is beyond the scope of this study to assess the feasibility of sand nourishment as a long-term option. Solutions dependent upon this option have been minimised where possible. Costs are based on the artificial engineered beach rate from the stage 2 report and other projects. Costs could significantly vary based on the type of the source and production method, i.e. if sourced from an offshore extraction, the unit rates are likely to be lower than if sourced from land and transported by roads.

Risk and Protection

It is assumed that all protection options will provide, unless otherwise stated, an equivalent residual risk.

Materials

For cost estimating purposes the typical design materials used in WA for a given protection were used. For example, costing of groynes, breakwaters and seawalls was based on implementing rock armour structures rather than geotextile sand containers or precast concrete units which may represent an alternative design option during the design stage of these works. It should therefore be noted that the use of alternative materials would alter the cost estimates presented.

Rates

The unit rates for each protection works item was based on either recent GHD experience with industry pricing or the rates presented in the Stage 2 report. The exact rates of construction may vary based on the final design developed and the timing of construction. The costing and rates are intended for comparative assessment of the options through MCA process. The costings are indicative and should not be used for budgeting purposes.

Table 4 Interim Protection Cost Estimates - Building/Commissioning

Description	ID	Bed Level	Crest Level	Height	Raised By	Crest Width	Side Slope	Volume / Area	Unit	Cost /unit	Cost/m	Cost/m inc. Contingency + Mob/Demob
Offshore Breakwater or Groyne	**003**	-2.0	+3.0	+5.0	N/A	2	1.5	35.0	m³/m	$250	$9,000	$11,700
Revetment /Seawall 1	**004**	-3.0	+3.0	+6.0	N/A	3	2	30.0	m³/m	$250	$8,000	$10,400
Revetment /Seawall 2	**005**	-1.0	+3.0	+4.0	N/A	3	2	22.0	m³/m	$250	$6,000	$7,800
Beach 1	**007**	-1.0	+3.0	+4.0	N/A	30	10	120.0	m³/m	$30	$4,000	$5,200
Beach 2	**008**	-1.0	+3.0	+4.0	N/A	50	10	200.0	m³/m	$30	$6,000	$7,800
Raising Existing Breakwater 1	**010**	-2.0	+3.0	+5.0	+1.0	2	2	24.0	m³/m	$250	$6,000	$7,800
Dune Stabilisation	**012**	+0.0	+5.0	+5.0	N/A	10	4	30.0	m²/m	$30	$1,000	$1,300
Raise Land	**013**	N/A	N/A	N/A	+1.0	N/A	N/A	1.0	m²	$50	$50	$70
Levees (15m wide with road on top)	**015**	+3.0	+4.5	+1.5	N/A	+15.0	+1.5	25.9	m³ and m²/m	$50 and $100	$3,000	$3,900
Oneway Valves	**016**							1.0	no	$5,000	$5,000	$6,500
Tidal Gates	**017**							1.0	no	$15,000,000	$15,000,000	$19,500,000
Groyne Removal	**018**			+4.0		3	1.5	18.0	m³/m	$150	$3,000	$3,900
Dune Elevation Increase	**019**	+2.0	+5.0	+3.0		10	5	50.0	m³/m	$50	$3,000	$3,900

Table 5 Interim Protection Cost Estimates - Decommissioning and Maintenance

Description	ID	Area	Cost /m³ or m²	Cost/m run	Cost/m run inc Contingency + Mob/Demob	Percent of Capital for Yearly Maintenance
Offshore Breakwater	**003**	35 m³/m	100 m³/m	$3,500	$5,100	0.50%
Revetment /Seawall 1	**004**	30 m³/m	100 m³/m	$3,000	$4,400	1.00%
Revetment /Seawall 2	**005**	22 m³/m	100 m³/m	$2,200	$3,200	1.00%
Beach 1	**007**	N/A	N/A	N/A	N/A	5.00%
Beach 2	**008**	N/A	N/A	N/A	N/A	5.00%
Raising Existing Breakwater 1	**010**	102 m³/m	100 m³/m	$10,200	$14,700	0.50%
Dune Stabilisation	**012**	N/A	N/A	N/A	N/A	2.00%
Raise Land	**013**	N/A	N/A	N/A	N/A	0.25%
Levees (15m wide with road on top)	**015**	$26	$50	$1,294	$1,900	0.50%
Oneway Valves	**016**	N/A	N/A	N/A	$3,250	2.00%
Tidal Gates	**017**	N/A	N/A	N/A	$9,750,000	2.00%
Groyne Removal	**018**	N/A	N/A	N/A	N/A	0.00%
Dune Elevation Increase	**019**	N/A	N/A	N/A	N/A	1.00%

6.4 Option Evaluation Process

6.4.1 Triggers 1 and 2

Trigger 1 reflects that risk is tolerable, although land and assets are located within an area of coastal risk. Trigger 2 reflects an increasing likelihood that risk will become intolerable.

Where trigger 1 or 2 were anticipated to occur in the immediate or long-term planning horizons, avoid and accommodation options are considered appropriate for implementation. Locally specific management options were provided in each adaptation plan for each location, management unit, or local government area as appropriate. For locations experiencing erosion or inundation impacts that do not reflect an intolerable risk, these accommodation options provide the short-term coastal management tasks required to manage impacts in the immediate planning horizon.

6.4.2 Trigger 3

To inform anticipated trigger 3 decisions in the study area, appropriate interim protection measures were identified and assessed. A two-pass assessment approach was used.

In the first pass assessment, options were evaluated for each coastal management unit in turn to identify:

- whether interim protection measures are justifiable; and
- where they are justifiable, the nature of the works.

The second pass assessment considered those locations in the study area where trigger 3 is anticipated in the immediate planning horizon (15 years) or has already been reached. This assessment prepared and assessed more detailed concepts related to the preferred coastal protection approach.

The approach to assessing options at the time of trigger 3 was based on the adaptation pathway developed for the study area, i.e. that any decisions retain full flexibility of alternative options (including retreat) being taken at future trigger points. Any coastal protection works that are undertaken are interim only with a specific design life and should not be considered permanent. Beyond the current long-term (100 year) planning horizon, the likelihood of erosion and inundation of the vulnerable coastal zone (as identified in Stage 1 of the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project) will eventually be certain.

This means that the losses (land value) and costs (disruption to operations) associated with retreat are common to all possible measures taken in the foreseeable future. The various adaptation measures (accommodate or protect or combination thereof) will have a finite effective life and therefore will only delay these losses and costs, albeit considerably in some cases. To be financially preferable, the capital and ongoing costs of interim protection measures must be less than the benefit obtained by delaying the inevitable losses and costs of eventual retreat.

In line with the trigger based adaptation planning pathway, the option analysis (including but not limited to financial costs) for trigger 3 compared the following options:

- Retreat when risk become unacceptable; and
- Interim protection incorporating a range of 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 3 or trigger 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:

- at the decision trigger point which is determined by the level of risk to coastal assets; and
- over the life of that protection measure.

The technique known as multi-criteria decision analysis (MCDA) was used to make these comparisons (Department for Communities and Local Government: London, 2009). The Hi View software[4] was used for the analysis.

The generic steps in MCDA are:

1. Identify the options to be appraised;
2. Identify the criteria to be used to discriminate between options;
3. 'Score' each option in respect of each criterion;
4. 'Weight' the criteria to reflect their relative importance to the decision;
5. Combine the scores and weights to derive an overall weighted score and ranking for the options; and
6. Carry out sensitivity analysis to determine how changes in scores or weights affect the ranking.

In MCDA it is important that the criteria used to compare options meet a range of characteristics, namely:

- completeness -all important criteria have been included
- redundancy - exclude criteria that don't differentiate between the options
- operationality - each option must be able to be measured against each criterion
- mutual independence of preferences - preference scores of an option on one criterion can be assigned independently of knowledge of the preference scores on all the other criteria
- double counting - avoid criteria that are effectively reflecting other criteria
- number of criteria - avoid excessive numbers of criteria
- impacts over time - incorporate criteria that reflect impacts that occur over time (e.g. discounting of cash flows)

The decision criteria and metrics selected for the analysis are described in the following sections. The development of decision criteria was informed by the values reported in the Stage 2 report, to ensure that criteria encompassed all values identified in the risk assessment. This enabled the options evaluation process to respond to the risk assessment and weight the relative importance of the various values, based on the weighting of criteria.

Criterion: Loss of land value

Coastal erosion/inundation will eventually lead to a loss of the land within the zone denoted by the proposed special control area (SCA). The assessment assumes the retreat option leads to a loss of land value occurring linearly over a 50 year period from the time a decision is taken to retreat. It has been assumed that the interim protection options delay retreat for the design life of the protection measure (typically 20 to 50 years) and the same loss is incurred immediately thereafter.

[4] http://www.catalyzeconsulting.com/index.php/software/hiview3/

The metric is the discounted cost (loss of land value) over a 100 year timeframe from the point in time that a decision is made to retreat or protect. The difference between the retreat and protect options is therefore merely the difference in the discounted cost of the same $ land loss. Urban zoned land has been assumed to have a value of $1,500 / m^2 and industrial zoned land $200 / m^2. This was based on analysis of land sale data for the study area and in close proximity. Land values have not been attributed to other land uses. Escalation has been excluded from the calculation and a real discount rate of 2.1 percent has been applied.

Criterion: Interim protection costs

One or more coastal protection measures have been developed for each coastal management unit. The discounted capital, annual operating, and decommissioning costs for each option have been estimated and aggregated to provide an idea of the potential total discounted cost for a given approach.

Criterion: Industrial property impact

In addition to the cost of land loss, the owners of assets on the lost land will have additional impacts such as disruption and relocation costs. These are costs to the economy in general and are therefore appropriate to consider separately from land value. The loss of value of the buildings/facilities has not been considered, as to do so requires a lot-by-lot assessment which is far beyond the scope of this study, and in any case cannot be done without intimate knowledge of the nature of the land use and the existing and future value of those assets.

The number of lots within the proposed SCA has been taken as an appropriate metric to measure the overall scale of impact to owners of assets on land that will be protected for the life of the measure, albeit eventually lost. Industrial properties have been calculated as one metric.

Utility services are generally associated with zoned urban or industrial land and have therefore not been separately accounted for. Roads are similarly coupled with zoned land. However rail in the northern most management units has been treated as a special case. In coastal management units 1-3, there are no industrial lots. However the rail line services industry links between the port and industries to the south of these units. For Units 1-3 the rail reserve has been taken as a proxy for the existence of industrial property.

Criterion: Residential & commercial property impact

As urban zoned land incorporates both residential and commercial activities, these have been combined as one criterion. The metric is again, the number of lots within the SCA.

Criterion: Residual risk to property

Interim protection measures are designed to accommodate a specific risk, e.g. a 1 in 100 year storm event. Accordingly, such measures carry residual risk associated with either a failure of the coastal protection or an exceedance of the design event. These risks are dependent on the nature of the protection measure and the consequence of the failure/exceedance. These risks are absent from the Retreat option.

The metric for this criterion is a scale of 1-5 as judged by the coastal engineers that developed the proposed protection measure.

Criterion: Parks and reserves impact

Retreat and protection options both have implications for the enjoyment of the coast. An encroaching shoreline will eventually impact on the western edge of coastal parks and reserves, leading to the incremental loss of land unless the parkland can be supplemented through rezoning of land to the east. This criterion also includes the environmental value of the vegetated dune system that exists within the foreshore reserve. The retreat option is generally considered to retain this value as it is assumed that retreat will involve expansion and remediation of the foreshore reserve to maintain all values set out in SPP 2.6, unless the geography of a coastal management unit (such as a peninsular or point) does not facilitate such expansion.

The metric associated with this criterion is the area of parks / reserves within the SCA.

Criterion: Beach recreation/amenity impact

The coastal protection measures that involve armouring of the coastline itself (e.g. seawalls and revetments) temporarily protect the assets landward of the shoreline. However they also lead to the erosion and eventual loss of existing beaches and may impede coastal recreation. Beach nourishment offsets those impacts for the period that nourishment is feasible. Allowing the shoreline to recede naturally retains the recreation and amenity value of the beach environment.

The metric for this criterion is the lineal metres of beach in the coastal management unit. Weighting for this criterion considered the quality of the beach environment, and whether the beach is a public beach.

Criterion: Heritage

Heritage assets in the SCA will be protected for the life of the measures.

The metric used is the number of heritage properties in the coastal management unit.

Criterion: Habitat loss

The narrowing and disappearance of beaches has a number of ecological impacts including for shorebirds and coastal flora and fauna. This criterion relates to the ecosystem at the shoreline, particularly the intertidal macroinvertebrates and the shorebirds that feed on those species.

The metric used is the area of the intertidal zone, i.e. the length of beach x the distance between the high and low tide lines.

Table 6 summarises the criteria used and how they were used to score the options.

Table 6 Option decision crtieria

Decision Criteria	Metric	During the life of the interim protection measure:	
		Retreat means …	**Interim protection means …**
Loss of land value	Discounted cost ($)	Immediate loss of land value	Delayed loss of land value
Interim protection costs	Discounted cost ($)	Nil	Capital and operating costs
Industrial property impact	Number of potential lots affected	Relocation & disruption	Nil
Residential & commercial property impact	Number of potential lots affected	Relocation & disruption	Nil
Residual risk to property	Scale of 1-5	Nil	Risk from failure and / or extreme events
Parks and reserves impact	Area (ha)	Area lost to encroaching foreshore	Nil
Beach recreation / amenity impact	Lineal m of beach	Nil	Beach loss (for hard-passive engineering approaches)
Heritage impact	No. of heritage properties affected	Loss / degradation of heritage assets	Nil
Habitat loss	Area (ha)	Nil	Shoreline loss

6.4.3 Scoring of Options

Scoring in MCDA can be carried out in a number of different ways. In this exercise most of the criteria use quantitative data: discounted $, no. lots etc. Only residual risk to property was scored using a scale (1-5). The relative scoring method was used for all criteria, meaning that the scores are normalised, i.e. the option with the best result is given a normalised score of 100 and the option with the worst given a score of zero. Intermediate options are ascribed a pro-rata score between 100 and zero.

The assessment of the protection options included in the MCDA for each management unit, where an option included staging over time in relation to several trigger points within a management unit (e.g. current, 2070 and 2110), was based on only the extent of the infrastructure required to manage the extent of the risk at the time. For example, if only a small section of a management unit is experiencing intolerable risk in the immediate term, the MCDA scoring considered the costs and impacts associated with the immediately required stage of the option required to address immediate risk, rather than the ultimate long-term option. This ensured greater reliability of MCDA outcomes where immediate decisions are required.

6.4.4 Weighting of Criteria

The ‘swing weighting’ method was used to assign weights to each criterion. This method ascribes a relative weighting that reflects both the importance of the criteria and the range of difference in the raw scores. For example, cost is usually considered an important criterion but if the costs of all options are similar, the weighting is reduced to reflect that similarity. In the extreme, if costs were identical for each option, the relative weighting would be reduced to zero, reflecting the fact that cost is not a differentiator between options in that case.

It is GHD’s usual practice to survey stakeholders to determine the nominal weighting for the criteria set, i.e. the weighting that reflects the overall importance of each criterion. This nominal weighting is then adjusted by assessing the range of raw scores.

A survey was prepared to obtain input from stakeholders through meetings and consultation sessions. Figure 11 illustrates the range of weightings obtained from a small meeting of 11 community members and Curtin planning students at a consultation session at the City of Fremantle on the 7th September 2015.

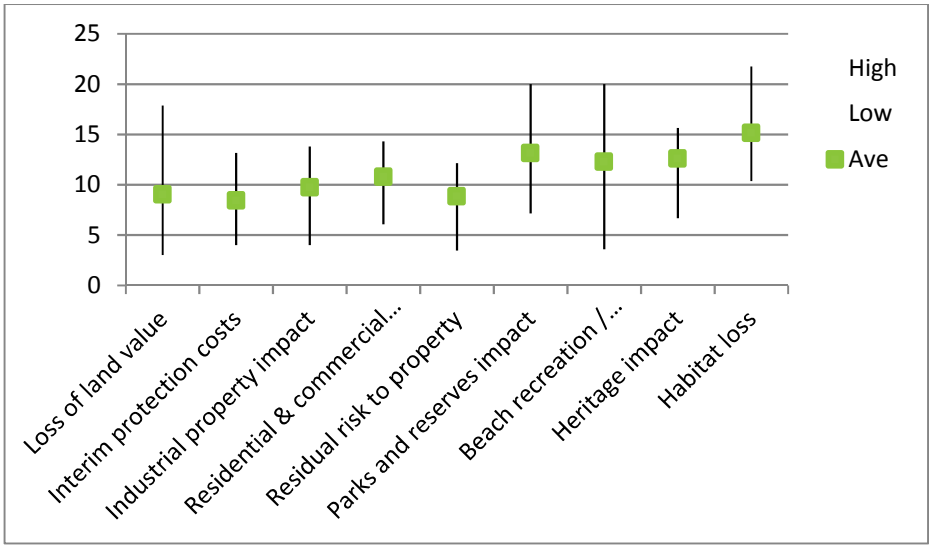


Figure 11 Nominal criteria weighting – meeting of 7th September 2015

It can be seen that there is considerable variation within this group. Figure 12 shows the average of these results in comparison to those of the GHD team.

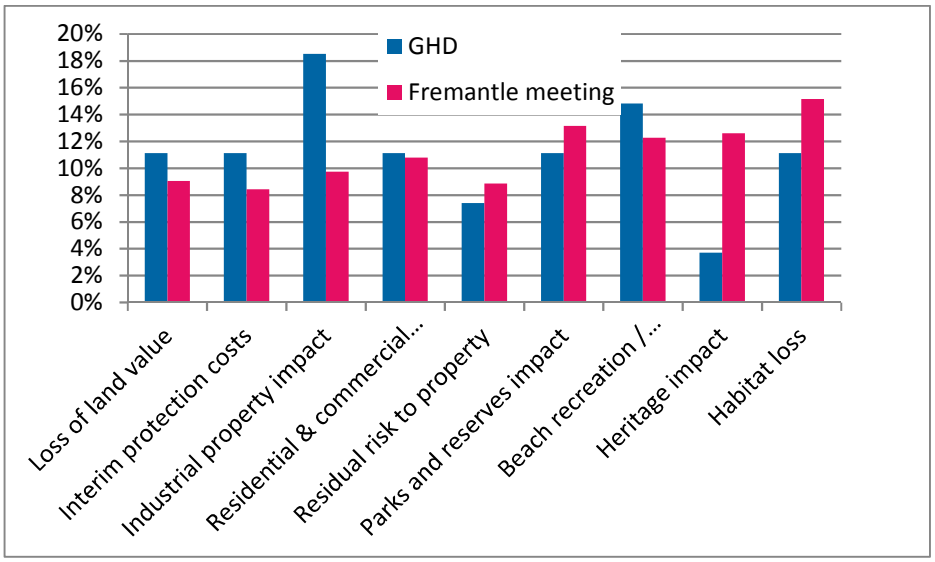


Figure 12 Nominal criteria weighting – GHD & community members

The results are similar for most criteria, differing significantly only in respect of industrial property and heritage impacts. As there have been insufficient survey responses to develop a nominal weighting representative of the views of stakeholders, the nominal weightings used for the MCA were assumed, informed by the local and regional significance of assets in the area and stakeholder inputs.

Because this exercise involves a large number of separate MCDA matrices with separate scoring (one for each coastal management unit), it is not feasible to engage with stakeholders to develop the final swing weightings. This was done initially in a workshop involving the GHD and Coastal Alliance teams on 10th September 2015, and then adjusted by GHD in preparing the final MCDA reported here.

6.4.5 MCDA process

The MCDA process used to evaluate adaptation options is described below. No assessment was made of certain management units for the following reasons:

- Units 6 & 7 Woodman Point –it is not considered feasible to protect this coastal zone.
- Unit 8 Australian Marine Complex (AMC) – there is very little impact in this area to 2110, the coast is already armoured in this area and additional protection measures will be determined by the asset owner.
- Unit 9 South of AMC boundary – rocky coastline with little impact to 2110.

The MCDA process was undertaken and reported here for Management Units 16, 17 and 18 on the Rockingham peninsula. However the risk in these units is also dependent on the coastal processes to the south of the peninsula which is outside of the study area. Results for these units are therefore only provisional.

The primary purpose of the MCDA process is to identify the relative preference for retreat or protect over the life of the protection measure. The secondary purpose is to rank the interim protection measures themselves. Accordingly the MCDA simulates an assessment made at the time that triggers a decision (Trigger 3), rather than any specific date.

The measures in many cases are staged. In the following the trigger point and time lag between stages has been nominally assessed for the purposes of the MCDA, but in reality will be dependent on the rate of sea level rise and actual erosion. The process to determine the initial trigger points is set out in detail in Section 1.1.

A discounted cash flow (DCF) analysis was used to compare the interim protection options for each coastal management unit. The full DCF spreadsheets are set out in the Adaptation Plans.

The process for swing weighting varies somewhat for each of the criteria types.

Costs

The normalised weighting was varied to reflect the variation in costs between the options. The variance is denoted in the following tables as the range of costs (R) divided by the average costs (A).

Other criteria

The normalised weighting was varied by assessing the relativity of the impact compared to the whole the study area, e.g. the percentage of all parks and reserves within the management unit. Where the criteria is not relevant to the management unit (e.g. there are no parks) the weighting falls to zero.

Sensitivity analysis

Sensitivity analysis was carried out on all the MCDA matrices to identify the robustness of the results to the weightings. The HiView software facilitates this analysis through identifying:

- the broad sensitivity of the result to the increase or decrease in criterion weighting:
- the sensitivity of a specific criterion to the most preferred option.

Plots depicting the former and most relevant criteria of the latter are set out in the adaptation plans.

6.4.6 MCDA Results

The full details of the MCDA weighted scores are included in the Adaptation Plans. The MCDA rankings are summarised in Table 7, with the preferred approach highlighted.

Table 7 MCDA Ranking of Options

CMU	Retreat	Hard- Active Protection Options	Soft Passive and Hard-Passive Protection Options
1	4	3 **1** 2	N/A
2	3	2	1
3	4	3 2	1
4	2	1	N/A
5	1	3	2
6/7	1	N/A	N/A
10	3	2	1
11	3	2	1
12	1	3	2
13	2	N/A	1
14	2	3	1
15	3	2	1
16	2	3	1
17	2	3	1
18	1	2	N/A

Table 7 illustrates the strong performance of the hard and soft passive engineering approaches in the MCDA. This arises essentially because these options provide protection to the landward assets as well as beach retention for the life of the measures. However as discussed in the following sections, the results need to be considered carefully in the light of other considerations such as materials availability and environmental impact.

6.4.7 Additional Evaluation

The Cockburn Sound – Adaptation Options Compendium was prepared to provide a listing of local adaptation options relevant to each coastal management unit of the study area based on the Stage 1 and Stage 2 reports. The compendium provides a strategic adaptation pathway, localised listings of interim protection and planning options, and a summary description of all adaptation options. The options defined in the Compendium represent a range of interim protection methods including beach nourishment, revetments, breakwaters, stabilisation etc.

Following the Compendium, the MCDA was undertaken. The primary purpose of the initial MCDA process was to identify the relative preference for Retreat or Protect over the life of the protection measure. In order to undertake an MCA, a limited number of potentially suitable interim protection strategies were selected for each unit which represented soft, hard, passive and active engineering principals to be compared against undertaking retreat. These concept options were based on a preliminary review of the coastal units and the protection options defined in the Compendium, with the objective to identify which approach is most preferred for a given stretch of coastline.

Based on the hazard mapping from Stage 1 and 2, the trigger points for decisions to either retreat or implement interim coastal protection works are well into the future for most parts of the coast in the study area. However in order to address growing erosion and inundation risks in CMU 3 and 15, more immediate planning and implementation was identified to be required. And therefore to ensure the local governments were better prepared to address these hazards, it was determined that a more detailed strategic MCA would be undertaken for these CMUs.

The purpose of this option evaluation process was to compare the benefits of different interim protection measures which fall into the preferred approach identified in the initial MCDA for coastal management units with a near term protection need.

As the options within the preferred approach would have the similar (or the same) values under the initial MCDA criteria, the options were compared by assessing the perceived performance within a given CMU and the potential costs of works.

Criterion: Performance

Coastal erosion / inundation will eventually lead to a loss of the land within the zone denoted by the proposed Special Control Area (SCA). The effectiveness of the interim protection options to reduce erosion was ranked through perceived performance and empirical evaluation.

Criterion: Capital Costs

The capital costs, annual operating, and decommissioning costs for each option would ultimately depend on the final design developed for construction. Therefore only preliminary high level cost estimates have been aggregated to provide a total discounted cost for a high level comparison between options. The difficulty in achieving a workable design and ability to construct a coastal protection structure varies significantly between protection options.

6.4.8 Results

The details of the additional evaluations for CMU3 and 15 are included in the respective Adaptation Plans.

6.5 Provisional Recommended Coastal Adaptation Measures

The provisionally recommended measures for each coastal management unit are described in detail in the adaptation plans, together with:

- explanations about the further work required to finalise near term decisions; and
- approximate trigger dates for future decisions.

The provisional recommendations are summarised in the following sections.

6.5.1 No action required

No action is proposed for the rocky coastline of Unit 9 (Henderson Cliffs Reserve area) which was identified as at minor risk of erosion / inundation to 2110.

6.5.2 Retreat

It is not considered feasible to protect the coastal zone in Units 6 & 7 in the Woodman Point area. The MCA process also identified retreat as the preferred option in Unit 5 (South of Coogee Marina), Unit 12 (Wells Park in Rockingham) and Unit 18 (Point Peron peninsula).

Accordingly it is recommended that the retreat option is adopted for these coastal units in accordance with the planning measures described in Section 5.

6.5.3 Immediate planning horizon (15 years) protection works

The trigger points for decisions to either retreat or implement interim coastal protection works are well into the future for most parts of the coast in the study area. Works that are presently required are as follows, based on the risks identified in Stage 1 of the study. All recommendations are subject to further work to confirm their feasibility.

Table 8 Provisional recommendations for near term protection measures

Coastal Management Unit	Local government / boundaries	Provisional recommendation	Subject to:
3	City of Cockburn / Pickled Fig Café to South extent of Robb Road	Initial stage (Present) • Build offshore breakwaters or groynes • Beach nourishment • Dune redevelopment • Investigate modifications to Catherine Point Groyne Later stage (2070) • Build additional offshore breakwaters or groynes	• Availability of materials • Relocation of the rail line • Environmental assessment
10	City of Kwinana South boundary of Naval Base Shacks camp ground to South boundary of Kwinana Power Station	Initial stage (Present) • Build seawall along the shore*	• Availability of materials • Influence of the outer harbour • Absence of public foreshore • Environmental assessment
11	City of Kwinana South boundary of Kwinana Power Station to South boundary of Kwinana Bulk Jetty	Initial stage (Present) • Build seawall along the shore*	• Availability of materials • Influence of the outer harbour • Absence of public foreshore • Environmental assessment
15	City of Rockingham Railway Terrace to Hymus Street	Initial stage (Present) • Install groynes or offshore breakwaters (nom. four) along the coastline • Undertake beach nourishment to establish artificial beach Later stage (2070) • Elevate the dune system • Install one way valves (Flap or Duck) on ocean storm water outfall pipes	• Availability of materials • Stormwater/groundwater studies • Environmental assessment • Mangles Bay Developments

* The MCA process identified that groynes and beach nourishment were the preferred options for CMU 10 and 11. However the recommendation is to adopt the 2nd ranked option (seawalls) due to the very large quantity of materials needed on an ongoing basis for the beach nourishment option (see also section 6.5.6).

6.5.4 Possible future protection works

The following summarises the coastal protection works provisionally identified as preferred through the MCA process.

Table 9 Provisional recommendations for future protection measures

CMU	Local government / boundaries	Provisional recommendation	Subject to:
1	City of Fremantle / South Mole to North boundary of South Beach	Initial stage (2070) • Build flood levee along rail road and protect • Raise revetments/breakwater along South Mole Fremantle • Install one way valves (Flap or Duck) on ocean storm water outfall pipes Later stage (2110) • Armoured flood levee at Bathers Beach	• Long-term planning of Fremantle west end • Availability of materials • Stormwater / groundwater studies • Environmental assessment
2	City of Fremantle / North boundary of South Beach North boundary Pickled Fig Café	Initial stage (2070) • Upgrade, extend and build new groyne structures • Place sand and build beach	• Availability of materials • Environmental assessment
4	City of Cockburn / South extent of Robb Road to Socrates Road/Pelinte View intersection	Initial stage (2110) • Adjust reclamation levels • Build additional seawalls	• Updated planning for Port Coogee • Availability of materials
8	City of Cockburn / West boundary of Woodman Point Facility to South boundary of Australian Maritime Complex	Initial stage (2070) • Raise breakwater, seawalls and general ground levels	• Updated planning for the AMC • Availability of materials
13	City of Rockingham / Kwinana / Rockingham local govt boundary to Wanliss Street	Initial stage (2070) • Dune stabilisation	• Availability of materials • Longevity of effectiveness of stabilisation
14	City of Rockingham / Wanliss Street to Railway Terrace	Initial stage (2070) • Install offshore breakwaters or groynes • Place sand and build beach	• Availability of materials • Environmental assessment
16	City of Rockingham / Mangles Bay	Initial stage (2070) • Upgrade, extend and build new groyne structures • Place sand and build beach	• Whole of peninsula assessment • Availability of materials • Environmental assessment • Mangles Bay Developments
17	City of Rockingham / Perron Foreshore	Initial stage (2070) • Upgrade, extend and build new groyne structures	• Whole of peninsula assessment • Availability of materials

CMU	Local government / boundaries	Provisional recommendation	Subject to:
		• Place sand and build beach	• Environmental assessment • Mangles Bay Developments

6.5.5 Costs

The land value has been assessed as the present market value of urban zoned and industrial land at unit rates of $1,500 and 200 per m^2 respectively. No financial value has been attributed to other land uses. The total land value is around $3.8 billion in present day 2015 dollars, the majority of which relates to urban uses, i.e. residential and commercial. Nearly 50% of the total study area land value is associated with Coastal Unit 15 in Rockingham.

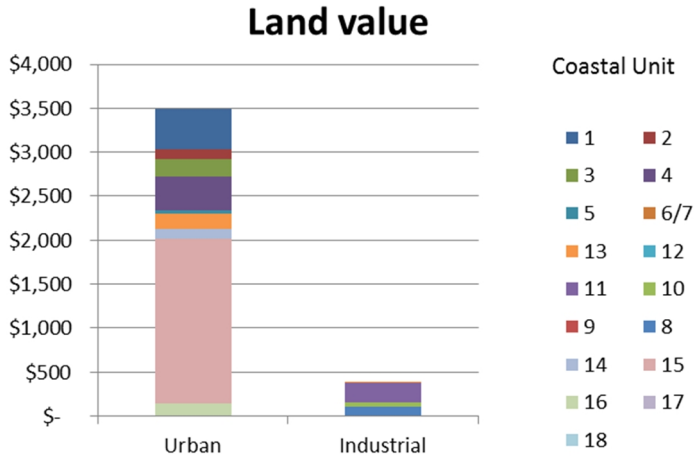


Figure 13 Urban and Industrial Land value

The adaptation measures invest in protection works (incurring costs) to delay the loss of land to erosion/inundation (loss of land value).

Table 10 summarise the potential accumulated costs that may arise from the provisionally recommended adaptation measures for all CMUs. All figures are in present day 2015 dollars. More detailed cost details are provided in the respective Adaptation Plans

Table 10 Cost of Provisional coastal works

Cost Items	Cost of works
Capital costs	$157 million
Operating costs	$165 million
Decommissioning costs	$47 million
Total	$369 million

Figure 14 presents the cumulative cost of the provisionally recommended adaptation measures through time to show the large ongoing expenditure that may be required. The loss of land value is delayed through the interim protection works is also shown to compare to the loss of land that would occur through retreat in all CMUs as deemed necessary through time if interim protection works were not implemented.

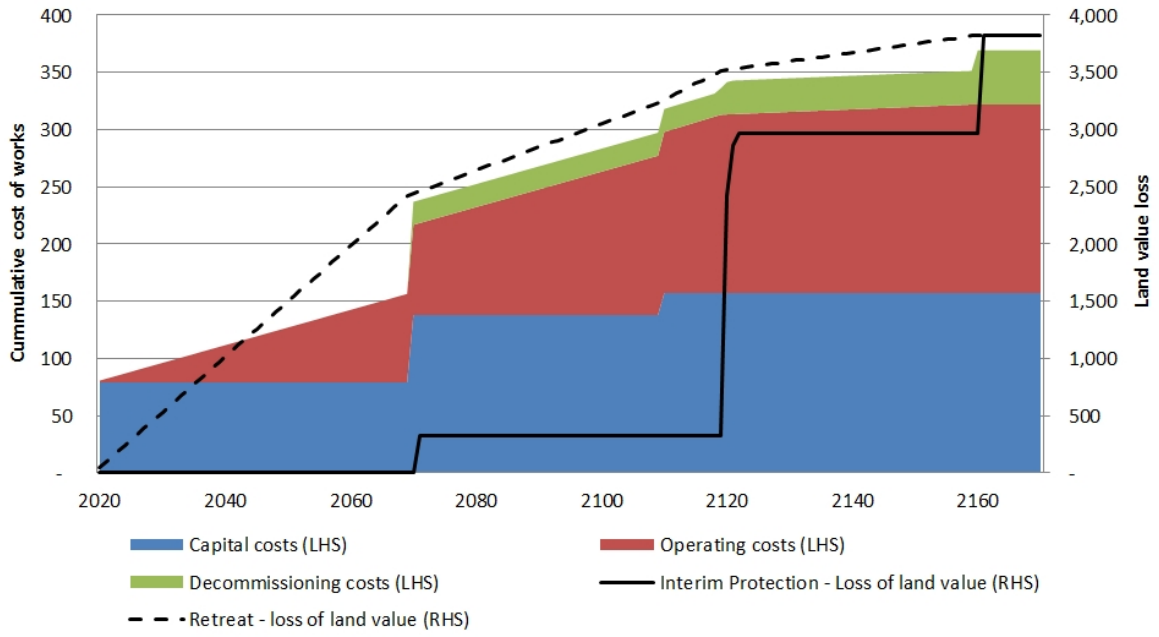


Figure 14 Cost of works and loss of land value

6.5.6 Availability of materials

The quantity of materials required for the preferred coastal protection options identified in Section 6.5 is very large over the period to 2110. Table 11 indicates the in-place volumes of materials and the installed cost in 2015 $ of these structures (which represents a significant proportion of total costs). The volume of sand is equivalent to the entire beach area along the subject coast to a depth of nearly 3m.

Table 11 Materials quantities required to implement provisional recommendations

	Volume (m3) in place	Cost (2015 $m)
Sand for beach nourishment	3,000,000	87
Rock for seawalls / revetments	560,000	140

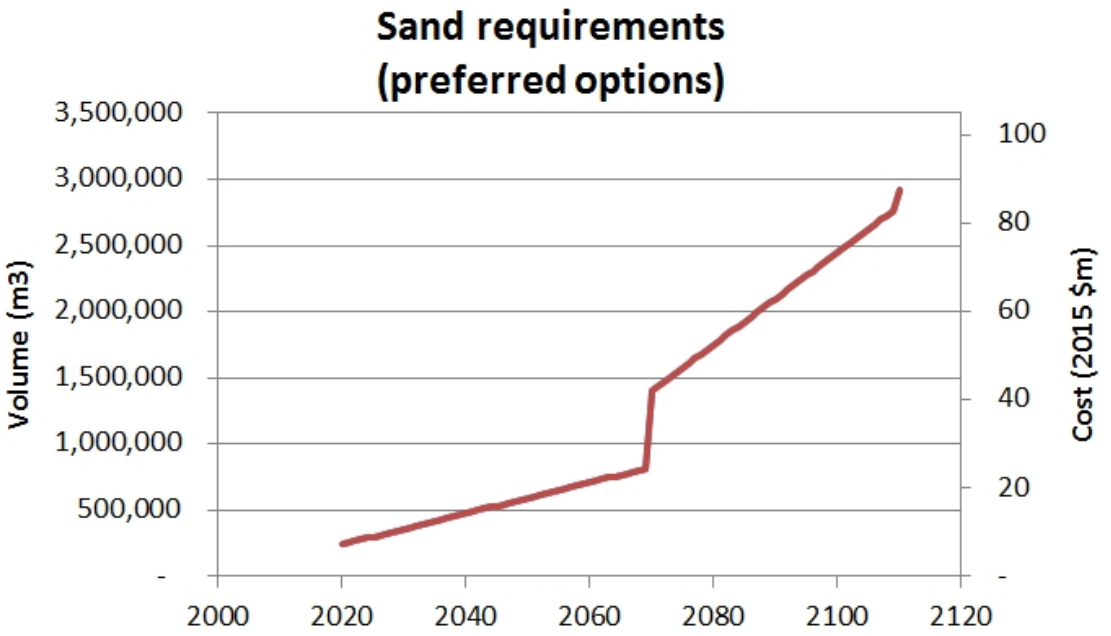


Figure 15 Sand quantities

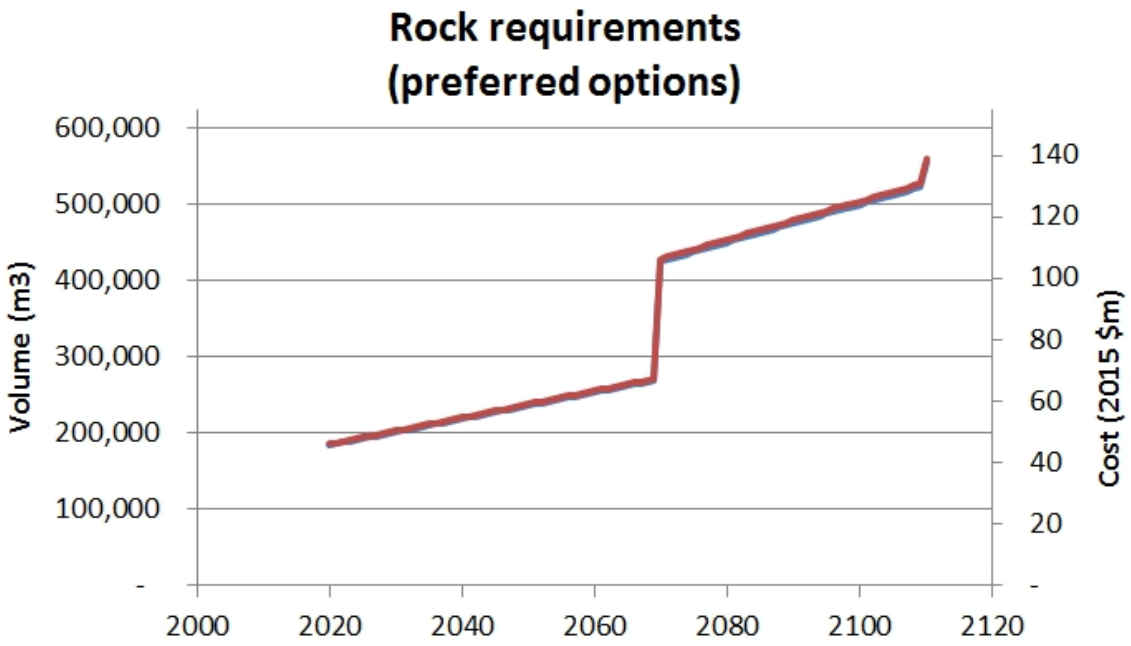


Figure 16 Rock quantities

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 lead to a limit in the supply of suitable materials required for the preferred provisional interim protection options.

Additionally, beach nourishment is proposed for a number of the CMUs in order to maintain public beach amenity which will place a long-term demand on a limited supply. Although sand may initially be sourced at localised accretion locations and from offshore dredging, the availability of suitable sources is likely to become increasing limited in the future in the Owen Anchorage and Cockburn Sound. The Stage 1 report suggests that there will be net erosion from the area by 2070.

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. Attempting to undertake a long-term material resource plan would require a detailed feasibility assessment which is outside the scope of this project. However, some commentary on the matter has been extracted from the recent Environmental Protection Authority Perth and Peel at 3.5 million Environmental Impacts, Risk and Remedies Report on the availability of land based raw materials:

- Raw materials are produced relatively cheaply, with the major cost being the transport to the construction site. Basic raw materials extraction sites are therefore required close to established and developing parts of the metropolitan area in order to keep projects feasible.
- Many sites which would otherwise be suitable occur in locations where the area has either been zoned for urban/industrial or already developed, commonly referred to as 'sterilised basic raw materials'. Basic raw materials also occur in areas with significant environmental values, these mainly being remnant vegetation, fauna habitat, and wetlands.
- The EPA considers basic raw materials should be used efficiently and for the most important uses, recognising supplies are not inexhaustible. In coming years, changed practices may reduce demand and alternative products may come on the market.
- Initial projections of the future supply and demand for basic raw material resources in the Perth and Peel regions by the Department of Mines and Petroleum indicate that local basic raw material resources will become scarce as the Perth and Peel regions expand to 3.5 million. This is particularly relevant for limestone and sand supplies in the southern corridor.
- Basic raw material supply constraints in Perth and Peel have been significantly exacerbated by a lack of sequential land use planning (e.g. zoning and developing land before basic raw material extraction has occurred). A significant portion of potential basic raw material supplies are currently 'sterilised' due to existing urban and industrial developments and encroachment, the majority of which occurred in the 1990s in the north-west corridor.

To test and confirm the longer term adaptation responses in the adaptation plans, it will be necessary to investigate 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 for each CMU over the long-term planning horizon. If it is determined that obtaining the required volumes of materials is unlikely to be viable then alternative techniques or pathways may be required.

As this is an issue for local governments across the metropolitan area, it is appropriate that such investigations are led by the state government. The study will enable government to prioritise coastal protection in future planning horizons.

6.5.7 Environmental Impacts

Coastal Recession

As the sea level rises and the coastline recedes, any contaminants present in the adjacent soil and / or groundwater will increase in mobility, potentially entering the sea. The land to the east of Cockburn Sound has included industrial land uses for many decades, and is known to be facing stresses from associated pollutants, including nutrients and toxicants such as metals and non-metallic inorganics (CSMC 2006).

Whilst the adaptation plans recommend protection in the current planning horizon, which would impede coastal recession, in line with the flexible adaptation pathway the issue of increasing risk of water quality from land contamination in Cockburn Sound will require investigation at some point to address how retreat is managed.

Coastal Protection Works

The provisional measures described in Section 6.5 involve significant ongoing coastal engineering works. Quite aside from the financial implications and availability of materials, the environmental consequences of such works needs to be considered, in particular:

- the impact of soft measures such as beach nourishment on the shoreline habitat; and
- the broader impact of construction works on the waters of Owen Anchorage and Cockburn Sound.

Beach Nourishment

While there is much focus on the consequences of hard engineering measures such as seawalls and similar structures, beach nourishment also has ecological consequences.

In particular the intertidal fauna (e.g. benthic invertebrates) is impacted either through the deposition process itself (compacting sediments or crushing animals) or through burial of the habitat. Schlacher et al (2012) found initial environmental impacts of beach nourishment in research in eastern Australia, and varying degrees of recovery after 5 months.

Research in Holland (Leewis et al, 2012) found no negative long-term consequences of beach nourishment on the abundance of four macroinvertebrate species, although noted that the responses of the species studied in the years following beach nourishment are species specific.

To test and confirm the longer term adaptation responses in the adaptation plans, it will be necessary to investigate the cumulative impacts of beach nourishment, including consideration of the environmental impacts of the beach nourishment program inferred by the provisional protection works.

Water quality

Marine works such as dredging, the construction of breakwaters, groynes and seawalls can create turbidity and elevated levels of Total Suspended Solids (TSS) leading to the exceedance of light attenuation coefficient (LAC) criteria. Elevated TSS can also be problematical for seawater intakes (e.g. the desalination plant).

The benthic habitat can be adversely affected by these factors, leading to a temporary loss of benthic primary producers (BPP) such as algae, aquatic plants and seagrass. Marine fauna and fisheries can also be impacted, noting that Cockburn Sound contains an important snapper nursery.

The provisionally identified coastal protection works, although quite limited in scope in each local government area, would occur sequentially over the next 100 years, and the cumulative impact of such works requires careful investigation. Cockburn Sound has its own State Environmental Policy that establishes standards and processes for monitoring ecosystem health. The policy provides the basis for the operations of the Cockburn Sound Management Council (CSMC).

To test and confirm the longer term adaptation responses in the adaptation plans, it will be necessary to investigate the cumulative environmental impacts of the provisional coastal protection works program identified in this report. Terms of reference for such a study should be developed in consultation with the Environmental Protection Authority (EPA) and the CSMC.

6.6 Accommodation measures

Under the approach recommended in this report, accommodation measures (see Table 12) would be considered both by public authorities and private asset owners / managers. Whether the responses of private owners should remain voluntary or be required by regulation (if possible) needs to be considered.

Table 12 Consideration of accommodation measures

Phase	Trigger	Government responses	Private responses
Phase 1	Assets at risk from rare events (500 year ARI)	Advice about increasing risk of future erosion / inundation	
Phase 2	Assets at risk from extreme events (100 year ARI)	Updated advice about increasing risk of future erosion / inundation Take emergency planning measures to accommodate inundation events	Building retrofitting to accommodate inundation events
Phase 3	Assets at risk from more frequent events (50 year ARI)	Coastal protection measures implemented: Take emergency planning measures to accommodate inundation events	Building retrofitting to accommodate residual risk of inundation
Phase 4	Assets at intolerable risk and coastal protection unviable	Retreat implemented: Take emergency planning measures to accommodate inundation events while assets are removed and relocated	

6.6.1 Emergency Planning

As the risk of inundation from storm events increases over time with sea level rise, it will be necessary for government to consider emergency planning to deal with such instances. There are many examples of emergency plans to deal with cyclones in Australia's north and the same basic elements apply, including:

- warning systems
- advice to infrastructure providers and occupants
- evacuation plans
- emergency services plans

6.6.2 Building retrofitting

The response of private owners remaining after risk levels rise, premises should be retrofitted to accommodate inundation events through flood proofing measures in accordance with the Building Code of Australia. Such measures need to consider not only the effect of flooding on the building fabric but also on services, particularly electrical equipment / cables.

6.6.3 Public infrastructure

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

7. Conclusions and Recommendations

7.1 Summary of adaptation approach

In summary, the adaptation pathway proposed in the adaptation plans would lead to:

1. The establishment of a special control area (SCA) for the land identified as at risk in the period to 2110 (noting that the landward extent will increase over time), which establishes a long-term intention to retreat from this area and provides for special planning instruments;
2. A firm concept plan for interim coastal protection of those parts of the coastline at risk in the current 15 year planning horizon, and a provisional plan for protection works thereafter;
3. Engagement with infrastructure providers to develop long-term plans to retreat from the SCA in the lead up to triggers that require such action, and servicing plans for the interim period;
4. Engagement with the owners of other assets in the SCA to develop long-term plans to retreat from the SCA in the lead up to triggers that require such action, and any plans for interim protection in the interim period; and
5. The updating of hazard mapping as new IPCC assessment reports are released, and implementation of the monitoring recommendations in the Stage 1 report.
6. Cockburn Sound Coastal Alliance requesting State Government funding to undertake a region-wide sand and rock availability and sourcing study.

The success of this approach will be dependent on strategic planning at the state and local levels to provide the necessary planning and support to deliver adaptation planning.

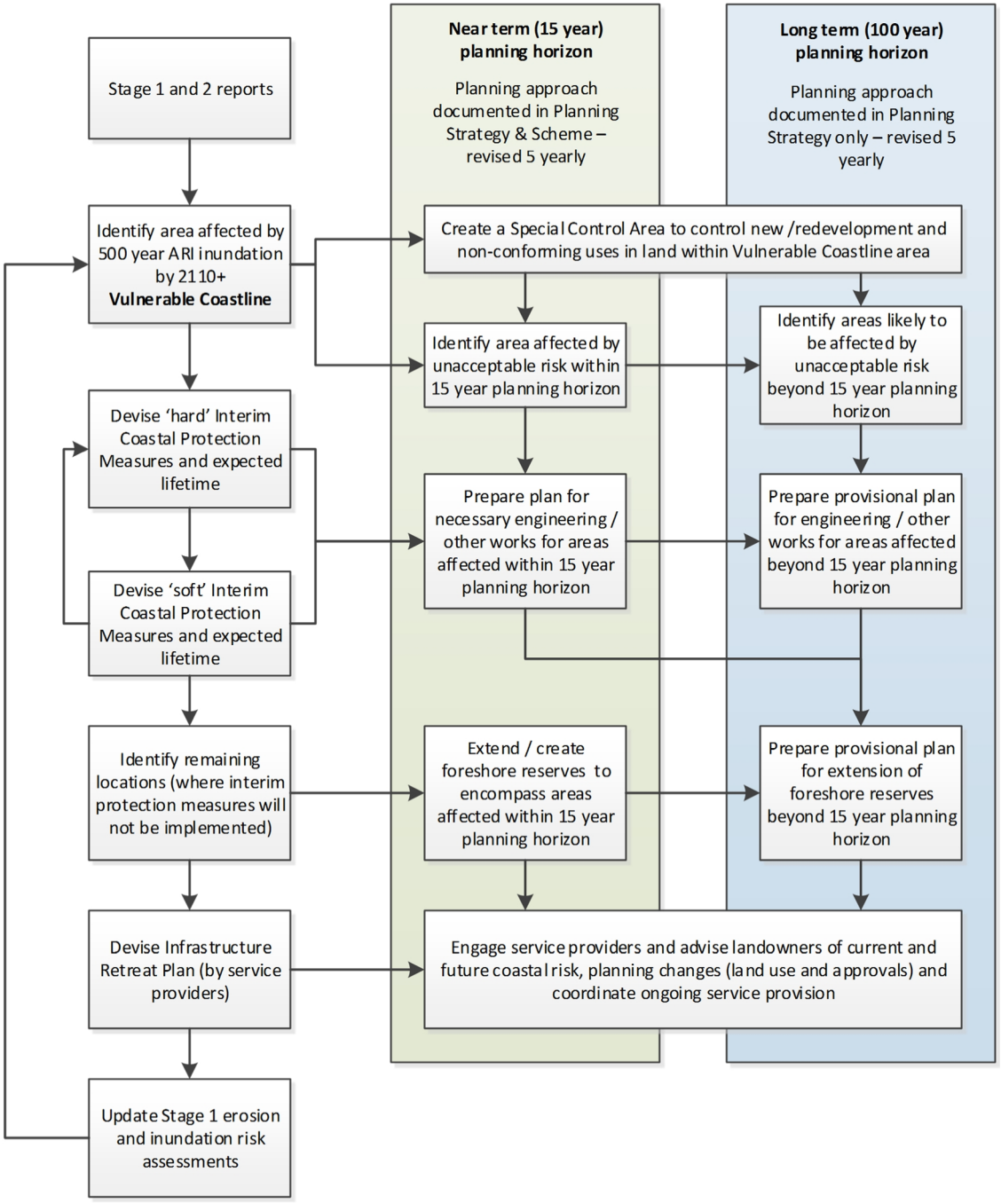


Figure 17 Summary of adaptation approach

7.2 Project Learnings and Recommendations

The key outcome of the Stage 3 identifies that, based on current day assumed community values, the community will pay for more time on the coast. However, there are limitations in the extent of the coast that is viable for protection, and it is likely that these values leading to a protection decision will change over time as the cost grows. It is important that adaptation pathways incorporate longer term strategic planning to prepare for retreat strategies for when the community no longer decides to pay for that time.

The following outlines the key conclusions and recommendations of Stage 3 of the Cockburn Sound Coastal Vulnerability and Flexible Adaptation Pathways Project.

Stakeholder engagement	
Key findings	Limited awareness and engagement by stakeholders and community Community stakeholders challenged to think beyond immediate planning horizons
Lesson learned	Adaptation planning projects should focus on awareness raising on hazards, risks, and impacts prior to attempting meaningful consultation on adaptation
Recommendations for future projects	Commence awareness drives during earlier project stages, rather than waiting for the adaptation planning phase. Ensure project delivery timeframes enable significant timeframes to undertake awareness campaigns prior to commencing targeted engagement and feedback events. Recognise the role of stakeholder and community engagement and develop adaptation pathways that communicate the long-term cyclical nature of adaptation planning, and also respond to the specific need of community and stakeholders.
Adaptation pathways	
Key findings	Pathways from Stage 2 report including “maintain”, “retreat” and “intensify” suggest a current decision between three options based on current values, rather than providing a dynamic pathway that maintains full flexibility at every trigger. Greater flexibility is achieved by a rolling decision making framework, supported by strategic planning to keep all options open. There was insufficient community and stakeholder awareness to make reliable decisions about current values, which is unreliable to make committed decisions regarding future planning horizons.
Lesson learned	Need to be careful about how pathways are described, and focus on decision points and cyclical decisions over time rather than recommending specific measures as a single solution. Need to engage the community in the issue, before they will engage in the adaptation strategies and pathways. Community engagement is more likely where a specific location and proposal can be discussed.
Recommendations for future projects	Be mindful about the next planning horizon and prepare adaptation pathways that do not ignore future challenges. Need to provide opportunity in pathways for decisions to be made based on values of the time, rather than now.
Roles and responsibilities	
Key findings	Local government does not have planning jurisdiction to deliver retreat strategies, as zoning of land and reservation of land for key infrastructure in the Perth Metropolitan Region is a State responsibility through the Western Australian Planning Commission.
Lesson learned	The success of adaptation planning requires engagement and delivery by the government agency that holds the authority for planning and zoning decisions.
Recommendations for future projects	Need for state government to lead coastal adaptation planning in the Perth Metropolitan Region, in particular to consider long-term impacts and retreat strategies in regional planning and schemes so that local governments can update their local planning strategies and schemes in response.

Coastal adaptation measures	
Key findings	Land-based approach, rather than asset based approach, reduced uncertainty regarding asset life and costs. Weightings were not adequately sourced from stakeholders and could not be determined beyond the immediate planning horizon.
Lesson learned	Conventional MCA techniques may not be best for binary decisions such as retreat vs protect. Consideration of the coast on unit by unit basis does not properly consider the cumulative impact of all proposed measures The full environmental consequences of cumulative measures over a long time-frame need to be considered on a whole-of-metropolitan basis.
Recommendations for future projects	Studies for local areas should be considered in the context of metropolitan-wide analysis

Specific adaptation measures for each coastal management unit are presented in the coastal adaptation plans.

7.3 Additional recommendations and actions

7.3.1 Community engagement

It is clear from general attendance at events, interest and queries received on the project, and other communications received, that the project and the Alliance have a significant task ahead in improving the overall efficacy of stakeholder engagement and involvement. Attendance to date has indicated either apathy or complete unawareness of the coastal vulnerability issues. Evaluation of the engagement activities to date suggests that a modified consultation approach is required to address new or emerging matters.

The Stage 3 Stakeholder Engagement and Communications Strategy has demonstrated significant gaps between the desired interest, awareness and concern of industry and community and the actual interest, awareness and concern of industry and community, in relation to climate change adaptation and coastal vulnerability.

Successful adaptation planning requires a pathway of long-term change management; this is clearly a long-term challenge. The following recommendations should be implemented to deliver long-term community awareness and enable the community to better engage with long-term adaption solutions.

1. Councillor and stakeholder briefings should be held upon completion of the various adaptation plans. Any stakeholder who has participated in previous events should be directly invited. All stakeholder groups in the stakeholder database should also be invited.
2. Upon completion of the adaptation plans, the Alliance website should be updated.
3. Upon completion of the adaptation plans, an internal staff memo should be produced for each local government to detail the potential short-term impact on members of staff.
4. Upon completion of the adaptation plans a media release should be prepared and forwarded by each of the local government to local news and media outlets.
5. All stakeholders who have participated in the project should be provided with a short outcomes summary. This should also include updated FAQs and links to the website, as well as a direction to the longitudinal survey. These participants should be asked if they are happy to continue to be contacted regarding the project.

6. The stakeholder database should be updated twice annually to ensure currency of contact personnel. It is common for people to move on from time-to-time; however this will ensure the database is as accurate as possible. This database should be considered an asset for future reviews of the adaptation plans.

7. The longitudinal survey should be mailed to the stakeholder database contacts annually. At this time the various Facebook and social media pages of the local governments should also include a link to the survey and website.

8. The website should be reviewed annually.

9. FAQs should be reviewed annually.

10. An annual program of focus group sessions is recommended. This will encourage long-term interest and awareness of the challenges of climate change adaptation and coastal vulnerability and potentially enable community groups to more actively participate in decision making.

The Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways project is an important project, which will have a significant and direct impact on a broad cross section of the community. Whilst the community has generally not shown a significant interest in this thus far, it is expected that once the significance of the financial, environmental and social impacts is better understood, the community will take a much greater interest. The Alliance should continue to be proactive in communicating the project, using the adaptation plans as a catalyst for engagement, and the above recommendations provide a coordinated pathway.

7.3.2 Testing adaptation recommendations

MCDA results across management units in Cockburn Sound and Owen Anchorage illustrate a strong preference for hard – passive engineering structures to delay the costs associated with retreat. To test the feasibility of these preferences across the study area, additional investigations will be necessary to consider feasibility of the individual decisions. Investigations that might be carried out at a regional scale by the Cockburn Sound Coastal Alliance include:

1. 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 for each CMU over the long-term planning horizon

2. Cumulative environmental investigation of engineering protection options on the water of Owen Anchorage and Cockburn Sound[5]

7.3.3 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.

1. The Department of Transport and other state agencies currently undertake monitoring and data collection regimes 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 this data by the City is recommended to allow for trends to be identified that may be affecting their coastline and to ensure that the information required for the design of coastal structures is readily available.

[5] The environmental investigation could be undertaken by, or of interest to the Cockburn Sound Management Council

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

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

4. 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.

5. Local tidal stations should be tracked to record, storm water level extremes and monthly mean sea level, to help interpret coastal management pressures, along with annual means (and exceedance levels) to help track requirements for adaptation. 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 local government boundaries to be identified.

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Appendices

Appendix A – Stakeholder and Community Engagement Outcomes Report

COCKBURN SOUND
COASTAL ALLIANCE

Cockburn Sound Coastal Adaptation Plan

Stakeholder Engagement and Communications Outcomes Report

March 2016

This Stakeholder Engagement and Communications Outcomes Report *("Report"):*

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The services undertaken by GHD in connection with preparing this Report:

- *were limited to the development of a strategy and does not include any assumptions relating to tasks and/or deliverables;*
- *did not include the completion of the activities recommended by this strategy.*

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to):

- *the discussions and agreements between GHD and the Client in preparing this Report;*
- *the general methodology for stakeholder engagement provided to the Client in the GHD response to tender.*

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Project Background

The City of Cockburn, on behalf of the Cockburn Sound Coastal Alliance (the Alliance), engaged GHD to deliver the Cockburn Sound Coastal Adaptation Plan.

The project forms part of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project, which includes:

- 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 – Close out and project evaluation

The objectives of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project are:

- 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;
- Facilitate the understanding of climate science, coastal hazards and risk management amongst key stakeholders (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.
- In consultation with the key stakeholder groups and community verify the intrinsic current and anticipated economic, socio-economic, community and ecologic values of assets (both physical and environmental) 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 (the project) supports a number of the above objectives, and 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. Sections of the Cockburn Sound and Owen Anchorage coastline are particularly exposed and vulnerable to the impacts of sea level rise, storm surge and changes in sediment regimes associated with a changing climate.

Outcomes Reporting

Purpose

The Stakeholder Engagement and Communications Outcomes Report (this document) describes the activities and tasks undertaken by the Project Team to engage with project stakeholders in the development of the Coastal Adaptation Plans (CAP). It describes both the process and the outcomes of each activity, and should be read in conjunction with the Stakeholder Engagement and Communications Strategy (the Strategy) upon which the activities and tasks were based.

Outcomes

Stakeholder engagement during the course of the project has not yielded significant stakeholder interface. The observations of the team, in relation to both the community and industry stakeholder groups, is that awareness levels for a project such as this and the potential impacts of climate change are very low. This is not inconsistent with the approach identified in the Strategy which proposed a long term change management approach to the subject matter, starting with basic levels of understanding and building awareness over time. However, *the level* of interest in the matter was extremely low and suggests a significant effort is required to communicate the adaptation plans to the community.

This report considers the low level of stakeholder interface and provides a recommendation for future activities that will continue to increase engagement into the future.

Engagement and Communication Activities

The engagement methodology involved a number of key activities to identify stakeholders, inform them about the Project process, provide opportunities for comment and document feedback for consideration by the Project Working Group. **Table 1** provides a brief description of the activity and purpose for each activity, as well as expected trimming and completion.

Table 1 Engagement and communications activities

Engagement Activity	Purpose	Timing	Complete?
Stakeholder scan	To identify stakeholders and other community members who will be affected by the project and ensure that all stakeholders are captured in the stakeholder database.	Initial Draft by mid-June	Yes
Stakeholder Database	Record and track all contacts made with community and other stakeholders. The system will hold information including contact details and issues raised.	Ongoing – Database set up by mid-June	Yes
Project website and email address	To provide mechanisms for ongoing information provision and feedback opportunities between the project team, key stakeholders and the broader community. It is anticipated that this will be managed through the Project Working Group.	Website review mid June	Yes
Project website and FAQs	Information about the project, including updates on project progress and activities will be made available online. This information will include all publicly released materials. Invitation to review the website will be via formal letter to key stakeholders and via local Government information channels for broader community.	FAQs mid June	Yes
Advertisements/media releases (prepared initially for project commencement and pre-prepared in case of events)	To raise awareness about the project amongst the broader community and highlight opportunities for the community to provide feedback on the Project. Media releases shall be prepared in the immediate term to enable quick response to various events.	Media release for early July launch	Yes

Engagement Activity	Purpose	Timing	Complete?
Information sheets/newsletters	To raise awareness and build understanding about the project and its progress, as well as to provide a summary of how stakeholder and community inputs have been considered and applied by the team throughout the Project. Newsletters will provide an opportunity for the project team to highlight project milestones and outcomes of work undertaken to date.	Start July launch	Yes
Key Stakeholder workshops	To provide information to the stakeholders about the project, seek their feedback and input into multi-criteria analysis and understand their main issues and concerns to ensure these are adequately considered in the Project.	July	Yes
One-on-one stakeholder meetings	To brief relevant stakeholders about the project and allow an opportunity for feedback/ questions. Follow- up meetings would be undertaken with key stakeholders as required.	July	Yes
Information Forum/s Focus Groups	To provide fora for interested or concerned community groups to be provided with relevant information or to be heard on matters which may concern them. Facilitated in a way which responds to the expected challenges of the engagement session at the time.	Late July for first information briefing Late July for first focus groups	Yes
Stakeholder Engagement and Communications Report	The information collated from all of the engagement activities will be synthesised into one report. This report will contain the 'top line' findings and will provide a summary of all the issues that have emerged from the stakeholders and community and how they have been addressed throughout the Project. The report will also provide a summary of how stakeholder and community inputs have been considered and applied by the team in completion of the Project.	Working Draft	Yes

Key Activities and Outcomes

This section details, by activity, the outcomes of the various stakeholder interface during the course of the Project.

Project website and email address

The CSCA developed a website and email address for the Project, and this went live in August 2015. http://cockburnsoundcoastalalliance.info/

Some amendments were made during August and September 2015 with the support of the City of Cockburn, generally to make the information more simple and user-friendly, noting that the subject matter is extremely complex for those without a technical background in coastal management.

Through the course of the stakeholder engagement program the website was periodically updated to include links to various events. In addition, the website was amended during September to enable counting of visitors to the site. The total number of visitors counted to the site is 66 (unique visits counted only).

Frequently Asked Questions

Frequently asked questions (FAQ's) were developed by the CSCA, and these were available when the website went live. The FAQ's include:

- CSCA Information Sheet
- FAQ - Coastal Project
- FAQ - Vulnerability Study
- FAQ - Port Coogee

These FAQ's were used heavily during community engagement events, and provide a useful information source when first visiting the website. Updated FAQs would be suitable once the adaptation plans are developed.

Media releases

A 'Project Introduction' media release was prepared at the commencement of the Project so that the Local Government Authorities (LGAs) could present some information to the media. It was assumed that each LGA would modify the media release as required.

In addition, a series of media releases were pre-prepared in case of events that may have affected the coast during the course of the Project, with one on 'Beach Erosion', one prepared for 'Storm Events' and one prepared for any other miscellaneous purpose (simply entitled 'Media Release'). Each of these pre-prepared

media releases enabled the various LGA to modify the name of the LGA as relevant, however, in general established a single line of response to ensure clarity and consistency of messaging.

The media releases are attached to this report at **Appendix A**.

Information sheets/newsletters

At the commencement of the Project, the Project team undertook to meet with a variety of internal stakeholders from each of the LGAs. A listing of the departments that the Project team engaged with is included under the heading 'One-on-one stakeholder meetings' below.

It became apparent at these meetings that knowledge of the Project, and in fact the overall adaption pathways project, was extremely low. The meetings themselves became an important first step in the communicating of information to the various internal stakeholders, however, it was determined that an internal staff memo which could be sent to all staff in the various LGA organisations would be suitable. Memos were prepared for each LGA and are attached to this report at **Appendix B**.

Key Stakeholder workshops

Key stakeholder workshops were offered to groups of key industry and business stakeholders. Attendance at these workshops was quite low; however, the following organisations attended:

- Water Corporation (Desalination Plant)
- BP Refinery
- Wesfarmers CSBP
- LandCorp
- City of Kwinana

The industry stakeholder workshop identified a lack of awareness of the project by industry operators. Coastal industries had a strong awareness of coastal hazards and risks, and some industries had undertaken their own assessments to inform their decision-making. There was a strong consideration that coastal adaptation along the Kwinana industrial strip requires a consistent, strategic approach in partnership between State Government and industries.

In addition to this key stakeholder workshop, the project team was also able to present to the Woodman Point Regional Park Community Advisory Committee which comprises the Department of Parks and Wildlife, the Department of Sport and Recreation, the Department of Transport and the Conservation Commission of Western Australia, and also includes a small number of community representatives. This session provided an overview of the project and encouraged members to be involved in the surveys and public forums described in in the next sections.

One-on-one stakeholder meetings

Local authority internal meetings

At the commencement of the Project, the Project team undertook to meet with a variety of internal stakeholders from each of the LGAs. The content of these meetings is not reported here, however, a listing of the departments that the Project team engaged with is below:

City of Cockburn

- Planning
- Infrastructure
- Parks
- Asset Management
- Communications

City of Fremantle

- Planning
- Urban Design
- Infrastructure
- Heritage
- Communications
- Office of the CEO
- Finance

City of Kwinana

- Planning
- Environment

City of Rockingham

- Planning
- Parks
- Coastal Engineering
- Communications
- Bushland Manager

Service Authorities and Key Industry Representatives

In addition to key stakeholder workshops, the project team directly offered a number of one-on-one workshops with various service authorities and industry representatives. A number of stakeholders did not respond to invitations; however, the following stakeholders took advantage of this offering between July and September:

- Brookfield Rail
- Water Corporation
- Western Power

Meetings were conducted with Water Corporation and Western Power to understand the processes used to identify assets at risk of climate change and the strategies for managing the assets impacted within the Cockburn Sound Coastal area. The meeting attendees included representatives from Infrastructure Planning, Asset Management and Environment. Both utilities have been considering climate change within their current asset management and infrastructure planning activities, but had not formalised their policy, strategy or procedures on climate change.

The assets at risk for Water Corporation include gravity sewer mains and pump stations. The asset lives of these assets will result in renewals of the current assets within the timeframe of the climate change predictions. Affected assets will be abandoned at the end of their life and retreated. This would be accomplished within the normal asset planning and replacement cycles. Western Power has a similar planning process and would abandon assets when the customer service connections were no longer needed or at the end of their useful life. Western Power's high risk assets are substations. There are none of these assets within the Cockburn Sound impact zones.

A meeting was conducted with Brookfield Rail to discuss risks to assets they manage, and assets managed by the Public Transport Authority which are leased to Brookfield Rail. Meeting attendees suggested that their lease agreement provides certainty that assets at risk would be protected, and anticipated this would be at the cost of the State Government. Attendees advised that broader strategic planning would be needed to consider the location and alignment of the freight rail, taking into consideration strategic planning and the future of both the Inner Harbour and the Outer Harbour.

Council Briefing

At the completion of the initial stages of the Project, and prior to holding public meetings with a broader cross section of the community, the Project team provided an opportunity for a briefing to the LGA Council groups. The City of Fremantle chose to have a briefing at this time, and a copy of the presentation is included in **Appendix C**. Other LGAs were able to utilise the presentation materials, website materials and staff memo information for feedback to other LGAs.

Information Open Day and Focus Groups

The Project team provided a number of opportunities for the broader community to be engaged in the Project, either by way of information only (one-way communication) or through a focus group environment. A variety of opportunities was offered as a way to provide a greater likelihood of engagement with the community.

Initially, two 'Information Open Day' and four 'Focus Groups' were offered. The invitation, attached at **Appendix D**, was directly emailed to a consolidated list of community organisations and representatives as follows:

- Perth Region NRM
- Friends of Woodman Point
- Naragebup Environment Centre
- Friends of Point Peron

- Friends of Bathers Beach
- Leighton Beach SLSC
- Coogee Beach SLSC
- Coogee Beach Progress Association
- Kwinana Beach Coastcare Group
- Secret Harbour SLSC
- The Cruising Yacht Club of Western Australia
- Mangles Bay Fishing Club
- Youth Advisory Committee
- Rockingham Volunteer Sea Rescue Group
- Rockingham District Historical Society
- Rockingham Triathalon Club
- Cockburn Volunteer Sea Search and Rescue
- Rockingham Parkrun
- The Rotary Club of Palm Beach
- Point Peron Camp School
- Rockingham Naval Club
- Jetpack Perth
- Skippers Ticket Boat School
- Cockburn Power Boats Association
- Perth Kitesurfing School
- Jervoise Bay Sailing Club Inc
- Woodman Point Recreation Camp
- Coogee beach Holiday Park
- Fremantle Sailing Club
- Fremantle Sea Rescue Group
- Rockingham Kwinana Chamber of Commerce
- Rockingham Wild Encounters
- Real Estate Industry of WA (Rockingham Branch)
- Perth Boat School
- Marine Safety Foundation
- Boating Industry Association (BIA - WA)
- Marine Industries Association
- SeaBird Rescue

Through this stakeholder group, the Project team was also able to attract some individual residents and students of planning.

The email comprised the following text:

To whom it may concern:

You have been identified as being a representative of an organisation that may have a specific interest in the development of coastal adaptation plans for the Cockburn Sound and Owen Anchorage coastal area.

The attached flyer provides a brief summary of the project and identifies various sessions that you, and your members and affiliate organisations, may be interested in attending. There are a number of opportunities to be involved and no one session is specific to any particular section of the coast.

We invite you and your members to attend one or more of these sessions. We also encourage you to forward this invitation to any affiliate organisations or members of the public that you think would be able to provide input to this process. Links to the website are provided if you are seeking further information.

The resulting response to the invitation was not strong, and a follow up Media Statement, Facebook advertisement and email (the email sent to the above invitees) to seek increased attendance at the final two focus groups was undertaken.

Notwithstanding, with no attendances registered at two of the focus group sessions, the Project team and CSCA agreed to hold a further Focus Group session on the 8th September. Again, the stakeholders identified above were directly emailed (invitation also attached at Appendix D), and the City of Fremantle undertook a strong Facebook campaign to increase awareness.

Attendance

In total, 26 people were engaged via the Information Open Day opportunities at the Fremantle Woolstores and the Rockingham Shopping Centre, and a total of 17 people were engaged via the Focus Group Sessions.

Content

Information Open Day

The resources used to discuss the Project with interested community members at the Information Open Days are attached at **Appendix E** which includes the combined vulnerability maps (erosion plus inundation) included as part of the overall presentation materials. The format was a typical shopping centre pedestrian capture opportunity, where community members had the opportunity to self-select to discuss the Project with the team in attendance. A summary of the outcomes of those discussions are included below.

Participants were provided FAQ forms, and invited to the Focus Group sessions, as well as asked to share information about the Project with their networks.

Focus Groups

The Focus Groups were a more formal activity, with a presentation provided followed by an opportunity for 'Question and Answers' (Q&A) and then a discussion about the weighting survey (see the section on Multi-Criteria Analysis below).

The presentation included a full run through along the coast of the reporting outcomes and can be found in **Appendix F**. The focus group presentation also included the combined vulnerability maps (erosion plus inundation).

Outcomes

Information Open Day

Four key themes were noted by the Project team from the Information Open Days:

1. The community have noticed a significant change in the coastline over the last few decades, and wondered what the LGAs were doing to manage the issue.
2. The community had not heard of the Project at all before this information was presented.
3. The community had a tendency to assume that any coastal impact that affected them would be managed by 'other' (generally identified as the LGA).
4. Some members of the community were alarmed about the lack of response to the issue of vulnerability compared to other places (e.g. Hervey Bay, Glenelg).

Other comments included a lack of concern due to the long term nature of the issue and the likelihood of it affecting them personally, and more specific commentary around the possible measure that the adaptation plan would take in response to the vulnerability identified.

Whilst some participants did note their concern for the future, few considered the issue substantial, and no participants subsequently attended the Focus Groups.

Focus Groups

Participants of the Focus Groups were noted as more likely to have had some previous information about the project or were generally interested in climate change and adaptation. The discussion themes were generally around more detailed elements of the adaptation planning process. The following comments reflect a cross section of the discussion during the Q&A session:

- Generally the extent of the vulnerability surprised many.
- Sand nourishment can impact nearby beaches creating off-site impacts e.g. people jumping off the jetty into shallow water etc.
- Regarding re-vegetation and volunteers - survival rates were relatively low; however, professionals make it more successful.
- Can we understand where the historical shoreline movement has come from and make a more localised assessment?
- Who picks up the cost?
- Who approves these developments and if the adaptation plan is endorsed does State Administrative Tribunal or Development Assessment Panels have any control - what frightens us is that the government overrides decision making of communities.
- Stakeholders want to know what it's all about, but we need to encourage more people to consider longer term issues.
- Is the state government involved?

Participants expressed a desire to continue to be involved in the Project going forward, and all attendees are registered will be invited to future events.

Longitudinal Survey

During the course of the Project, it was determined that a participant survey, which could be regularly undertaken, would be an excellent way of assessing long term changes in attitude to the issue of coastal vulnerability. The Project team has developed a survey which is not time specific and can be utilised by the LGAs to test improved knowledge of the adaptation plans, the potential impacts, and increase awareness of the actions being undertaken. The survey is intended to be repeated at intervals of one year, and can be an effective tool for use in future reviews of the various adaptation plans.

The draft survey is included at **Appendix G** and will be placed on the CSCA website and advertised to the stakeholder database at various intervals.

Multi Criteria Analysis (Stakeholder Weightings)

A multi-criteria analysis process has been used in the development of the adaptation plans. Whilst the methodology and analysis of the multi-criteria analysis tool is described in the Final Cockburn Sound Coastal Alliance Adaptation Plan Report, it is important to note that participants in the broader community engagement exercise were also invited to provide feedback on the weightings for the various criteria chosen by filling in a short spreadsheet.

These were received directly at the Focus Group sessions, via email and/or discussed over the phone with interested stakeholders. The content of the spreadsheet is comprised with the Focus Group presentation at **Appendix F**.

Adaptation Plan Councillor Briefings

At the conclusion of the draft adaptation plans, the project team presented the individual adaptation plan to each Council. Each of the Local Government elected member's briefings consisted of the same material albeit each presentation provided a more detailed analysis of the adaptation measures specific to that Council area. An example presentation can be found at **Appendix H**.

Each group focused on the slightly different aspects of the adaptation planning as was relevant to their administrative area, although each of the elected member groups were generally receptive to the adaptation planning approach. A consistent theme amongst the representatives was the need to be responsive to, and in some cases encourage liaison with, State Government in the adaptation planning process, given the variety and array of State Government assets that are actually at risk.

The representatives were also concerned by the engagement within their communities, and indicated a desire to achieve better engagement with the community in the future; this also extended to recognition that more information was required to be presented to the Councillors themselves to enable more communication with the broader community. This extended to the need to be better equipped to provide advice to the community on the various options available for mitigating risk, and being able to more simply enunciate the pros and cons of each option (i.e. the conflict between retaining beaches and constructing sea walls).

In general, each Council group consulted recognised the complexity of the adaptation planning process, the long time frames associated with the decision making process, and the layering of options that may be relevant in delivering on the adaptation plans.

Adaptation Plan Focus Groups

As a final follow up to the earlier information open days and focus groups, the original stakeholder engagement plan proposed a series of 'presentation' focus groups where the adaptation plans would be displayed so that the broader community could be informed of the project outcomes and be provided with an opportunity for feedback. However, based on the earlier observations of the project team around a general lack of awareness of the project, it was considered that these focus groups would likely be poorly attended and would not have the desired effect.

As such, the project team with the CSCA agreed that these focus groups sessions would not go ahead. It is now recommended that a more relevant program of establishing awareness of the project is proposed through various project based activities such as foreshore management planning and other community activities.

Evaluation

A critical component of any stakeholder engagement program is the monitoring and evaluation of performance against the desired outcomes. The key evaluation tools used for this Project have included

- Number and type of queries received through the stakeholder feedback mechanisms (information line, email, reply paid mail);
- Level of media interest;
- Quality and quantity of submissions received via engagement mechanisms;
- Attendance rates at engagement activities; and
- Project team de-brief session on lessons learnt at the completion of each phase of the Project.

It is clear from general attendance at events, interest and queries received on the Project, and other communications received, that the Project and the CSCA have a significant task ahead in improving the overall efficacy of stakeholder engagement and involvement. Attendance to date has indicated either apathy or complete unawareness of the coastal vulnerability issues. Evaluation of the engagement activities to date suggests that a modified consultation approach is required to address new or emerging matters.

This has already been actioned by the preparation of internal staff memos and the addition of a further Focus Group session, however, beyond the scope of the current Project, a number of important additional activities will need to be undertaken to improve outcomes over time. These are discussed in the following section.

Recommendations

The CSCA Stage 3 Stakeholder Engagement and Communications Strategy has demonstrated significant gaps between the *perceived* interest, awareness and concern of industry and community and the *actual* interest, awareness and concern of industry and community, in relation to climate change adaptation and coastal vulnerability.

Whilst the Strategy had proposed a pathway of long term change management, this position has been confirmed and is quite clearly a long term challenge. The following recommendations should be implemented to deliver long term community awareness and enable the community to better engage with long term adaption solutions.

1. Councillor and stakeholder briefings should be held upon completion of the various adaptation plans. Any stakeholder who has participated in previous events should be directly invited. All stakeholder groups in the stakeholder database should also be invited.
2. Upon completion of the adaptation plans, the CSCA website should be updated.
3. Upon completion of the adaptation plans, an internal staff memo should be produced for each LGA to detail the potential short term impact on members of staff (i.e. members of staff may be contacted by the public or Councillors seeking clarification or requesting more detailed information on matters that directly impact their property).
4. Upon completion of the adaptation plans a media release should be prepared and forwarded by each of the LGA to local news and media outlets.
5. All stakeholders who have participated in the Project should be provided with a short outcomes summary. This should also include updated FAQs and links to the website, as well as a direction to the longitudinal survey. These participants should be asked if they are happy to continue to be contacted regarding the Project.
6. The stakeholder database should be updated twice annually to ensure currency of contact personnel. It is common for people to move on from time-to-time, however this will ensure the database is as accurate as possible. This database should be considered an asset for future reviews of the adaptation plans.
7. The longitudinal survey should be mailed to the stakeholder database contacts annually. At this time the various Facebook and social media pages of the LGAs should also include a link to the survey and website.
8. The website should be reviewed at least annually. In the initial stages of publishing the plans, it would be suitable to provide an update at each major milestone (e.g. if a foreshore management plan is completed in the study area).
9. FAQs should be reviewed at least annually, or at such time as current knowledge/information would change the content of the FAQs, whichever is the earlier.

10. The CSCA should continue with awareness raising via a number of methods, including specific information on the website, social media, local media format (local newspapers especially when free), fact sheets, via an ongoing longitudinal survey, within projects (e.g. during preparation of individual foreshore management plans) and through an ongoing interaction with the broader community. The ongoing engagement strategy needs to be a process of regular and repeated opportunities to inform and engage with the community so that the values of the community can be properly assessed.
11. An annual program of Focus Group sessions is recommended. A primary role of this program would be to regularly gather information about the value of the coast to the community, and gauge the changing attitudes/values over time to the coast and coastal adaptation. This will also encourage long term interest and awareness of the challenges of climate change adaptation and coastal vulnerability and potentially enable community groups to more actively participate in decision making. This can be built into the program suggested in recommendation 10.

The CSCA Project is an important project, which will have a significant and direct impact on a broad cross section of the community. Whilst the community has generally not shown a significant interest in this thus far, it is expected that once the significance of the financial, environmental and social impacts is better understood, the community will take a much greater interest. The CSCA should continue to be proactive in communicating this Project, and the above recommendations provide for a coordinated pathway.

Appendix A

Media Releases

COCKBURN SOUND
COASTAL ALLIANCE

Project Introduction

The Cockburn Sound Coastal Alliance (CSCA) is a partnership between the Cities of Cockburn, Fremantle, Kwinana and Rockingham and Perth Region NRM. The Department of Transport, Department of Planning, Department of Environment and Regulation, Cockburn Sound Management Council and Department of Defence are key stakeholders. The overall aim of the CSCA is to identify the vulnerability of Owen Anchorage and Cockburn Sound coast to the effects of coastal erosion and inundation, to understand what this means for the people of the City and their assets, and to plan for and mitigate against the possible impacts.

The study area within being considered by the CSCA extends for approximately 45Km from the South Groyne of Fremantle Harbour in the north to the Garden Island Causeway in the south and includes the eastern side of Garden Island.

The City of [Cockburn] is currently in the third stage of this four stage project. The City of [Cockburn] is seeking to engage key stakeholders including community representatives that are affected, to assist in producing an adaptation plan.

The Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project (the project) is being run by the Cockburn Sound Coastal Alliance (CSCA). The Alliance is made up of four local governments, the Cities of Fremantle, Cockburn, Kwinana and Rockingham with project partners the Department of Planning, Department of Transport and Department of Environment Regulation.

The objectives of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project are:

- 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;
- Facilitate the understanding of climate science, coastal hazards and risk management amongst key stakeholders (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 under different timeframes and sea level rise scenarios
- Identify and evaluate potential adaptation options for vulnerable areas;
- Quantify the risks in terms of consequence and likelihood of those hazards identified.
- In consultation with the key stakeholder groups and community verify the intrinsic current and anticipated economic, socio-economic, community and ecologic values of assets (both physical and environmental) 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.

The project is made up of four stages:

Stage 1	Coastal Vulnerability Assessment (Commissioned in 2011 and completed in February 2013). This stage set out to analyse the existing effects of coastal processes and to determine the vulnerability of the coastline due to sea level rise, erosion and flooding.
Stage 2	Values and Risk Assessment (Commissioned in 2013 and completed in November 2014). This next stage took the results of that analysis and determined what impact would that have on existing assets and undertook an initial assessment of adaptation options.
Stage 3	Coastal Adaptation Plan (Commissioned in April 2015). This is the existing stage of the project that carries on from Stages 1 and 2 to refine the adaptation options by consulting with stakeholders. Please see further detail in next section.
Stage 4	Close out and Project Evaluation (TBA). This stage looks to implement the first stage of the adaptation actions such as management plan reviews and dune vegetation planting.

The present stage (Stage 3) of this project is 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 due to storm surge and sea level rise. The objectives of this engagement are:

- To consult with government agencies to ensure relevant issues are captured in the Coastal Adaptation Plan (CAP);
- To ensure all interested stakeholders have the opportunity to participate in the CAP project phase;
- To effectively engage with key community groups and stakeholders to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone and potential adaptation options;
- To inform the community and other stakeholders on opportunities to participate in the delivery of an effective CAP (or Plans);
- To encourage informed comment on the CAP;
- To progress engagement about impacts, issues and benefits; and
- To assist the project team in developing appropriate mitigation measures in response to key issues raised as part of the engagement process

For more information on this project including inundation prediction maps please visit the CSCA website http://cockburnsoundcoastalalliance.info/

If you would like to get engaged, please contact Craig Perry, CSCA Coastal Project Coordinator on (08) 9411 3426 or email cperry@cockburn.wa.gov.au

COCKBURN SOUND
COASTAL ALLIANCE

What is the City of [Cockburn] doing about beach erosion?

The City of [Cockburn] has been proactive in dealing with and adapting to environmental effects such as storm events, sea level rise and erosion. A significant step towards addressing this issue has resulted in the proactive formation of the Cockburn Sound Coastal Alliance (CSCA). The CSCA are currently in Stage 3 of a four stage project preparing the *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Plan*. For more information on this project please visit the CSCA website http://cockburnsoundcoastalalliance.info/

Further to this extensive project, the City of [Cockburn] is carrying out dune rehabilitation [and sand nourishment]. The health of the dunal system is vital to minimise the impact of storm events as they act as a natural barrier. This rehabilitation involves improving beach access points to minimise the impacts on dunes caused by non-formal access, through revegetating dunes with native vegetation and through nourishment of beaches when significant storm events have occurred. The City encourages the community to engage with community groups that assist with these rehabilitation programs. For information on how to get involved please visit the City's website.

COCKBURN SOUND
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Media Release

Since 2011, the City of [Cockburn], along with the Cities of [Fremantle, Kwinana and Rockingham], and project partners the Department of Planning, Department of Transport and Department of Environment Regulation, have been working to address erosion and coastal inundation of the Cockburn Sound coastline. Erosion and inundation have been apparent along the Cockburn Sound throughout history with the coastline constantly moving and re-shaping; however, over time the coastline has been developed and there are now areas of vulnerability which need to be addressed in the short term.

The work being undertaken by the project partners is via a four staged project; the *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project*. This alliance of Local Governments and resource managers all share responsibility for the Cockburn Sound coastline and have formed the Cockburn Sound Coastal Alliance (CSCA).

The CSCA is now in the third stage of the project. Stage three involves investigating the results of the previous stages which analysed the existing conditions and potential impacts, and then engaging with coastal communities, key stakeholders and Local Governments to ensure they are prepared to respond to the potential challenges posed.

For more information on what the City of [Cockburn] is doing to address coastal inundation and erosion, please visit the City's website [www.cockburn.wa.gov.au] or the CSCA website http://cockburnsoundcoastalalliance.info/

COCKBURN SOUND
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Storm Events

One of the greatest impacts to both the physical coastline and the assets along the coastline occurs as a result of naturally occurring major storm events. The impact of these can be predicted by modelling, however, the actual impact, and the time and date of the impact are unknowns. The City of [Cockburn] has been addressing the impact of storm events through rehabilitating the natural barriers that are provided by a healthy dunal system [as well as regular sand nourishment programs]. However, the time has come to be proactive in dealing with and adapting to significant natural events including storms, coastal erosion and coastal inundation.

A significant step towards addressing this issue has been to join the Cockburn Sound Coastal Alliance (CSCA). The CSCA is currently in stage three of a four stage project referred to as the *Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project*. For more information on this project please visit the CSCA website http://cockburnsoundcoastalalliance.info/

Appendix B

Staff Memos

COCKBURN SOUND
COASTAL ALLIANCE

How the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project affects you

The City of Cockburn is currently in the third stage of a four stage project that looks at the short and long term impacts of **erosion and coastal inundation** on our coastline. The Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project (the project) is being run by the Cockburn Sound Coastal Alliance (CSCA). The Alliance is made up of four local governments; the Cities of Cockburn, Fremantle, Kwinana and Rockingham with project partners the Department of Planning, Department of Transport and Department of Environment Regulation.

The **aim of the project** is to understand what this means for the people of the City and their assets, and to plan for and mitigate against the possible impacts. The City is seeking to engage key stakeholders including community representatives that are affected, to assist in producing an adaptation plan.

The present stage (Stage 3) of this project is 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 due to storm surge and sea level rise. What this entails includes:

- Consulting with government agencies;
- Engaging with all interested stakeholders;
- Engaging with key community groups and members to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone;
- Assisting the project team in developing appropriate mitigation measures in response to key issues raised as part of the engagement process.

As a member of the City of Cockburn staff, you may soon start to hear more about the project, either from internal staff or from the community at large. You are encouraged to find out more information on this project (including erosion and inundation prediction maps) by visiting the CSCA website at http://cockburnsoundcoastalalliance.info/

Alternatively, your internal point of contact for any queries relating to this project is:

Craig Perry – Coastal Project Coordinator, on 9411 3426, cperry@cockburn.wa.gov.au

COCKBURN SOUND
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How the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project affects you

The City of Fremantle is currently in the third stage of a four stage project that looks at the short and long term impacts of **erosion and coastal inundation** on our coastline. The Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project (the project) is being run by the Cockburn Sound Coastal Alliance (CSCA). The Alliance is made up of four local governments; the Cities of Cockburn, Fremantle, Kwinana and Rockingham with project partners the Department of Planning, Department of Transport and Department of Environment Regulation.

The **aim of the project** is to understand what this means for the people of the City and their assets, and to plan for and mitigate against the possible impacts. The City is seeking to engage key stakeholders including community representatives that are affected, to assist in producing an adaptation plan.

The present stage (Stage 3) of this project is 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 due to storm surge and sea level rise. What this entails includes:

- Consulting with government agencies;
- Engaging with all interested stakeholders;
- Engaging with key community groups and members to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone;
- Assisting the project team in developing appropriate mitigation measures in response to key issues raised as part of the engagement process.

As a member of the City of Fremantle staff, you may soon start to hear more about the project, either from internal staff or from the community at large. You are encouraged to find out more information on this project (including erosion and inundation prediction maps) by visiting the CSCA website at http://cockburnsoundcoastalalliance.info/

Alternatively, your internal point of contact for any queries relating to this project is:

Melanie Bainbridge – Sustainability Officer, on 9432 9735, melanieb@fremantle.wa.gov.au

COCKBURN SOUND
COASTAL ALLIANCE

How the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project affects you

The City of Kwinana is currently in the third stage of a four stage project that looks at the short and long term impacts of **erosion and coastal inundation** on our coastline. The Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project (the project) is being run by the Cockburn Sound Coastal Alliance (CSCA). The Alliance is made up of four local governments; the Cities of Cockburn, Fremantle, Kwinana and Rockingham with project partners the Department of Planning, Department of Transport and Department of Environment Regulation.

The **aim of the project** is to understand what this means for the people of the City and their assets, and to plan for and mitigate against the possible impacts. The City is seeking to engage key stakeholders including community representatives that are affected, to assist in producing an adaptation plan.

The present stage (Stage 3) of this project is 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 due to storm surge and sea level rise. What this entails includes:

- Consulting with government agencies;
- Engaging with all interested stakeholders;
- Engaging with key community groups and members to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone;
- Assisting the project team in developing appropriate mitigation measures in response to key issues raised as part of the engagement process.

As a member of the City of Kwinana staff, you may soon start to hear more about the project, either from internal staff or from the community at large. You are encouraged to find out more information on this project (including erosion and inundation prediction maps) by visiting the CSCA website at http://cockburnsoundcoastalalliance.info/

Alternatively, your internal point of contact for any queries relating to this project is:

Ashley Harding – Environmental Coordinator, on 00000000, ashley.harding@kwinana.wa.gov.au

COCKBURN SOUND
COASTAL ALLIANCE

How the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project affects you

The City of Rockingham is currently in the third stage of a four stage project that looks at the short and long term impacts of **erosion and coastal inundation** on our coastline. The Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project (the project) is being run by the Cockburn Sound Coastal Alliance (CSCA). The Alliance is made up of four local governments; the Cities of Cockburn, Fremantle, Kwinana and Rockingham with project partners the Department of Planning, Department of Transport and Department of Environment Regulation.

The **aim of the project** is to understand what this means for the people of the City and their assets, and to plan for and mitigate against the possible impacts. The City is seeking to engage key stakeholders including community representatives that are affected, to assist in producing an adaptation plan.

The present stage (Stage 3) of this project is 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 due to storm surge and sea level rise. What this entails includes:

- Consulting with government agencies;
- Engaging with all interested stakeholders;
- Engaging with key community groups and members to gain their opinions and values (economic, environmental, social and cultural) regarding coastal assets (natural and built) at risk in the coastal zone;
- Assisting the project team in developing appropriate mitigation measures in response to key issues raised as part of the engagement process.

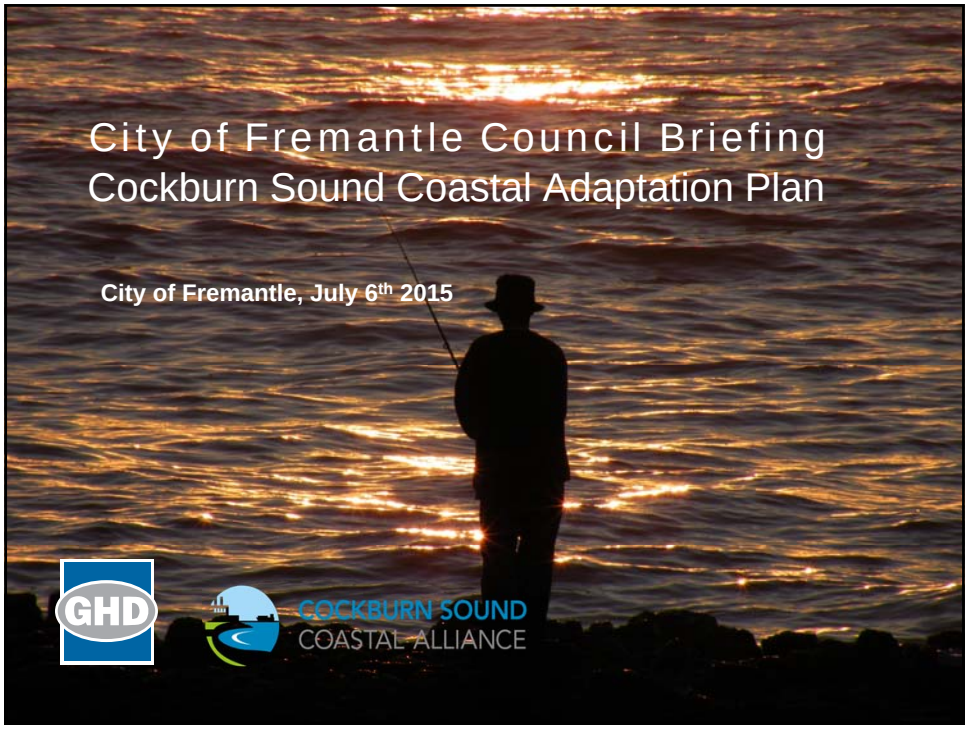
As a member of the City of Rockingham staff, you may soon start to hear more about the project, either from internal staff or from the community at large. You are encouraged to find out more information on this project (including erosion and inundation prediction maps) by visiting the CSCA website at http://cockburnsoundcoastalalliance.info/

Alternatively, your internal point of contact for any queries relating to this project is:

Kim Byrnes – Environmental Planning Officer, on 9528 0372, kim.byrnes@rockingham.wa.gov.au

Appendix C

Initial Council Briefing Presentation



Cockburn Sound Coastal Alliance

The Cockburn Sound Coastal Alliance is comprised of four Local Governments, the City of Cockburn, City of Fremantle, City of Rockingham and the City of Kwinana as well as the Perth Region NRM.

The alliance is working collaboratively to identify the vulnerability of the Cockburn Sound and Owen Anchorage coastal zone to coastal processes, to determine what built and natural assets are likely to be impacted by those processes in a changing climate and, in consultation with a broader stakeholder group, develop adaptation plans to address those identified vulnerabilities.

The study area runs the full coastline from south of the Swan River mouth to the north of Point Peron.

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The Project

Cockburn Sound Coastal Vulnerability & Flexible Adaption Pathways Project

- 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 – Close out and project evaluation

http://cockburnsoundcoastalalliance.info/

Overall Project Objectives

Understand the coastal processes Cockburn Sound & Owen Anchorage;

Understand the coastal erosion and inundation risks of each section of coast now and for various future SLR and storm event scenarios;

Understand what built and natural assets are at risk from those coastal processes and SLR/storm event erosion and inundation scenarios

Understand in consultation with the stakeholders including the community what value is placed on those assets and features at risk;

Develop up adaptation options in respect to the features and assets at risk, test those with the stakeholders including LG's and the community;

Finalise recommendations for short, medium and long term adaptation actions and plans that can be built into town planning schemes, local coastal management plans, short term site specific remediation works etc.

Articulate the lessons learned.

Stage 3 Project Objectives

- Develop an effective Coastal Adaptation Plan (Plans) to be implemented by the relevant local governments and stakeholders with sufficient detail for coastal managers to endorse and action.
- Effectively engage with key community groups and stakeholders to gain their opinions and values; and
- Build capacity in the community, local governments, NRM groups, Coastcare groups, industry and other stakeholders by facilitating understanding.

Project Outcomes

- Increased understanding within LGs, communities and other key stakeholders of risks presented by coastal processes to the year 2110;
- Improved understanding (consensus) amongst coastal managers and other stakeholders of values of assets at risk from coastal processes;
- Recommendations as to the most suitable and effective adaptation actions;
- Building capacity in both the identification of assets and the development and implementation of adaptation actions; and
- Progressive implementation of the adaptation actions.

Project Outcomes - Deliverables

- Stakeholder and Community Engagement Strategy + delivery
- Adaptation Option Compendium
- Coastal Adaptation Plan + Report +Presentations

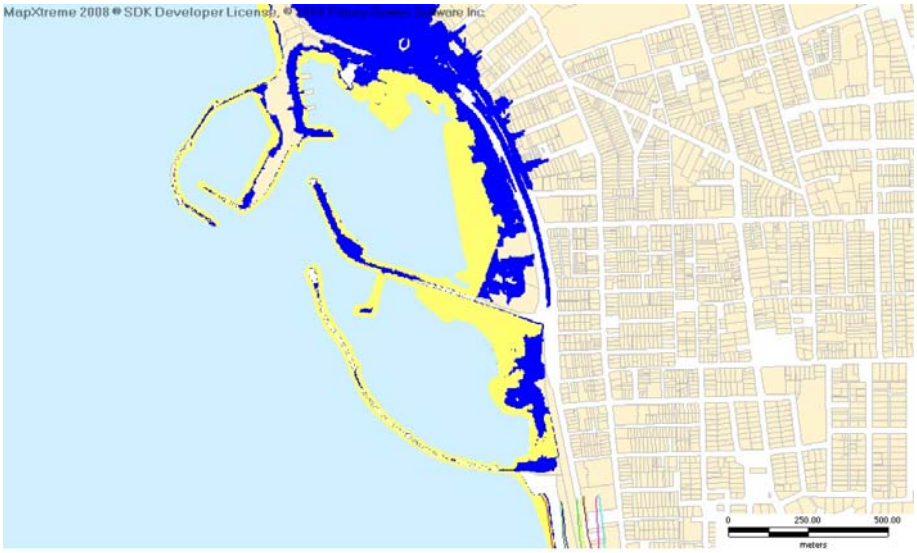
To be complete by the end of 2015

A quick snapshot....

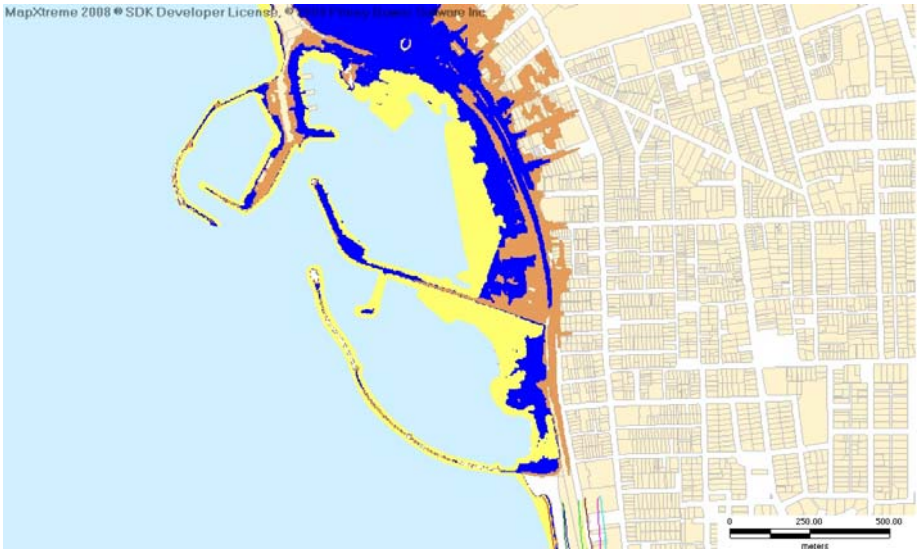
Erosion

Inundation – Present Day

Inundation – 0.5m sea level rise



Inundation – 0.9m sea level rise



Communication needs to be clear and honest – but not alarmist

we do have some time…

Stakeholder Engagement and Communications Strategy

Communication Plan Key Components

1. Project website
2. FAQ's (including key information about the project and its timelines)
3. Media information
4. Information sheets/newsletters
5. Council briefing/s
6. Key Stakeholder workshops
7. One on one stakeholder meetings
8. Community Survey
9. Information Open Days
10. Focus Groups

Next Steps

1. Intensive industry and key agency liaison
2. Community engagement program commences (late July)
3. Options assessment - Multi-criteria analysis workshops (August)
4. Further website updates and briefings (August/September/October)

Appendix D

Invitation to Information Open Days and Focus Groups

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INFORMATION SESSIONS & FOCUS GROUPS

Cockburn Sound Coastal Adaptation Plan

The Cockburn Coastal Adaptation Plan is Stage 3 of a four-stage project known as the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project (the Project). The Project is being developed by the Cockburn Sound Coastal Alliance (CSCA or the Alliance) as a response to the identified vulnerability of Cockburn Sound to erosion and coastal inundation (flooding). The Project is developing adaptation measures to address those identified vulnerabilities.

The CSCA was formed in 2011 and is a collaboration between four Local Governments (Cities of Cockburn, Fremantle, Kwinana and Rockingham) and the Perth Region NRM organisation.

More detail on the project, including FAQs, can be found at http://cockburnsoundcoastalalliance.info/

PLEASE JOIN US

The Project has determined the potential vulnerability of the Cockburn Sound and the project team is now embarking on a program of stakeholder engagement and information sharing. All members of the community are invited to participate in this and provide feedback.

Opportunities to be involved are as follows.

Type	Date/Time	Location
Information Display	Saturday 8th August 1:00-3:00pm	Woolstores Fremantle Shopping Centre 28 Cantonment Street Fremantle
Focus Group	Monday 10th August 5:30-7:00pm	City of Fremantle Council Chambers Town Hall Centre, 8 William Street Fremantle
Focus Group	Wednesday 12th August 5:30-7:00pm	Coogee Beach Surf Life Saving Club 20 Poore Grove, Coogee
Information Open Day	Saturday 15th August 1:00-3:00pm	Rockingham Shopping Centre 1 Council Avenue Rockingham
Focus Group	Monday 17th August 5:30-7:00pm	Darius Wells Library and Resource Centre Corner Chisham Avenue and Robbos Way Kwinana
Focus Group	Wednesday 19th August 5:30-7:00pm	Gary Holland Community Centre 19 Kent Street Rockingham
RSVPs		Email RSVPs to julian.turco@ghd.com Enquiries can be directed to Anna Kelderman on 0459 787 888

INFORMATION SESSIONS

The two Information Displays provide an opportunity for the community to find out about the Project via mapping, graphics and images and face-to-face interaction with Project team members. The displays are designed to allow attendance at any time throughout the two-hour period, rather than a requirement to attend the whole session.

FOCUS GROUPS

Focus Groups will provide a more formal workshopping environment, where information will be presented and attendees asked to provide feedback on matters such as visual amenity, beach access, beachfront parklands and the value placed by the community on the coast.

Community members are welcome to attend information open days and/or focus groups at any of the locations (these are not restricted to individual Local Government residents); however, RSVP's are required so that the appropriate information can be supplied to all participants. Please RSVP to. julian.turco@ghd.com

General feedback on the project can also be provided through the CSCA website.

We look forward to your participation.

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FOCUS GROUP INVITATION

Cockburn Sound Coastal Adaptation Plan

The Cockburn Coastal Adaptation Plan is Stage 3 of a four-stage project known as the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project. The Project is being developed by the Cockburn Sound Coastal Alliance (CSCA or the Alliance) as a response to the identified vulnerability of Cockburn Sound to erosion and coastal inundation. The Project is developing adaptation measures to address those identified vulnerabilities.

The CSCA was formed in 2011 and is a collaboration between four Local Governments (Cities of Cockburn, Fremantle, Kwinana and Rockingham) and the Perth Region NRM organisation.

More detail on the project, including FAQs, can be found at http://cockburnsoundcoastalalliance.info/

The potential vulnerability of the Cockburn Sound has now been assessed and the project team is seeking to share the outcomes and provide an opportunity for feedback. All members of the community are invited to participate in this and provide feedback.

FOCUS GROUPS

Some Focus Groups have been held, however, it is considered that an additional opportunity is required to provide feedback and allow discussion. Information will be presented and an opportunity will be provided for the community to provide feedback on matters such as visual amenity, beach access, beachfront parklands and the value placed by the community on the coast.

RSVP's are required so that the appropriate information can be supplied to all participants. Please RSVP to anna.kelderman@ghd.com or via phone on 0459 787 888.

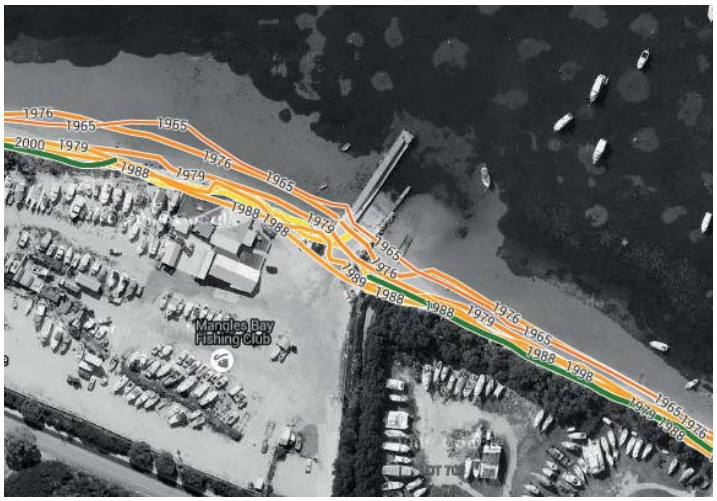
General feedback on the project can also be provided through the CSCA website. We look forward to your participation.

Appendix E

Information Open Day Resources

Our Coast is Changing

History shows our coast has changed over time

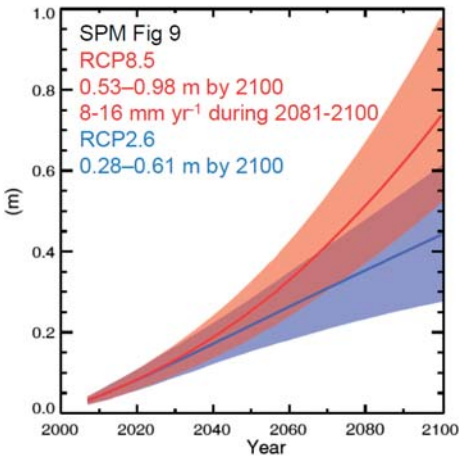


The history of coastline movement in the area show how the beaches around Rockingham have changed over the past few decades.

Our coast is dynamic and erosion is happening now

How erosion is affecting our coastline in the present day.

Erosion and recession is expected to accelerate over the coming century due to climate change and rising sea levels



Projections of sea level rise to 2100 (Source: IPCC 2013)

We are planning now to act when the time is right

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How might we adapt?

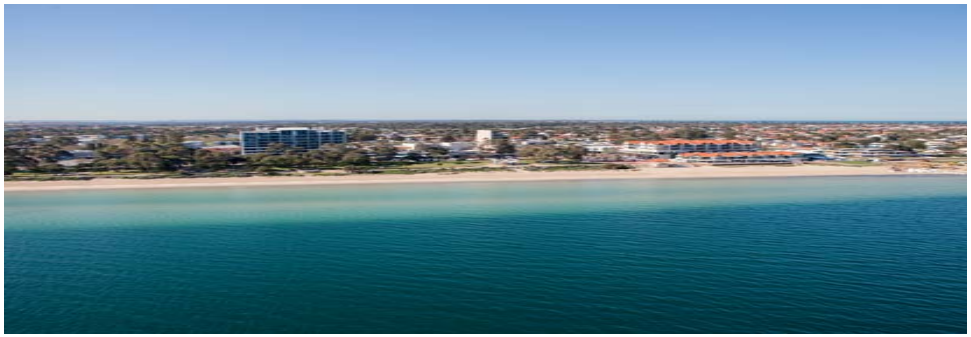
Long term strategic planning

Reducing the risk of erosion and flooding by managing development in areas that will be affected now, in 50 and in 100 years time.

Expand coastal foreshores

Manage development in areas of near term risk

Relocate facilities back over time

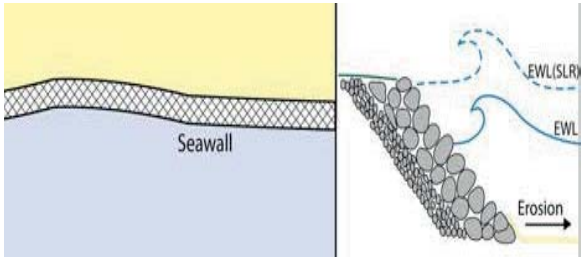


Interim protection

Coastal engineering can help us manage risk in the near term, although can impact adversely on beaches.

Seawalls

Structures separating land and water areas, designed to prevent coastal erosion and other damage due to wave action and storm tide inundations.

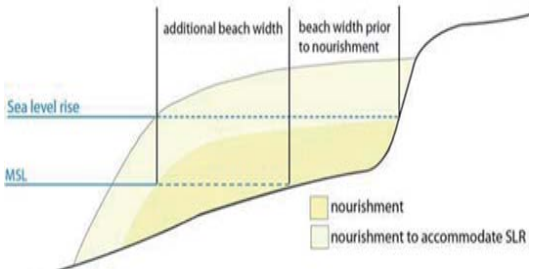


Groynes

Structures built perpendicular to the shoreline that trap sand moving along the coast, causing sand buildup on the downdrift side.

Beach nourishment

The artificial addition of sand to a beach system, increasing the buffer against erosion and maintain and/or advance the shoreline position in an area which has a sediment deficit or inadequate buffer zone.



Existing residential areas are currently not under immediate threat

However it's important to develop a plan for the future to be ready for when impacts may occur

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Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project

Who is the Cockburn Sound Coastal Alliance (CSCA)?

The CSCA was formed in 2011 and is a collaboration between four Local Governments (Cities of Cockburn, Fremantle, Kwinana and Rockingham) and the Perth Region NRM (Natural Resource Management) organisation.

What is the Project?

The Coastal Vulnerability & Flexible Adaptation Pathways Project has identified the vulnerability of Cockburn Sound to erosion and coastal inundation (flooding).

The Project is developing detailed adaptation measures to address those identified vulnerabilities.

How can I learn more?

Join a focus group to provide your inputs into the process.

Visit the CSCA website at www.cockburnsoundcoastalalliance.info

Project Study Area

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Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project

For more information and to join the conversation, visit the Cockburn Sound Coastal Alliance website at:

www.cockburnsoundcoastalalliance.info

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Combined vulnerability maps (erosion plus inundation)

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:10,000 at 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 A
Date 05 Aug 2015

Management Unit 1

Coastal Hazard

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate Imagery - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

381,500 382,000 382,500

6,451,000

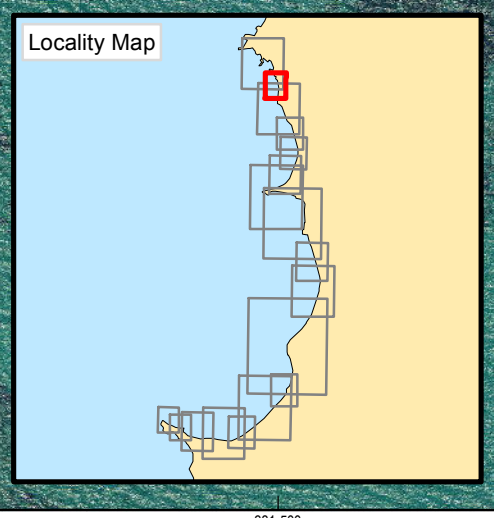
CITY OF FREMANTLE

6,450,500

CITY OF COCKBURN

6,450,000

Locality Map



LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:5,000at A3

0 20 40 80 120 160 200

Metres

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

N

GHD

City of Cockburn — wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number	61-32106
Revision	A
Date	05 Aug 2015

Management Unit 2

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate Basemap Topographic - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

381,000 381,500 382,000 382,500 383,000 383,500

6,450,500 6,450,000 6,449,500 6,449,000 6,448,500 6,448,000

CITY OF FREMANTLE

CITY OF COCKBURN

DRAFT

Locality Map

381,000 381,500 382,000 382,500 383,000 383,500

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:10,000 at A3

0 50 100 200 300 400 500

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 3

Figure 1

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239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

382,000 382,500 383,000 383,500

6,448,500 6,448,000 6,447,500 6,447,000

CITY OF COCKBURN

Locality Map

DRAFT

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:6,500at 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 A
Date 05 Aug 2015

Management Unit 4

Coastal Hazard

Figure 1

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239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

382,500 383,000 383,500

6,447,000 6,446,500 6,446,000 6,445,500

CITY OF COCKBURN

Locality Map

DRAFT

382,500 383,000 383,500

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:6,500at A3

0 30 60 120 180 240 300

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number	61-32106
Revision	A
Date	05 Aug 2015

Management Unit 5

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

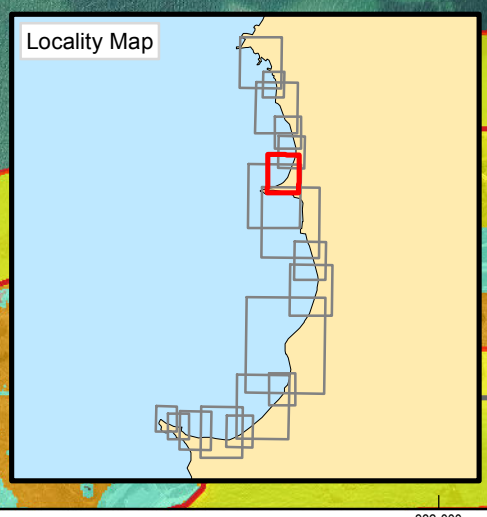
239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

382,000 382,500 383,000 383,500

6,446,000 6,445,500 6,445,000 6,444,500 6,444,000

CITY OF COCKBURN



DRAFT

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:7,500at A3

0 35 70 140 210 280 350

Metres

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

N

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 6
Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

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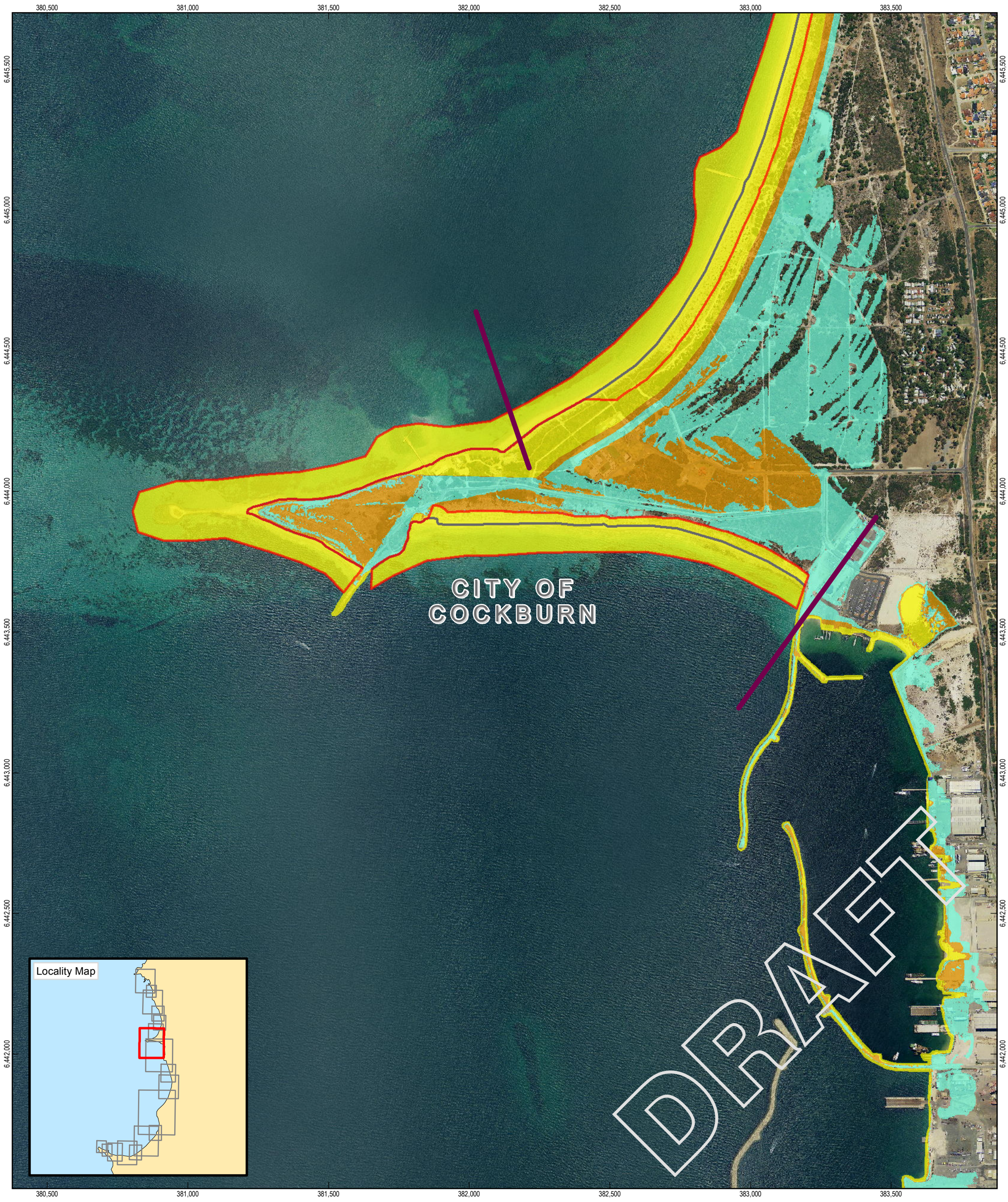
Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj



LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:12,500 at A3

0 62.5 125 250 375 500 625

Metres

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

N

GHD

City of Cockburn — wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

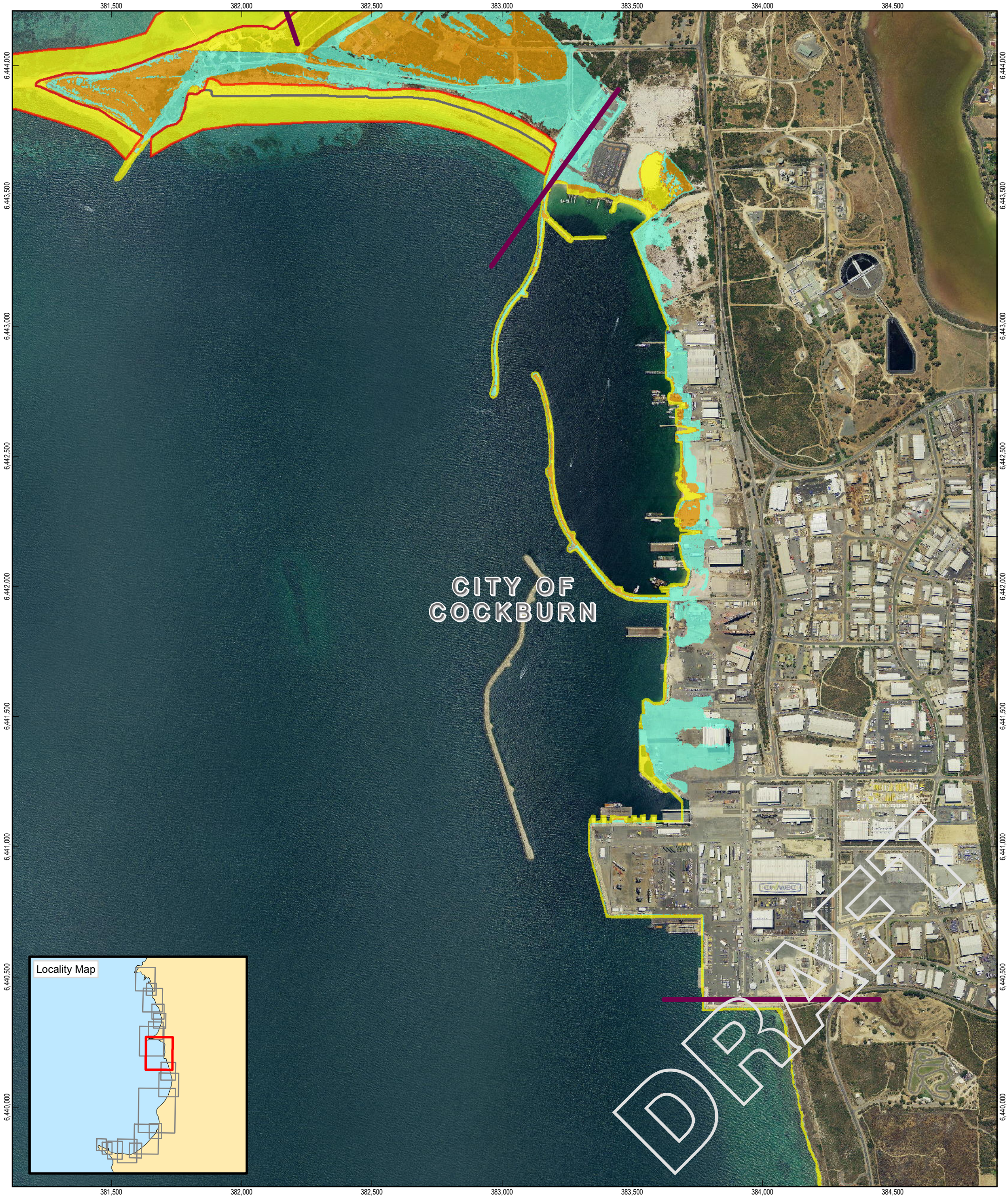
Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 7
Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj



LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:13,500 at A3

0 65 130 260 390 520 650

Metres

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

N

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 8
Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate 30/10/2015; DPaW - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

383,500 384,000 384,500 385,000

6,440,500 6,440,000 6,439,500 6,439,000 6,438,500

CITY OF COCKBURN

CITY OF KWINANA

Locality Map

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:7,500at A3

0 35 70 140 210 280 350

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 A
Date 05 Aug 2015

Management Unit 9

Coastal Hazard

Figure 1

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239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data sources: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

383,000 383,500 384,000 384,500 385,000 385,500

6,439,000
6,438,500
6,438,000
6,437,500
6,437,000
6,436,500

CITY OF COCKBURN

CITY OF KWINANA

Locality Map

DRAFT

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:10,000 at A3

0 50 100 200 300 400 500

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

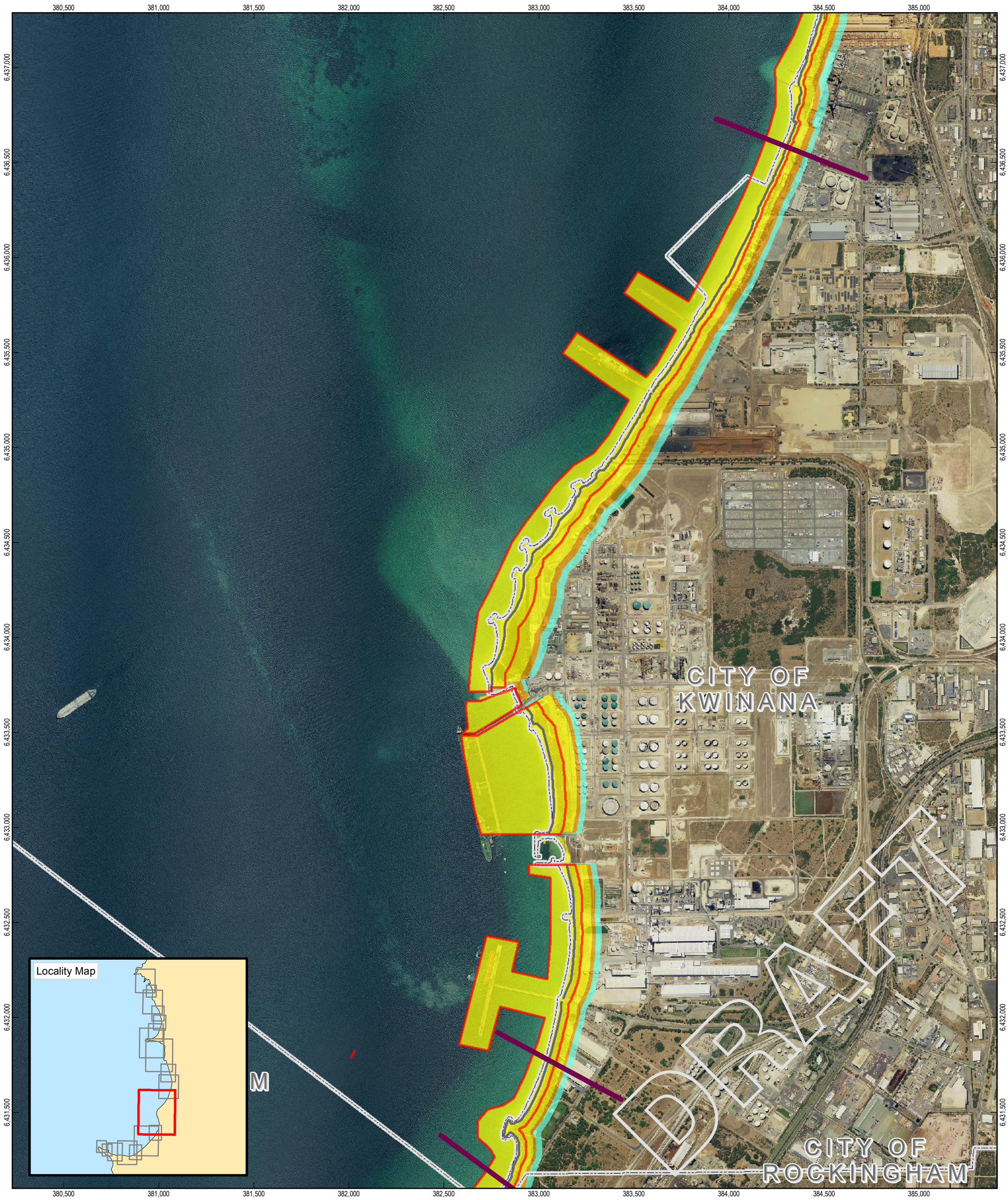
Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 10
Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj



LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:18,500 at A3

0 90 180 360 540 720 900

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 A
Date 05 Aug 2015

Management Unit 11

Coastal Hazard

Figure 1

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239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

382,000 382,500 383,000 383,500

6,432,500 6,432,000 6,431,500 6,431,000 6,430,500

CITY OF KWINANA

CITY OF ROCKINGHAM

DRAFT

Locality Map

382,000 382,500 383,000 383,500

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:6,500at A3

0 30 60 120 180 240 300

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 12

Coastal Hazard

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

380,000 380,500 381,000 381,500 382,000 382,500 383,000

6,432,000 6,431,500 6,431,000 6,430,500 6,430,000 6,429,500 6,429,000 6,428,500

CITY OF KWINANA

CITY OF ROCKINGHAM

DRAFT

Locality Map

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:12,500 at A3

0 62.5 125 250 375 500 625

Metres

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

N

GHD

City of Cockburn — wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 13

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

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Data source: Landgate Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

380,000 380,500 381,000

6,429,500 6,429,000 6,428,500 6,428,000

CITY OF ROCKINGHAM

Locality Map

DRAFT

380,000 380,500 381,000

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:6,500at A3

0 30 60 120 180 240 300

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number	61-32106
Revision	A
Date	05 Aug 2015

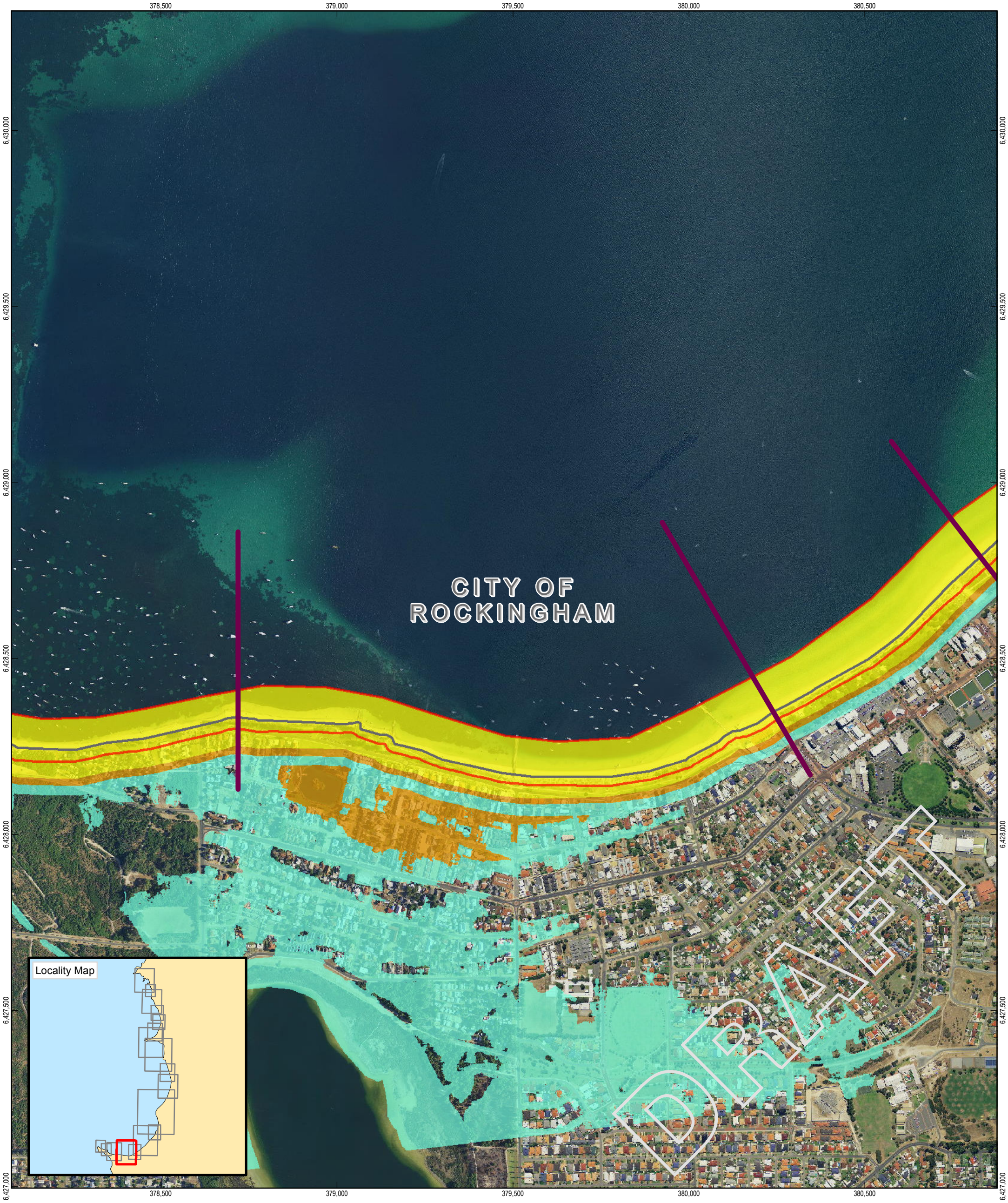
Management Unit 14

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj



LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:10,000 at 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

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 15
Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

377,500 378,000 378,500 379,000

6,430,000 6,429,500 6,429,000 6,428,500 6,428,000 6,427,500

CITY OF ROCKINGHAM

Locality Map

DRAFT

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:7,500at A3

0 35 70 140 210 280 350

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 16

Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

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Data source: Landgate Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

376,500 377,000 377,500

6,429,500 6,429,000 6,428,500

CITY OF ROCKINGHAM

DRAFT

Locality Map

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:5,000at A3

0 20 40 80 120 160 200

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 A
Date 05 Aug 2015

Management Unit 17

Coastal Hazard

Figure 1

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239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: Landgate Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

376,000 376,500 377,000

6,430,000

6,429,500

6,429,000

CITY OF ROCKINGHAM

DRAFT

Locality Map

376,000 376,500 377,000

LEGEND

- Indicative Management Unit Boundary
- 1m AHD
- Almost Certain Inundation Line
- Local government area boundary

Combined Coastal Risk Likelihood

- Almost Certain
- Possible
- Rare

1:5,000at A3

0 20 40 80 120 160 200

Metres

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

N

GHD

City of Cockburn wetlands to waves

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Cockburn Sound Coastal Alliance
Cockburn Sound Coastal Adaptation Plan

Coastal Hazard

Job Number 61-32106
Revision A
Date 05 Aug 2015

Management Unit 18
Figure 1

G:\61\32106\GIS\Maps\Working\6132106_008_RevA.mxd

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Data source: Landgate: Cadastre - 20150727; GHD: Indicative Management Unit Boundaries - 20150416; CSCA: 1m AHD - 20121217, Combined Coastal Risk Likelihood - 20140310, Almost Certain Inundation Line - 20140310. Created by: mczekaj

Appendix F

Focus Group Presentation

Agenda

1. Who – Cockburn Sound Coastal Alliance
2. What – About the Project
3. Where – Project findings
4. How – Adaptation options
5. Why – Your support
6. Next Steps

http://cockburnsoundcoastalalliance.info/

Who is the Cockburn Sound Coastal Alliance?

The Cockburn Sound Coastal Alliance (CSCA) is comprised of four Local Governments, the City of Cockburn, City of Fremantle, City of Rockingham and the City of Kwinana as well as the Perth Region NRM.

The CSCA is working collaboratively to plan for the future.

Stage 3 Cockburn Sound Coastal Adaptation Plan – Focus Groups August 2015
http://cockburnsoundcoastalalliance.info/

What is the Project about?

Cockburn Sound Coastal Vulnerability & Flexible Adaption Pathways Project

- 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 – Close out and project evaluation

Stage 3 Cockburn Sound Coastal Adaptation Plan – Focus Groups August 2015
http://cockburnsoundcoastalalliance.info/

The study area runs the full coastline from south of the Swan River mouth to the north of Point Peron.

Overall Project Objectives

- Understand coastal processes;
- Understand the coastal erosion and inundation risks;
- Understand what built and natural assets are at risk;
- Understand what value is placed on those assets and features at risk;
- Develop adaptation options;
- Make recommendations for short, medium and long term adaptation actions.

Stage 3 Cockburn Sound Coastal Adaptation Plan – Focus Groups August 2015
http://cockburnsoundcoastalalliance.info/

Project Outcomes

- **Increased understanding** within LGs, communities and other key stakeholders **of risks** presented by coastal processes to the year 2110;
- **Improved understanding** (consensus) amongst coastal managers and other stakeholders **of values** of assets at risk from coastal processes;
- **Recommendations** as to the most suitable and effective adaptation actions;
- **Building capacity** in both the identification of assets and the development and implementation of adaptation actions; and
- **Progressive implementation** of the adaptation actions.

What are the challenges (project findings)?

GHD COCKBURN SOUND COASTAL ALLIANCE
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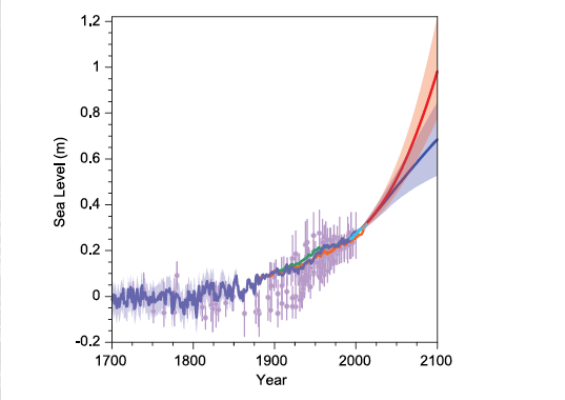
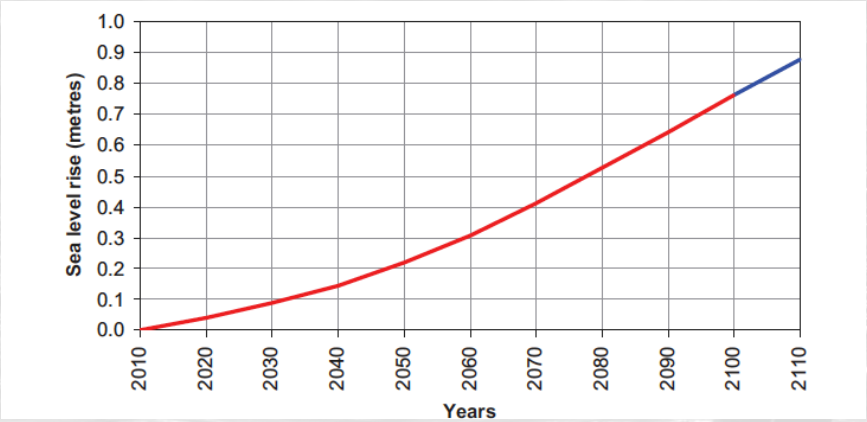
http://cockburnsoundcoastalalliance.info/

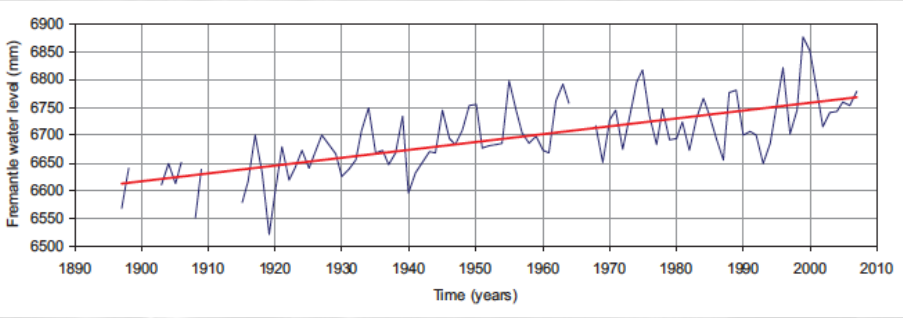
Background



IPCC Global Mean Sea Level Rise estimates through the 21st Century (Fifth Assessment Report 2013)



Recommended allowance for sea level rise in WA Coastal Planning (agreed SPP 2.6)



Time series of annual mean tide guage recordings at Fremantle with linear trend superimposed

Period	Global sea level rise	Reference
Jan 1870 to Dec 2004	1.44 mm/yr	Church et al. (2006)
20th century	1.7 ± 0.5 mm/yr.	IPCC AR4
1961 to 2003	1.8 ± 0.5 mm/yr	IPCC AR4
Jan 1993 to Jul 2009	3.32 ± 0.6 mm/yr	Aviso (2009)

Estimated rates of historic global mean sea level rise

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Study Outcomes

Mapping

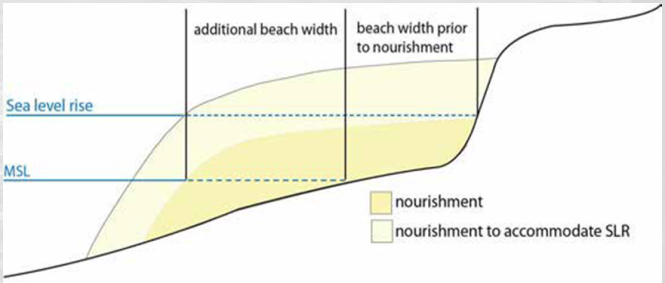
How to adapt

Strategic Planning

- Expand Coastal Foreshores
- Manage (restrict) development in areas of near term risk
- Relocate facilities over time (as they reach the end of their lifespan)
- Adopt alternative approvals mechanisms or temporary development

Short term measures

Beach Nourishment



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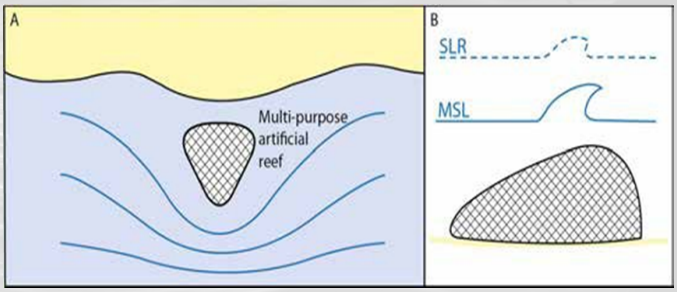
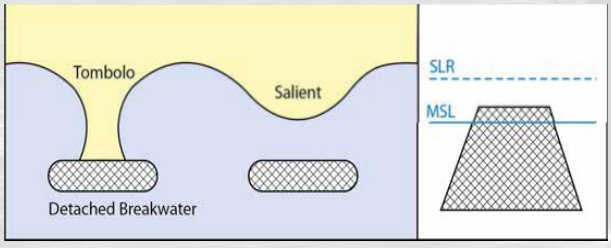
Engineered options

Artificial reefs



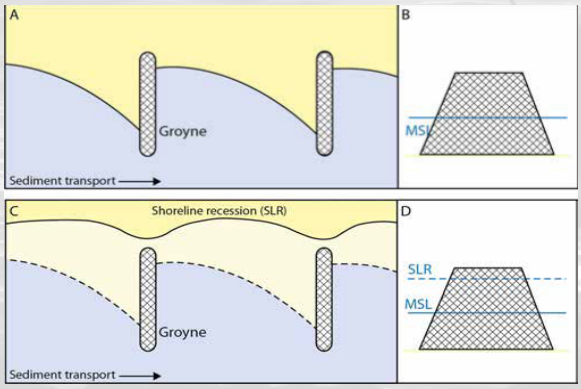
Engineered options

Detached Breakwaters



Engineered options

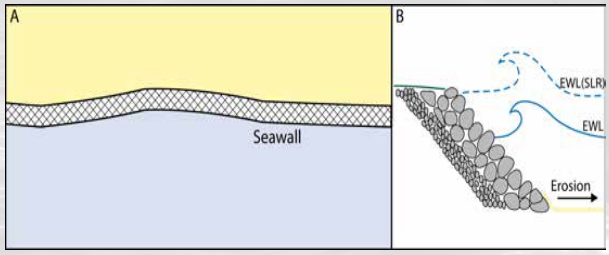
Groynes and artificial headlands



COCKBURN SOUND COASTAL ALLIANCE

Engineered Options

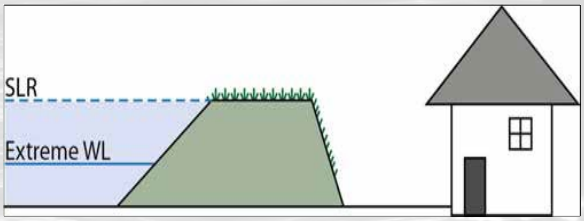
Seawalls



COCKBURN SOUND COASTAL ALLIANCE

Engineered Options

Sea dykes



Discussion/Questions?

COCKBURN SOUND COASTAL ALLIANCE

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Your Inputs

The Options Available

Managed retreat

- Gradually relocate assets landward of coastal risk zone

Interim protection (before eventual retreat)

- Long / short term coastal protections
  - Sea walls / groynes etc
- Short term protection
  - Beach nourishment etc
- Combination of long and short term protections

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Multi criteria analysis

- Used to discriminate between options
- Each option given a 'score' for each criteria
- Each 'score' is weighted to reflect its relative importance to the stakeholders
- The weighted scores are summed to provide a ranking of options from low to high

How would you weight the criteria?

How the criteria will be used to discriminate between the options

Decision Criteria	Metric	Guidance for scoring of options	
		Retreat	Long term protection
Economic Impact			
Cost	Discounted cost ($)	Loss of land value Creation of new foreshore reserve (where necessary) Decommissioning redundant structures	Capital, maintenance, monitoring and decommissioning costs Delayed loss of land value Delayed creation of new foreshore reserve (where necessary)
Commercial / industrial property impact	No. potential lots affected	Relocation & disruption to business	Delayed relocation & disruption to business
Risk to property	No. lots affected x probability of event	Nil	Residual risk of storm damage at 2110
Social impact			
Residential property impact	No. potential lots affected	Relocation & disruption	Delayed relocation & disruption
Parks and reserves impact	Area (m2)	Area lost to encroaching foreshore	Delayed loss
Beach recreation / amenity impact	Scale of 1-5	Nil	Beach / foreshore loss Benefits from new structures (eg fishing)
Heritage impact	No. of heritage properties affected	Progressive loss of assets	Delayed loss of assets
Environmental impact			
Habitat loss	Area (m2)	Nil	Beach / foreshore loss
Impact on adjoining coastline	Scale of 1-5	Progressive influence on existing structures	Induced erosion / accretion

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To weight the criteria complete the spreadsheet

Cockburn Sound Adaptation Plan				
Adaptation option evaluation				Instructions for completing the weighting process
Multi-criteria assessment - weighting process				The process allocates points out of 100 to each criterion to reflect its relative importance
Name:	J. Beachgoer			Step 1
Affiliation:	Local resident (Fremantle, Cockburn, Kwinana, Rockingham)			Record your name and affiliation
CRITERIA		WEIGHTING		
Ec1	Cost	5	11	Step 2
Ec2	Commercial / industrial property impact	5	11	Consider the criteria
Ec3	Risk to property	5	11	Identify the most important criterion in your view
S1	Residential property impact	5	11	Using the drop down list in Column C - select the number 5
S2	Parks and reserves impact	5	11	Identify the least important criterion in your view
S3	Beach recreation / amenity impact	5	11	Using the drop down list in Column C - select the number 1
S4	Heritage impact	5	11	Rank remaining criteria in turn, noting:
Env1	Habitat loss	5	11	- if criterion is equally most important > select 5
				- if criterion is equally least important > select 1
Env2	Impact on adjoining coastline	5	11	- if criterion is in between, select a number between 2 & 4 reflecting its rank in your view
			100	
				Step 3
				Review your selections and modify if necessary

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1. Options assessment - Multi-criteria analysis workshops (late August)
2. Draft Adaptation Plans (September/October)
3. Updated information, FAQs and additional opportunities to be engaged
4. Final Adaptation Plans

Final Message....

We have time to plan and must do so wisely...

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Appendix G

Longitudinal Survey

COCKBURN SOUND
COASTAL ALLIANCE

Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project

The Cockburn Sound Coastal Alliance (the Alliance) is an alliance between the Cities of Cockburn, Fremantle, Kwinana and Rockingham and Perth Region NRM, which has been established to deliver the Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project.

The aim of the project is to identify the vulnerability of Cockburn Sound to erosion and coastal inundation (flooding) and to develop adaptation measures to address those identified vulnerabilities. The Project will consider coastal features and potential processes and hazards, and identify significant risks for the coastline between the south of the Swan River mouth in Fremantle to the north of Point Peron in Rockingham and taking into account all coastal areas within Cockburn Sound and the Owen Anchorage (including the eastern side of Garden Island).

As part of this plan, the Alliance would like to develop an understanding of community awareness of coastal processes and the use and enjoyment of the coast.

The Alliance invites you to fill in this short survey.

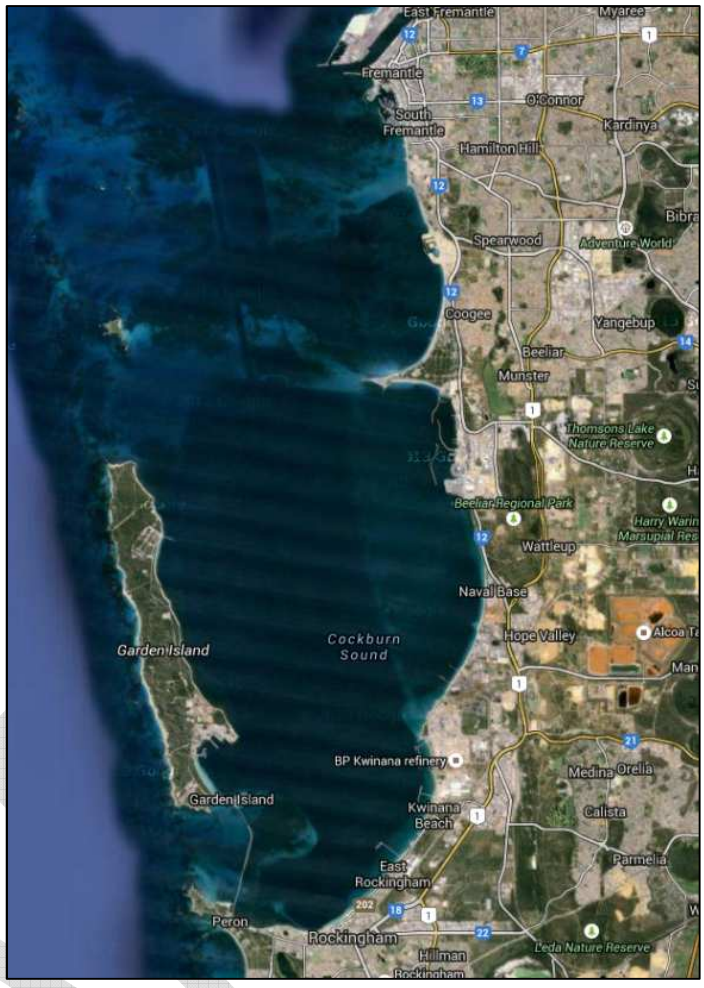


Figure 1: The study area for the Project

1. To what extent are you aware of the impacts of climate change on sea level rise and coastal erosion?

(Choose one)

Not at all

Very limited awareness

Quite aware; have followed this in the media and other outlets

Aware of global research and predictions

Aware of global research and local policy responses

2. To what extent do you believe sea level rise and coastal erosion will change over time?

(Choose one).

I don't think sea levels and coastal erosion will change over time

I think sea levels and coastal erosion will remain stable over time

I think sea level rise and coastal erosion will increase at the same rate as historically

I think sea level rise and coastal erosion will happen quicker in the future

3. How often do you visit the Cockburn Sound Coast?

Daily Weekly Monthly Annually

4. To what extent have you noticed changes to the beaches and waterfront areas along the coast within the study area? (You can choose more than one and reflect on what you have noticed over time).

Nothing has changed in the places I visit

I have noticed that the beaches have been eroding, with a narrower beach area to use when visiting

I have noticed dune vegetation becoming sparser, or more areas identified as 'dune under repair'

I have noticed that the groynes and jetties appear to be impacted by big storm events

I have noticed significant changes to the coastline, including buildings/development along the coast

Do you have any comments on the above question? ……..

……..

……..

5. What are the most important assets, facilities and services on the Cockburn Sound coast? (Please rank these in order of importance to you)

Beaches

Waterfront cycle and pedestrian paths

Parks

Boardwalks or promenades

Picnic/BBQ areas

Restaurants/Cafes

Amenities such as toilets and changerooms

Leisure activities, surf clubs etc

Function venues/centres

Residential housing

Car parking

Public transport

Fishing areas, jetties and fish cleaning

Boat ramps and launching facilities

Other _____

6. What asset, facility or service on the Cockburn Sound coast is most valued to you? (You may identify up to three assets, facilities or services. Please be very specific about its name and location.

1. Name_____

Location_____

2. Name_____

Location_____

3. Name_____

Location_____

7 a). Have you visited the Cockburn Sound Coastal Alliance website?

Yes No

7 b). If yes, when was the last time you visited the website?

This week In the last 3 months In the last 6 months Longer than 6 months

END

Thank you for undertaking our survey, we appreciate your time and input. Please visit the Cockburn Sound Coastal Alliance website http://cockburnsoundcoastalalliance.info/ **for updates, including registering your interest to be on a mailing list or to be notified of upcoming events.**

Appendix H

Example Coastal Adaptation Plan Council Briefing

Overview

Community and stakeholder engagement

Adaptation plan

Strategic recommendations from the project

Please feel free to ask questions during the presentation

Community and Stakeholder Engagement

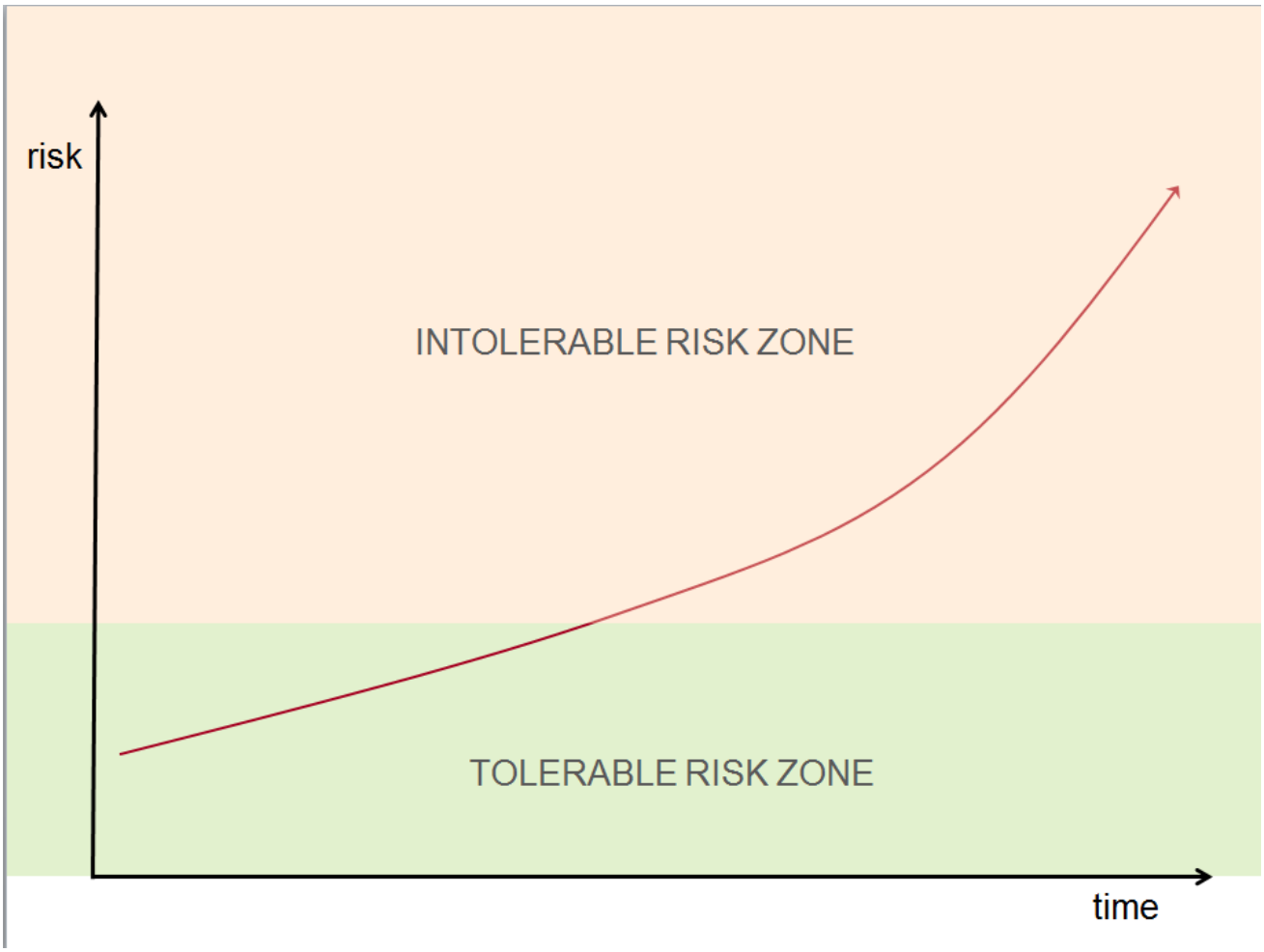
COCKBURN SOUND COASTAL ALLIANCE

Stage 3 Cockburn Sound Coastal Adaptation Plan

Draft Adaptation Plan

Avoid, retreat, accommodate, interim protection?

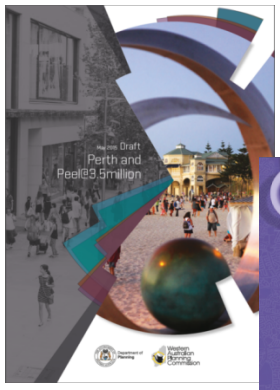
What are the values we are trying to protect?

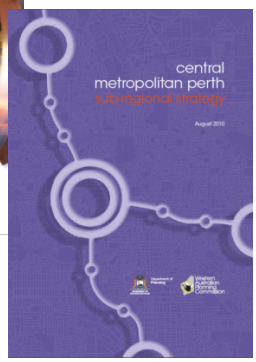


Flexible adaptation: we prepare our governance and planning frameworks so that the right community informed decisions can be made at the right time.

Different focus for the immediate (15 year) and long term (100 year) planning horizons.

The sets a framework to incorporate adaptation planning into the City's strategic plans, land use planning framework, and long term financial plan.





Incorporation of coastal adaptation planning into strategic planning provides the framework for integrated decision making in relation to strategic land use, infrastructure and capital works planning.

…foreshore management plans will be a key tool for communication and engagement with the community…

Immediate Planning Horizon

No "trigger" decisions required in relation to coastal risk in the immediate (15 years) term

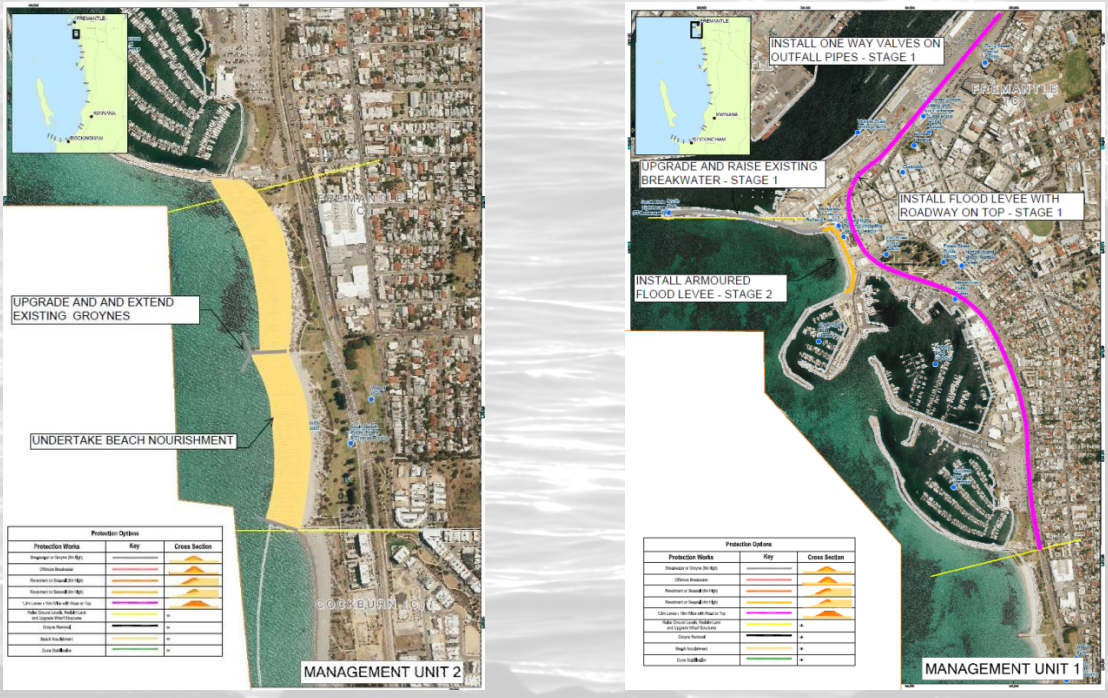
Responsive beach nourishment to erosion events at Bathers Beach

Engage community and landowners

Additional investigations

Long Term Planning Horizon (up to 2070)

Long Term Planning Horizon



Protection may be viable – but a lot more work to do

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Document Set ID: 8016767
Version: 1, Version Date: 11/12/2018

GHD

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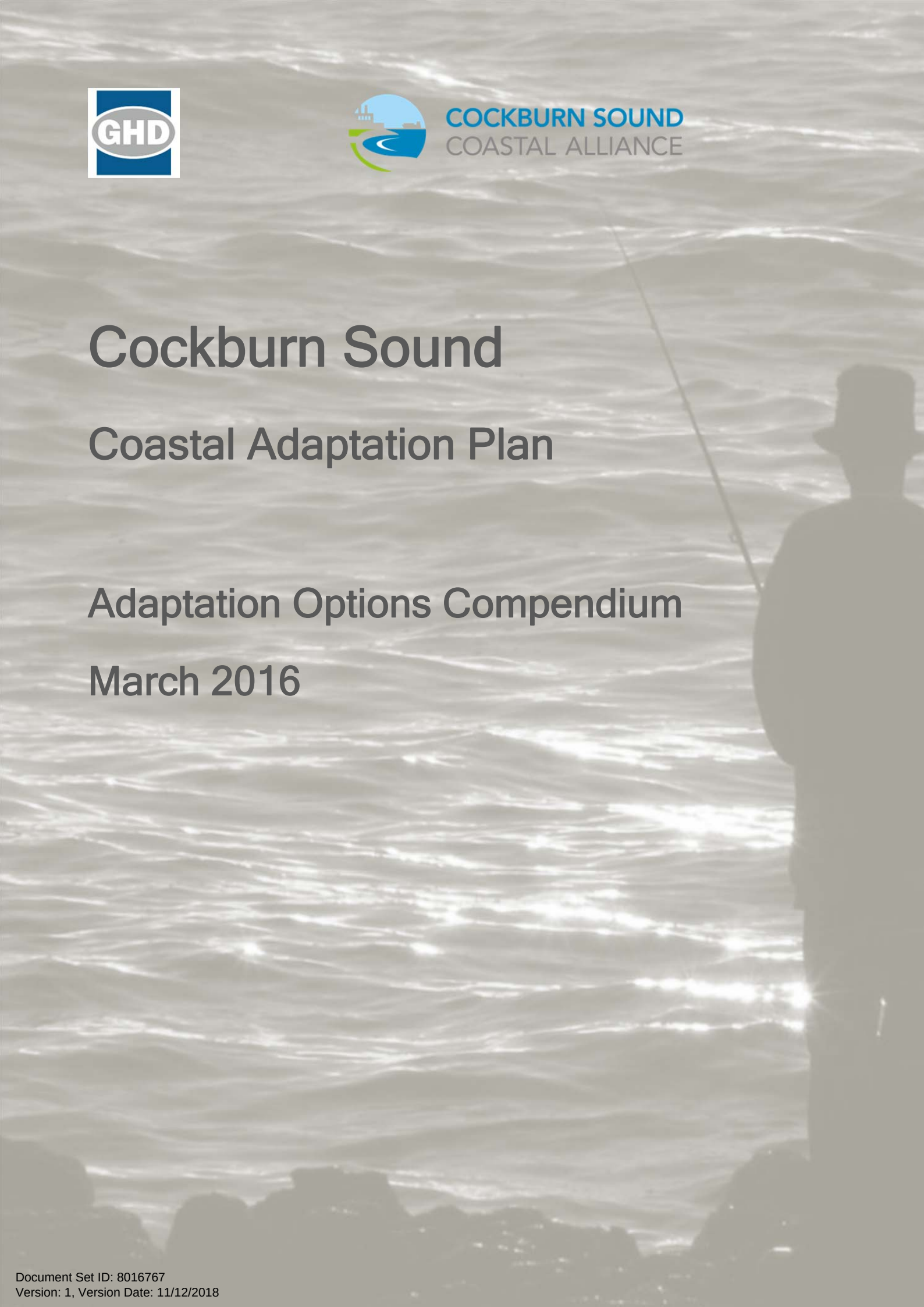
Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	Anna Kelderman	Colleen Thompson		David Horn		
0	Anna Kelderman	Colleen Thompson		David Horn		04/03/16

Appendix B – Options Compendium



Cockburn Sound

Coastal Adaptation Plan

Adaptation Options Compendium

March 2016

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1. Introduction

1.1 Project Background

The City of Cockburn, on behalf of the Cockburn Sound Climate Alliance (the Alliance), has engaged GHD to deliver the Cockburn Sound Coastal Adaptation Plan. The project forms Stage 3 of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project.

The objectives of the wider Cockburn Sound Coastal Vulnerability & Flexible Adaptation Pathways Project are:

- Improve the understanding of the coastal features, processes and hazards of the study area (coastal landforms, geological features, sediment supplies, sediment distribution and met-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;
- Facilitate the understanding of climate science, coastal hazards and risk management amongst key stakeholders (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.
- 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 (the project) will support a number of the above objectives, and 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. Sections of the Cockburn Sound and Owen Anchorage coastline are particularly exposed and vulnerable to the impacts of sea level rise, storm surge and changes in sediment regimes associated with a changing climate.

1.2 Purpose

This options compendium has been prepared to provide a listing of local adaptation options relevant to each coastal management unit of the study area. The compendium provides a strategic adaptation pathway, localised listings of interim protection and planning options, and a summary description of all adaptation options.

1.3 Scope

The scope of this document is to provide effective local adaptation option listing for coastal management units along the Owen Anchorage and Cockburn Sound Coast to address Coastal Hazards as described in Stage 1 and Stage 2 of the Cockburn Sound Coastal Alliance Coastal Vulnerability & Flexible Adaptation Pathways Project.

1.4 Limitations

This report: has been prepared by GHD for the City of Cockburn and may only be used and relied on by City of Cockburn for the purpose agreed between GHD and the City of Cockburn as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than City of Cockburn arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report . GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by the City of Cockburn and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

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.

2. Adaptation Pathways

2.1 Adaptation Principles

The consideration and determination of adaptation pathways needs to be informed by clear, agreed adaptation principles. This provides a clear policy framework against which values and costs of adaptation options can be considered and evaluated. The Cockburn coastal adaptation plans developed a series of principles, based on current coastal policy and outcomes of stakeholder engagement. These were important to provide the key rationale behind the adaptation pathway and strategic recommendations presented in the plans, and to link the adaptation plans to prevailing policy.

Principle 1 Adaptation planning in the current planning horizon does not impede the ability 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 dependent on the global action taken to mitigate climate change through greenhouse gas emission reductions, and are therefore uncertain. 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 likely to be 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 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.

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 the adaptation plans. The interest and values of the community will change over time as greater 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 and needs 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 Cockburn Sound 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 lifestyle, greatly contributing to the high quality public spaces enjoyed by the community. Our economy and quality of life is supported by coastal dependant strategic 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 Australia 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 into 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 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 measures require 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 options 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*".

2.2 Adaptation Pathways

The *Coastal Hazard Risk Management and Adaptation Planning Guidelines* (WAPC) set out coastal adaptation options available when making decisions about managing coastal risk**Error! Reference source not found.**. The options are considered in decision making 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 community to make when deciding on the future of coastal assets and land.

To develop an appropriate long-term pathway, the hierarchy of adaptation options was considered against the adaptation principles to determine a pathway that would apply it to the study area over time. The key learning of this was that:

- Decisions on risk should be made at the time that risk becomes intolerable (the trigger point) to avoid pre-empting decisions on incorrect values or community understanding
- Any decision made at the time of a trigger point – particularly accommodation and interim protection decisions – have a design life, after which risk will again rise to intolerable, and a new trigger point will be reached
- Decision on earlier trigger points must maintain all adaptation options at future trigger points, including opportunity to retreat
- Over time, into the long term planning horizon and beyond, increasing risk associated with increasing sea level rise may make interim protection options unviable on the basis of environmental, economic, and social cost, leaving retreat as the only viable adaptation option. The cost and impact of retreat increases if it has not been adequately prepared for in earlier planning horizons and at earlier trigger points.

In line with adaptation principles, the most appropriate pathway is one that enables the decision on adaptation measures to be made by the community that will bear the impacts (positive or negative) of that decision, in line with their values.

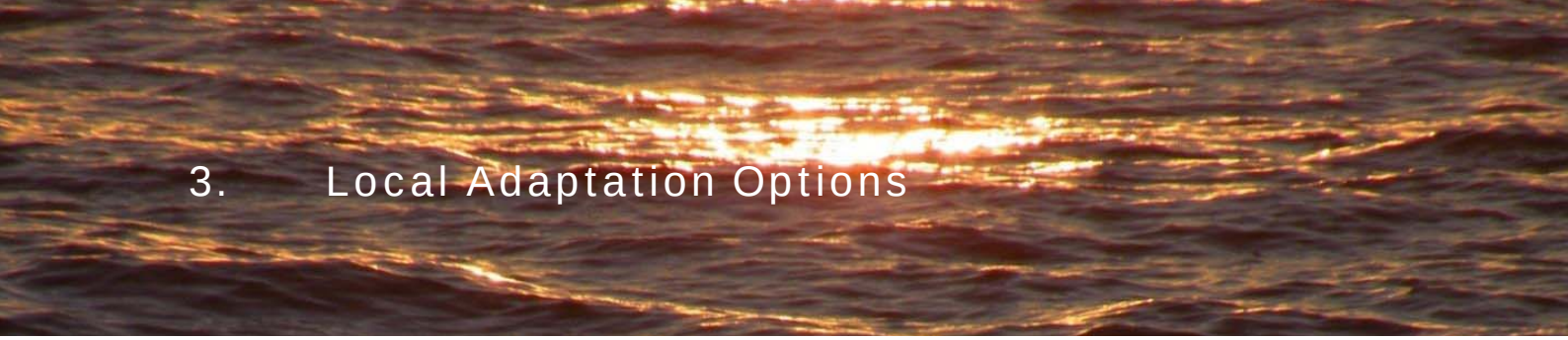
So as to not pre-empt the values of our current and future community, the most appropriate adaptation pathway for Cockburn Sound is:

> *Flexible Adaptation: we prepare our governance and planning frameworks so that the right community informed decisions can be made at the right time.*

The adaptation options appropriate to a coastal location will be dependent on the values and risks at the time of the trigger for action – when risk moves from being tolerable, to intolerable. Adaptation options become decisions for government and community to make when deciding on the future of coastal assets and land. As risk to assets increased from tolerable to intolerable, decisions must be made.

A successful adaptation pathway can be 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 adaptation pathway of “flexible” 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 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.



3. Local Adaptation Options

The dynamic nature of the coast brings risks of inundation and erosion, and the realisation of these risks over time changes the nature, shape, and location of our coast. The coastline of Cockburn Sound and Owen Anchorage has changed throughout history, particularly over the last 50 to 100 years. This will continue to change into the future. The risks of coastal erosion and inundation for the coastline have been modelled, looking at current risk, 2070 risk, and 2110 risk. The realisation of erosion and inundation risks will change the coast, the way we use the coast, and the nature (and location) of development along and in the vicinity of the coast.

As the coast changes through erosion and inundation, there are a range of planning and interim protection options available to manage how the changes impact on how we use and experience the coast. Options range from interim protection measures that will delay coastal processes for short term protection of assets through to the retention of natural coastal environments (retreating) that respond to the natural course of coastal processes. The latter approach may include strategic planning interventions and decommissioning of assets at risk.

Determining the most appropriate option for a certain location along the coastline requires consideration against social, economic, and environmental values. The preparation of the Cockburn Sound Coastal Adaptation Plan will engage community and stakeholders in weighting these values along the coast, and provide recommended responses for the local area. The key decision will be to identify those parts of the coast where Interim Protection is considered necessary, and those areas where the retention of natural beaches and coastlines can be achieved instead (Retreat).

Irrespective of the decisions made, 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 down the loss of land from erosion processes. These management techniques are not listed in the following table of options, as their use is less of a response to the changing coast than a management tool to delay interim protection and planning responses.

Management Unit 1

South Mole to North boundary of South Beach

Interim protection measures

Inundation measures

- Increase Height of Breakwaters, Revetments and Land Backed Wharfs.
- Flood Levees

Erosion measures

- Seawall
- Beach nourishment

Supporting planning measures

Development Control

- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Rezoning land (land use/density)
- Foreshore reserve expansion and retention (beach retention)
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 2

North boundary of South Beach to North boundary Pickled Fig Café

Interim protection measures

Erosion measures

- Seawalls
- Detached Breakwaters & Nourishment
- Increase Groyne Density & Nourishment
- Beach Nourishment

Supporting planning measures

Development Control

- Restriction of development in vulnerable areas
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

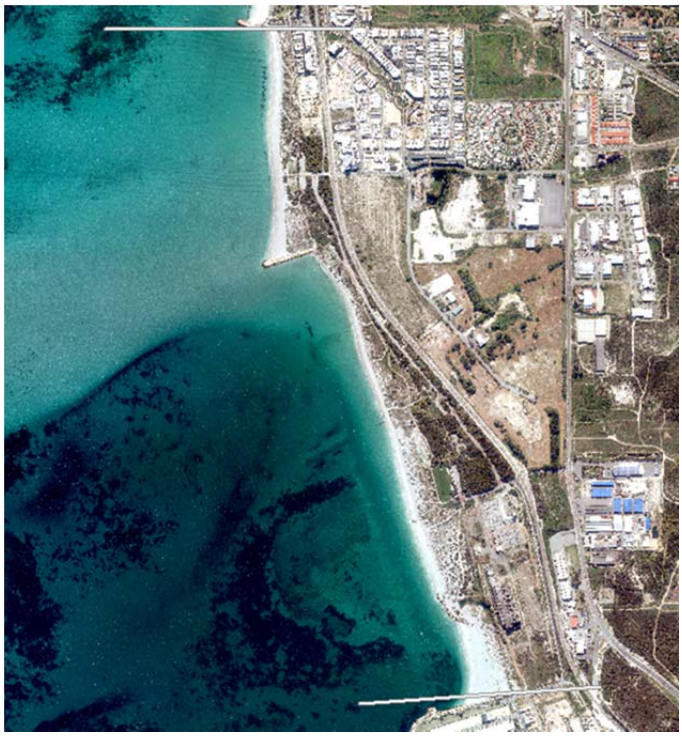
- Foreshore reserve expansion and retention (beach retention)
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 3

North boundary Pickled Fig Café to South extent of Robb Road



Interim protection measures

Erosion measures:

- Detached Breakwaters & Nourishment
- Seawalls
- Groynes & Nourishment
- Beach Nourishment
- Groyne removal & nourishment

Supporting planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Foreshore reserve expansion and retention (beach retention)
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 4

South extent of Robb Road to Socrates Road / Pelinte View intersection

Interim protection measures

Inundation Measures

- Increase Height of Breakwaters & Revetments

Supporting planning measures

Development Control

- Restricted redevelopment
- Design standards to manage risk

Strategic Planning

- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 5

Socrates Road / Pelinte View intersection to South boundary of Coogee Beach Surf Life Saving Club

Interim protection measures

Erosion measures:

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment
- Beach Nourishment

Supporting planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment

Strategic Planning

- Foreshore reserve expansion and retention (beach retention)

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure

Management Unit 6

South boundary of Coogee Beach Surf Life Saving Club to West boundary of Jervoise Bay Sailing Club

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment

Supporting planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development

Strategic Planning

- Foreshore reserve expansion and retention (beach retention)

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure

Management Unit 7

West boundary of Jervoise Bay Sailing Club to West boundary of Woodman Point Facility

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Beach Nourishment

Supporting planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development

Strategic Planning

- Foreshore reserve expansion and retention (beach retention)

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure

Management Unit 8

West boundary of Woodman Point Facility to South boundary of Australian Maritime Complex

Interim protection measures

Inundation measures

- Increase Height of Breakwaters, Seawalls and Land Backed Wharfs.

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

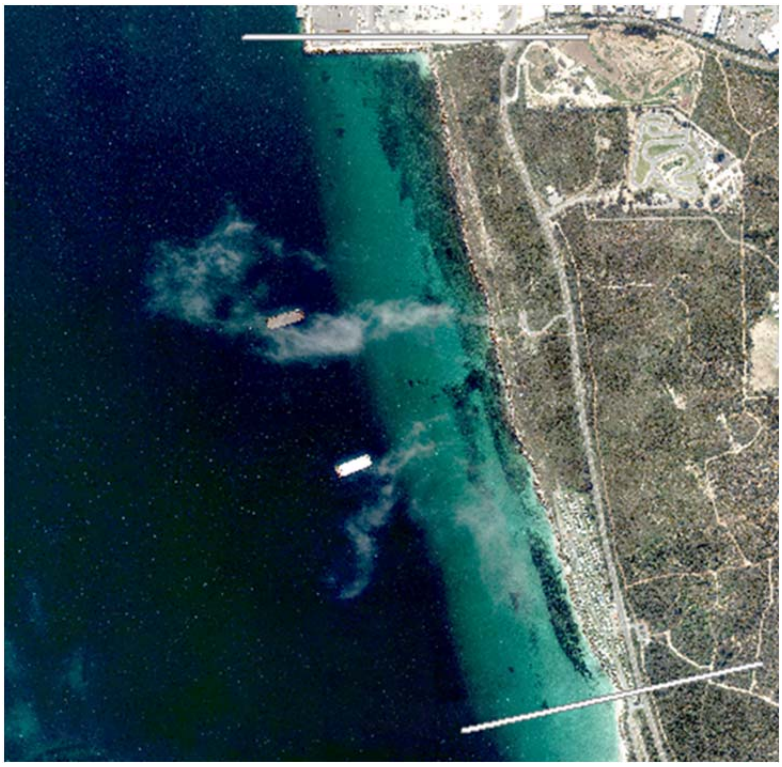
- Rezoning land
- Foreshore reserve expansion

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Lease conditions

Management Unit 9

South boundary of Australian Marine Complex to South boundary of Naval Base Shacks camp ground



Interim protection measures

Rock stabilisation measures

- Seawalls

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development

Strategic Planning

- Foreshore reserve retention

Management Unit 10

South boundary of Naval Base Shacks camp ground to South boundary of Kwinana Power Station

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment

Potential planning measures

Development Control

- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 11

South boundary of Kwinana Power Station to South boundary of Kwinana Bulk Jetty

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment

Potential planning measures

Development Control

- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 12

South boundary of Kwinana Bulk Jetty to Local Government boundary at coastline

Interim protection measures

Erosion measures

- Upgrade existing infrastructure
- Detached Breakwaters & Nourishment
- Seawalls

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 13

Local Government boundary at coastline to Wanliss Street

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Density changes
- Development incentives and split codings
- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 14

Wanliss Street to Railway Terrace

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

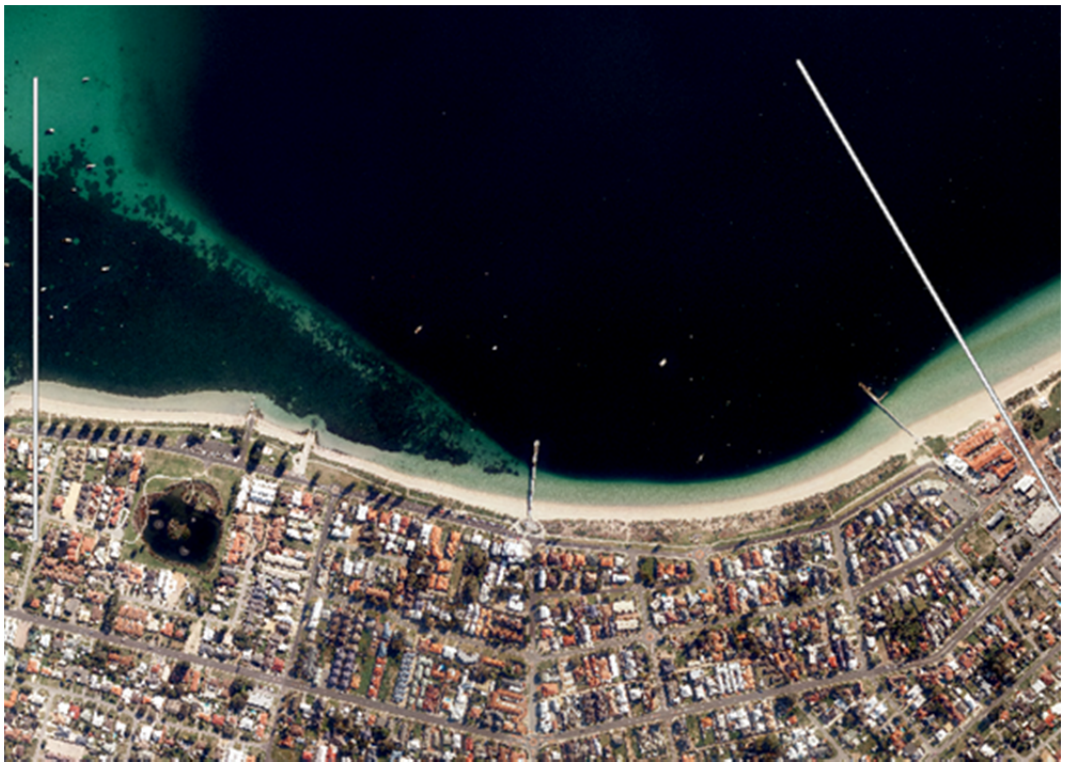
- Density changes
- Development incentives and split codings
- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 15

Railway Terrace to Hymus Street



Interim protection measures

Erosion measures

- Seawalls
- Sea Dykes

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Density changes
- Development incentives and split codings
- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 16

Hymus Street to Causeway

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment
- Beach Nourishment

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Rezoning land
- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 17

Causeway to Western boundary of Point Peron Recreational Camp

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment
- Beach Nourishment

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Rezoning land
- Foreshore reserve expansion
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition
- Impermanent land tenure
- Notifications on title

Management Unit 18

Western boundary of Point Peron Recreational Camp

Interim protection measures

Erosion measures

- Seawalls
- Groynes & Nourishment
- Detached Breakwaters & Nourishment

Potential planning measures

Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Foreshore reserve expansion

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure

(Images Source: Landgate, August 2014)

4. Summary of Adaptation Options

4.1 Interim Coastal Protection

The role of coastal protection is to reduce the risks associated with the coastal hazards of erosion and inundation to land and assets. There is a variety of options suitable to protect against these hazards involving either soft or hard engineering approaches. Some forms of coastal protection can provide protection against both hazards, but coastal protection is generally designed to protect against either erosion or inundation and not both.

The development of coastal protection measures can have implications to coastal processes and sediment transport experienced at other locations both upstream and downstream of the protection. The development of coastal protection therefore needs to consider scales larger than the area being protected as effects can be felt many kilometres away, particularly if there is a disruption to the pathways or quantities of sediment transport.

The State Coastal Planning Policy (SPP 2.6) only permits the development of coastal protection works where all other options (Avoid, Planned or Managed Retreat and Accommodate) have been considered as part of a Coastal Hazard Risk Management Process.

Coastal protection works are often expensive, require ongoing maintenance and therefore require ongoing funding for guarantee of the function of the protection over the design life.

The construction of hard engineering options alters the way coastal processes act on the land/beach and can therefore impact on the shape of the land. 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). As a result, the associated effects of the development of coastal protection and the future desired land use need to be assessed when deciding on coastal measures as the implications of a particular coastal measure itself may be in contradiction to the initial purpose of the coastal protection.

The following sections describe a variety of interim coastal protection measures that that could be used along the Owen Anchorage and Cockburn Sound coast. A background to how each protection functions, their general purpose and the main negatives associated with the style of protection are detailed below.

4.1.1 Beach nourishment

Beach nourishment is the artificial addition of sand to a beach system, increasing the buffer against erosion or halting erosional losses and is used to maintain and/or advance the shoreline position in an area which has a sediment deficit or inadequate buffer zone. Beach nourishment is commonly carried out in response to chronic shoreline erosion, while emergency works to cope with extreme storms cannot be considered within fixed timeframes.

Beach nourishment reduces the risk of storm tide inundation when combined with dune creation and vegetative stabilisation. It is important to note that beach nourishment does not halt erosion, but simply provides sediment from an external source in the form of a natural beach, upon which wave and current forces will continue to act.

Beach nourishment is undertaken for the two following purposes:

1. To control erosion and create a buffer for settlements and infrastructure (a wider beach system can reduce storm damage to coastal structures by dissipating energy across the surf zone, protecting settlements and infrastructure from extreme events); and

2. To broaden beaches for recreational purposes (beaches are valuable assets for tourism and recreation and economic drivers for coastal communities).

Sea level rise will require additional sand volumes to counterbalance beach recession (refer Figure 1).

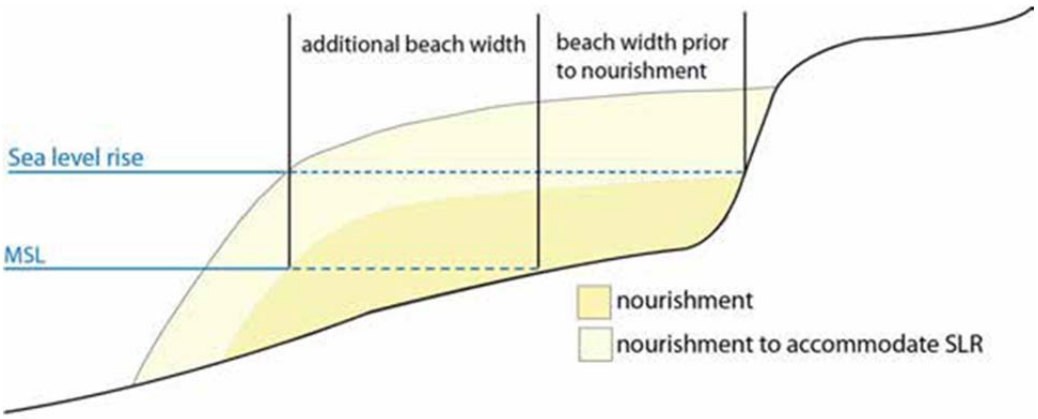


Figure 1 Diagram of typical beach nourishment cross-section [i]

Beach nourishment can require large amounts of sand. For example, creating a 100m wide beach requires approximately 500m^3 per linear metre of coastline, depending on beach slope and grain size. The identification of accessible sand deposits is therefore critical to prepare long-term strategies, especially in the light of the possible impacts of climate change.

Sand nourishment alone, without other forms of protection will not prevent erosion and the nourishment material will be transported offshore or longshore over time As such, beach nourishment should only be regarded as a short term option feasible for shore time scales of only 1 to 5 years maximum depending on the wave climate.

4.1.2 Artificial Reefs

Artificial reefs are submerged structures designed to reduce wave energy by causing waves to break or be disrupted at a suitable distance away from the shoreline in order to reduce erosive processes on the coastal foreshore. In some instances they can be designed to promote recreational amenity such as surfing and diving conditions. However due to the wave climate and the fact that it is difficult to create an artificial reef that offers coastal protection and a surfing amenity at the same time (due to different water depth requirements) an artificial surfing reef is not likely to be suitable to address coastal hazards in the Cockburn Sound.

Artificial reefs can be effective in localized erosion control, however issues related with design and sea level rise exist because effects of increasing sea level will impair their ability to reduce wave energy reaching the coast. Artificial reefs can change beach alignment and erosion patterns.

Wave energy is dissipated on the reef resulting in less energy at the beach in the lee of the reef and the consequent deposition of sediment.

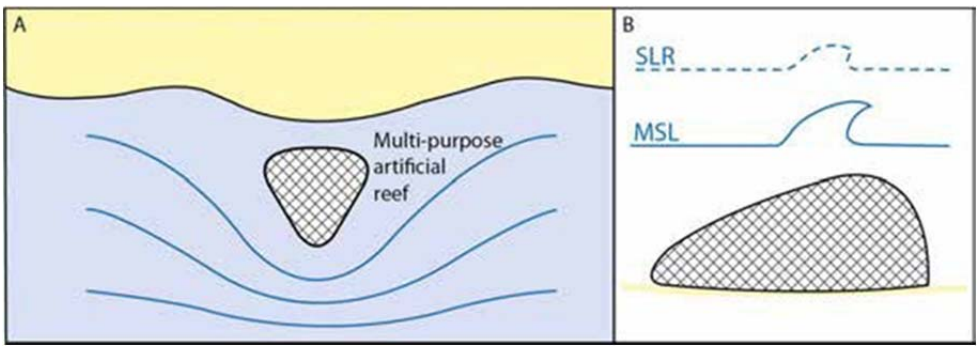


Figure 2 Typical diagram of a multi-purpose artificial reef [ii]

Sea level rise and changes in the wave climate can affect the efficiency and stability of artificial reefs, in the same way it can affect the efficiency of other emerged or submerged structures for wave energy reduction such as detached breakwaters. A rise in the sea level or substantial changes in the wave energy and direction can alter the reef's role in beach and shoreline stabilisation. Substantial changes in the wave climate can require expensive changes in the design of the structure (e.g. orientation). Artificial reefs can therefore be seen as a measure to control the shoreline position in the medium term (5 to 20 years), but their efficiency as a long term strategy to maintain the current shoreline configuration is limited.

4.1.3 Detached breakwaters

Detached breakwaters are erosion control structures. They are most frequently placed parallel to the coast to reduce wave energy and increase beach stability. Detached breakwaters can create salient (accretion of sand behind the structure) and stabilize the shoreline position against erosion.

They can be effective in defending the current shoreline position against erosion; however their effectiveness depends on the detailed design of the structure. Detached breakwaters can be used to reduce extreme and chronic storm erosion by reducing wave energy and sand movement and allowing for sand accumulation. They are not effective for protection against storm tide inundation.

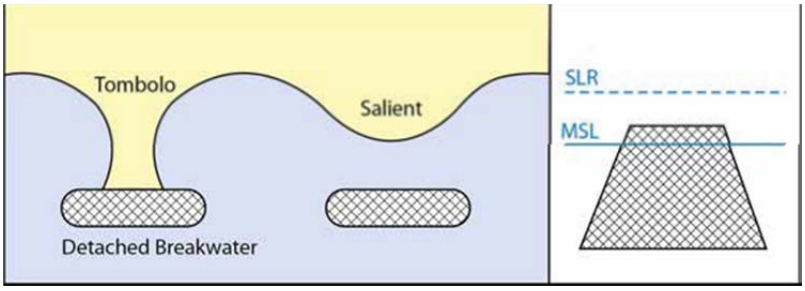


Figure 3 Typical detached breakwaters Note: MSL = mean sea level; SLR = sea level rise

Their purpose is to reduce wave energy transmission, long shore currents and therefore reduce cross shore and longshore transport and, as a consequence, reduce erosion and increase the beach width. However by reducing the longshore transport of sand, offshore breakwaters may cause or significantly increase erosion in nearby unprotected down drift beaches.

Figure 4 Detached breakwater (bottom right) forming a tombolo in Geraldton, Western Australia, as part of a coastal protection and harbour configuration (Source: Google Earth)

While breakwaters can be efficient in the short term, a rise in the sea level or substantial changes in the wave energy and direction can alter their role in beach and shoreline stabilisation. The crest freeboard can be submerged by rising sea levels, requiring further interventions to maintain their function. Changes in the wave climate can require expensive changes to the design of the structure (e.g. orientation). Detached breakwaters can therefore be seen as a measure to control the shoreline position in the medium term (5 to 20 years) but their efficacy as a long term strategy to maintain the current shoreline configuration is questionable.

4.1.4 Groynes and artificial headlands

Groynes are structures built perpendicular to the shoreline that trap sand moving along the coast, causing sand build up on the down drift side. A variant of a groyne is an artificial headland which acts in the same manner but has a larger footprint. They can be effective in controlling coastal erosion and longshore transport.

Groynes and artificial headlands can be effective in defending the current shoreline position against erosion. They are not effective for protection against storm tide inundation. As such, they should be combined with sand nourishment to mitigate the adverse effects on coastal processes. They can be used to reduce extreme storm erosion by reducing longshore sand movement.

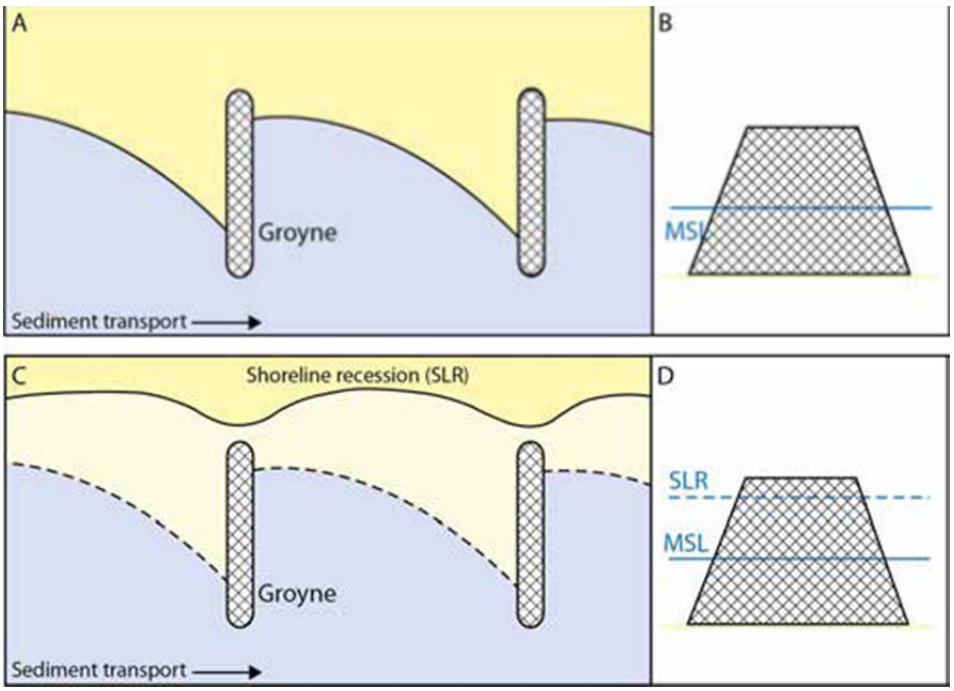


Figure 5 Groynes can be used to control longeshore transport and facilitate beach accretion. Sea level rise can affect groynes functionality in the future [iii]

The primary negative impact includes coastal erosion on the lee side of the structure. In the case of a group of groynes, the above effect appears on the lee side of the whole system. Therefore it is recommended that sand nourishment is undertaken at the time of groyne construction to mitigate immediate adverse effects down drift. The erosion is also observed in direct vicinity of the structures, particularly when waves approaching the shore are predominately perpendicular.

Sea level rise and changes in the wave climate can affect the efficiency and stability of groynes. While groynes can be efficient in the medium term (up to 50 years), a rise in the sea level or substantial changes in the wave energy and direction can alter their role in beach and shoreline stabilisation. These changes could require the implementation of adaptation measures to ensure that the groynes remain fit for purpose.

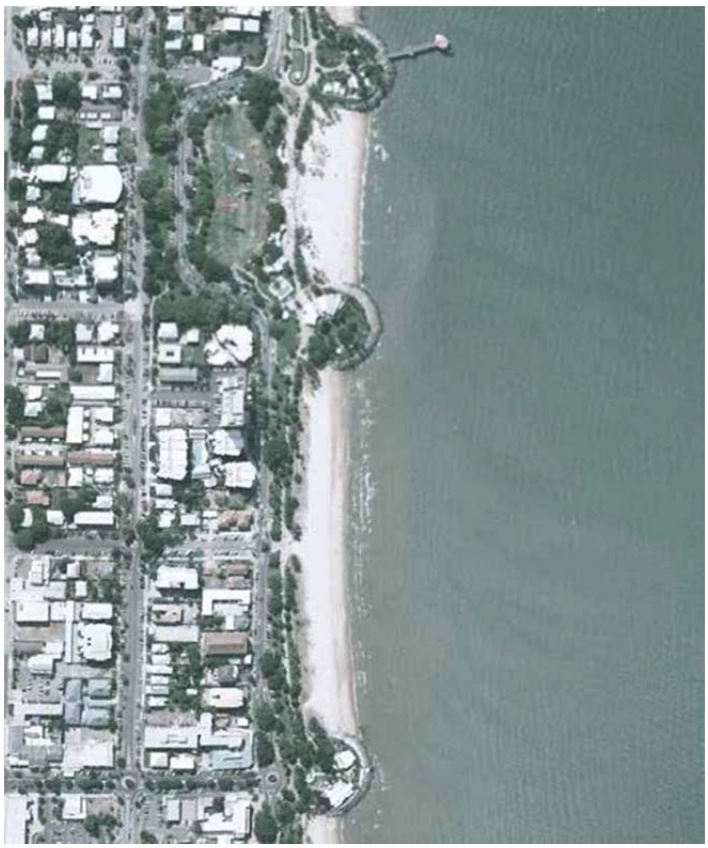


Figure 6 Artificial headlands along the Townsville esplanade[iv]

4.1.5 Sea dykes

A sea dyke or levee is an artificially constructed fill or wall commonly designed to regulate water levels and to avoid inundation from storm tides to low lying land. It is usually earthen, covered with vegetation and parallel to the shore of low-lying coastlines. Sea dykes can be used to control extreme water levels associated with storm tides and in conjunction with sea level rise. They can be used to defend low lying areas from the risk of inundation and erosion provided that they are appropriately armoured on the seaward face.

Sea dykes are typically expensive structures, which can require high levels of maintenance where extreme storms or rising sea levels challenge their efficiency and performance.

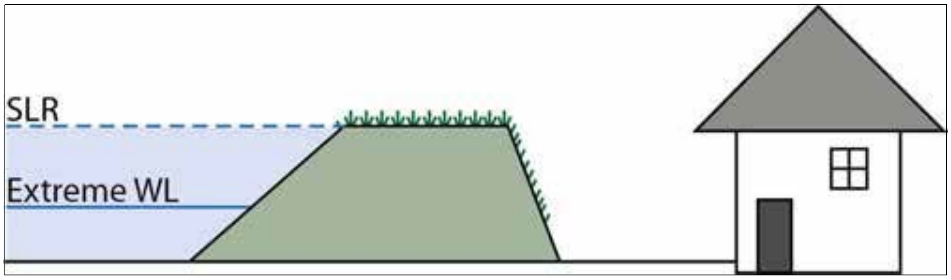


Figure 7 Typical sea dyke configuration Note: Extreme WL = extreme water level; SLR = sea level rise

Sea dykes can be used to protect human settlements from storm surge floods and sea level rise. However, sea level rise can threaten their efficiency and reshaping and upgrading may be required in the future if not adequately designed.

Sea dykes and levees can be an effective measure to reduce the risks of storm tides under sea level rise and could be designed with a 100 year or more design life, if adequate land and funding is available. However, raising sea dykes in response to sea level rise can cause the area of land required for dyke construction to increase if slope gradients are maintained. The construction and maintenance costs are likely to increase into the future; caused by increases in water depth in front of the structure, which in turn causes increased wave heights and wave loadings on the structure. Therefore the design life needs to be considered with a long term view in order to ensure the structure meets the needs and capabilities of future stakeholders.

4.1.6 Seawalls

Seawalls are structures separating land and water areas designed to prevent coastal erosion and other damage due to wave. Seawalls are normally very large structures as they are designed to resist the full force of waves and storm surges. Seawalls are effective in defending the current shoreline position against erosion. They are not effective for protection against storm tide inundation unless designed to be as they are often limited in height and may be porous. They should also be combined with sand nourishment to attempt to reduce the resultant adverse effects on coastal processes.

Seawalls are put in place to protect the land and associated land-based amenities behind them. While these structures are usually termed coastal protection structures, they better serve as land protection mechanisms as opposed to aiding in reducing coastal erosion. In many instances seawalls accelerate erosion on their seaward side, which ultimately results in a loss of the beach. In addition, these structures can be aesthetically unappealing and may hinder access to the beach.

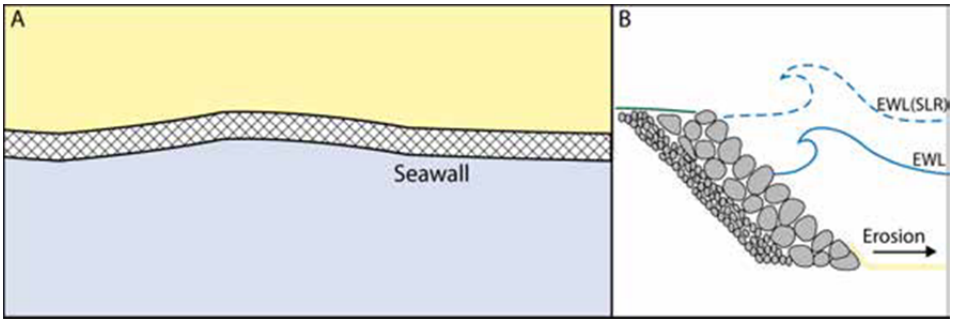


Figure 8 Typical seawall and the effect of sea level rise and erosion [v]

It is desirable for seawalls to cover the full length of the sediment cell within which they are located in order to prevent down-coast effects. In some instances this is not practical of feasible, in which case the potential for erosion to occur around the ends of the wall needs to be considered to ensure that the structure does not collapse adjacent to the unprotected coast.

Seawalls do not typically require continuous maintenance, however, extreme storms can damage the structures and intervention can be required.

Sea walls can be designed with a 100 year or more design life, if adequate land and funding is available. However, it is important that the design life is considered with a long term view in order to ensure the structure meets the needs and capabilities of future stakeholders. To address sea level rise, seawalls will either need to be designed and constructed to meet future requirements or planned for height increases to be undertaken periodically. However this will only be practical if the foundations of the wall have been built sufficiently robustly to allow the extra load. Otherwise the wall may need to be rebuilt.

4.2 Planning and Development Options

Planning adaptation responses are designed to reduce the risk of coastal hazards on human settlements by controlling development in high hazard risk areas and reducing the current urban footprint in high hazard risk areas. Planning responses ultimately contribute to strategic retreat pathways, however can also provide a framework for shorter term use and enjoyment of the coast prior to the realization of coastal risks. Planning responses can also provide for intensification of coastal development, where community, economic and social values support the long term (interim) protection of coastal developments.

Planning decisions made in short and medium term horizons should not pre-empt or restrict future planning decisions. This is supported by the WAPC's SPP 2.6 *State Coastal Planning Policy and Guidelines* which recommend that more favourable risk adaptation options will allow for a "wide range of potential future risk management options". For this reason, planning responses are most effective when considering the "avoid" and "planned or managed retreat" risk mitigation levels set out in the *Coastal Hazard Risk Management and Adaptation Planning Guidelines* (WAPC).

Figure 9 Levels of risk mitigation[vi]

Relevant planning mechanisms in Western Australia include the *Environment Protection and Biodiversity Act 1999* (Commonwealth); the *Planning and Development Act 2005* (WA); *Planning and Development* (Local Planning *Schemes) Regulations Act 2015*; State Planning Policy 2.6 *State Coastal Planning Policy* and *State Coastal Planning Guidelines*; local planning schemes and local planning strategies; structure plans; local area plans; foreshore management plans and coastal management strategies. These are mechanisms that can deliver/implement planning responses, however do not operate as the discrete response themselves.

For future development, risks can be avoided by policy approaches that restrict vulnerable development in high level coastal hazard risk areas. There is scope to accommodate risks through a range of planning policy mechanisms by providing warning to landowners, educating the community, government intervening to secure future vulnerable land, and reducing the consequences of impacts (e.g. development styles, construction techniques). Alternatively, there is an opportunity to accept the risk of development in vulnerable areas where the design life of the development is aligned with the expected timeframe until a certain risk level is reached.

As comprehensive infrastructure and works are already in place in settlements within the coastal hazard risk areas, it is much more difficult to manage existing development as there may be limited opportunity to avoid or accommodate the risk using planning responses alone. Risk management options, therefore, are mainly concerned with protecting the land or asset through redevelopment, rezoning and land acquisition to utilise land and development in the most efficient way in providing protection from high coastal risk.

State Planning Policy 2.6 provides an effective planning tool in Western Australia, and provides development control and strategic planning guidance for new coastal development and land use. The limitations of SPP 2.6 in managing coastal risks in the long term relate to the capacity of decision makers to understand and implement the policy, and the ability and precedence of the (non-statutory) policy to be varied in response to political outcomes. The focus of the SPP on new development and land use change limits its applicability to existing development within coastal risk areas.

The following planning options are described within this compendium. This information discusses the planning policy response to manage risks rather than the mechanisms in the Western Australia planning system that might be used to implement them. The mechanisms will be analysed and explored in the development of the adaptation plan:

Coastal Development Control

- Restriction of development in vulnerable areas
- Coastal development setbacks
- Temporary development
- Managed redevelopment
- Design standards to manage risk

Strategic Planning

- Rezoning land (density/land use)
- Development incentives and split codings
- Foreshore reserve expansion and retention
- Intensification planning

Retreat Strategies

- Strategic withdrawal of utilities/infrastructure
- Land acquisition (voluntary and compulsory, leaseback) and impermanent land tenure
- Notifications on title

4.2.1 Coastal Development Control

Restriction of Development in Vulnerable areas

Prevention of further development within coastal areas at high risk, including primary and fore dunes and low lying coastal areas, is an effective policy tool to avoid future hazard issues with coastal development.

Restriction policy, using scheme provisions, special control areas, local or state planning policy, can be implemented by local and state government to avoid the need to provide longer term interim protection for development in vulnerable locations.

The use of planning policy to restrict development on the basis of coastal vulnerability can be subject to challenge by developers and applicants, particularly where (interim) protection measures are seen to manage the risk in the current planning horizon. The use of statutory mechanisms (including scheme provisions and special control areas) can remove some level of discretion for such decisions.

Coastal development setbacks

Development setbacks establish fixed distances from a designated boundary (i.e. the high water mark, a hazard risk line, a defence line, or another specific line determined by the legislative framework) to the property line in which development is restricted, prohibited or regulated by specific design requirements to provide a safety buffer against extreme storms and future sea level rise.

Coastal development setbacks provide protection to properties and infrastructure against coastal flooding and erosion by ensuring that buildings are not located in an area susceptible to these hazards and that those structures which are susceptible are appropriately designed to mitigate against the risk. Coastal development setbacks can also be imposed to specify locations in which existing developments may not be rebuilt or improved following damage.

In general two types of setback can be implemented:

- Elevation setbacks to deal with flooding; and
- Lateral setbacks to deal with erosion.

Setback distances are determined either as:

- A fixed setback, which prohibits development for a fixed distance landward of a reference feature; or
- A floating setback, which uses dynamic, natural phenomenon to determine these distances case by case.

Building setbacks allow coastal processes, such as erosion, to continue naturally along strategic sections of the coast while ensuring that intensification of development in at-risk areas is restricted. Setback boundaries can be adopted on the basis of historical erosion rates, extreme water level rise predictions and sea level rise figures[vii].

A limitation of development setbacks is their relevance only for a single planning horizon; land outside the defined setback will (in a future planning horizon) become land at risk. Therefore setbacks require ongoing regular review, alongside the use of other planning mechanisms to provide for retention of foreshore environments/retreat of development over subsequent planning horizons.

Temporary development

Where coastal areas are identified for retreat or interim protection (to delay retreat), their use and enjoyment by the community does not dissipate with that decision. Many vulnerable coastal areas (outside areas currently at risk) will be available for appropriate use and development for 50 and 100 years. There is opportunity to enjoy economic and social benefits of the vulnerable coast before the risks are realized, through appropriate temporary development.

Temporary development can include:

- Structures and development that have an asset design life that will expire prior to physical processes affecting their location; and
- Structures and development that are transportable, enabling their relocation as physical processes (and the coast) move toward their location.

With appropriate planning policy and design guidelines, temporary development can create distinct 'pop up' communities and facilities along the coast under the stipulation that these communities will be relocated in the future, as the coast moves further inland. This option is a temporary measure to maximise (temporary) land use opportunities along coastal locations with the ultimate aim of a planned retreat.

Temporary development can also assist in generating greater awareness of the temporary nature of our current beaches, in their current form/location. Design guidelines that require the physical built form to appear temporary can assist the community in understanding that coastal environments are dynamic and will change.

Modular architecture is an effective sustainable building technique that should be considered for development along the coast. Structures at a low cost or that can readily be repaired at low cost following likely impacts of coastal erosion are ideal for sites within the vulnerable area.

Temporary development policy can be very effective when planning for public recreational facilities in coastal areas, or private development on leased land. Challenges in land tenure for private development can arise where private investment prefers long term or permanent land tenure.

Managed redevelopment

Conventional coastal development control policies have limited relevance to planning for existing freehold land located in vulnerable coastal areas. Existing policies in Western Australia tend not to be retrospectively applied to existing developed and zoned areas as decision makers are reluctant to remove existing development rights. The current policy framework and mechanisms do not facilitate adaptive planning and development in vulnerable coastal areas that can respond to changing conditions. Instead the current framework assumes an interim protection approach for the development and redevelopment of assets along the coast.

Planning policy that manages redevelopment of coastal processes can rely on the natural decommissioning and relocation of private assets at the end of their design life *prior* to coastal risks affecting the property and/or private asset through private redevelopment.

Alongside managed redevelopment policy, notifications can be placed on Certificate of Title that state that assets cannot be redeveloped beyond a certain date/risk level. This will enable freehold land to be developed now, but prevents redevelopment should the development exist within an identified coastal risk zone.

Design standards to manage risk

Increasing or changing asset design standards is one coastal adaptation option which can be used to withstand the impacts of coastal processes within coastal hazard zones. This measure should only be considered where avoiding risk or relocating an asset is not an option. This option is best implemented for new assets which are considered at risk due to the pressing coastal risk line to ensure reduced cost in mitigating the impacts with initial design outcomes. Retrofitting of existing assets can be undertaken through redesign and renovations; however this would be at an increased cost to the proponent.

A design approach can inform developments sensitive to the unique natural coastal characteristics. When addressing both new and existing redevelopment, this option can be initiated through built form design controls that appropriately address the coastal impacts presented to a coastal asset. Design guidelines can include ways to 'live' with the effects of coastal inundation, including vertical building design, reducing or shifting the building footprint, locating the development on the least hazardous portion of the site, and using appropriate building materials. Guidelines can be updated according to changes in the risk line.

Figure 10 An example of retrospective design requirements: flood wall/gates and doors added to a dwelling to protect existing property from storm related flooding in United Kingdom

4.2.2 Strategic Planning

Our continued, long term enjoyment of coastal environments and public beaches requires fundamental different approaches to planning of coastal settlements. Current practices, which result in intensive development adjacent to coastal foreshore due the market and amenity value of these locations, are not conducive to natural retreat of the coast, and therefore retention of the beach asset which creates the market and amenity value. Strategic planning measures therefore relate to changing settlement patterns, moving development away from the receding coastline, to retain public ownership of the beach and coast in the long term.

Changes in land-use, for example from residential to recreational purposes, can be considered as part of a strategy to mitigate future development from exposure to risks from coastal erosion and storm tide inundation. Changes to land-use designation should be considered as a preventative mechanism to ensure that the distribution and intensity of future uses are compatible with identified risks in high coastal hazard and erosion prone areas.

Changes in land-use can be carried out to reduce the intensification within coastal hazard areas. Exposure of coastal settlements to coastal hazards can be reduced through a gradual land-use transition. Conversely, where social and economic values allow, changes in land use might intensify development in coastal areas to better justify the cost-benefit of coastal protection works.

Proposals for land-use change should be supported by a broad stakeholder consultation process. This could be a challenging process, particularly

considering the loss of value of land that may be caused by land use planning changes.

There are several ways in which land use planning can mitigate the risks of high level coastal hazard risks through local planning scheme mechanisms, primarily to encourage the provision of better land uses that are more naturally appropriate to the coastal hazards risk levels.

Rezoning land

Rezoning strategies enable planning decision makers to restrict and discourage development on residential, commercial and industrial areas along the coast, particularly in high risk areas exposed to coastal hazards in the future. Rezoning forms a part of retreat strategies, effectively reducing and removing development potential in vulnerable locations to remove the need to protect private land from erosion over time.

Changes in land use – for example from intense commercial activities, to lower scale temporary activities – reduces the future cost of purchasing, compensating, and decommissioning private assets in vulnerable areas. Changing zones from intense residential and commercial zones to special use zones which restrict the nature of use and development can prepare private land and communities for eventual retreat.

On residential lots, rezoning to change density of development and redevelopment can ensure that intense, high density areas are planned for outside vulnerable coastal locations. For example, increasing residential density in the Rockingham city centre, and lowering density on the immediate coast can enable the coastline to recede naturally over time, with fewer properties/dwellings at risk, and without impacting on the overall supply of dwellings in the area. The decline in value of coastal land (from the reduced density) is offset by the increase in value of higher density land elsewhere. Whilst restriction and down coding of coastal land may result in claims for compensation due to injurious effect on land values on the coast, these costs may be offset by the avoidance of interim protection measures and/or the social benefit of retaining public beaches which are otherwise lost where interim protection of private land is undertaken (through sea walls and other engineering structures).

As coastal locations are currently considered of high market value, a comprehensive change in community perceptions would be required regarding the risks of coastal hazards to land, land use and property to ensure community outrage over reducing density/perceived loss of land values is managed. Stakeholder and community engagement will be important to engage the

community in decisions related to changing the structure of coastal settlements, to provide ongoing public benefit.

Development incentives

Development incentives provide a softer approach than rezoning to shift coastal development patterns. Opportunities to incentivize the ceding of private property at risk over time, through increased development potential elsewhere, can remove some of the angst felt by coastal landholders, and also alleviate compensation costs where land values are affected by rezoning policies.

Split coding (which tie increased development potential on a 'safe' lot to the ceding of a lot at risk) is an example of development incentives. These allow for more efficient land use along the coast as higher density development is encouraged outside of the hazard risk area, and the voluntary ceding of private land contributes to a generous setback, which could be used as public open space, community gardens or other public uses as the natural coastline continues to recede naturally. This option would make it appealing to developers and landowners who would likely benefit from the more flexible higher density coding.

The non-mandatory nature of developer incentives requires that private landholders choose to give up their coastal assets; in the context of the Cockburn Coast, many of these assets are homes – the coastal nature of which are highly valued by their owners. Developer incentives alone may not adequately shift coastal development patterns, and would require rezoning to restrict density on coastal lots to preclude redevelopment.

Foreshore reserve expansion and retention

For some time, Western Australia has had a policy of public ownership and foreshore reserve along the coast and waterways. In line with this policy, the State Government has acquired land over time and requires ceding of land to provide public foreshores. This practice supports the principal that, in Western Australia, the coast and beaches are a public asset for community benefit.

Foreshore reserves along the Cockburn Coast are threatened by two key processes:

- Reduction in the foreshore reserve as erosion risks are realized; and
- Rezoning of existing foreshore reserves to facilitate private coastal development (e.g. new marina proposals)

Where erosion extends beyond the foreshore reserve, or if no foreshore reserve exists, the ability to retain public beaches and foreshore reserves is entirely removed unless private land is relocated/acquired and land is reserved. The use of reserves also enable greater control of development in vulnerable areas, as private land use and development is subject to lease and approval, with no as of right development potential that exists in many zones.

In many areas of the Cockburn coast, the existing foreshore reserve is insufficient to provide a beach and associated open space along the coast in 2070 to 2110 as physical processes erode the existing reserve. Expanding the foreshore reserve to include all vulnerable land and some adjacent land, is the only planning response that enables retention of public beaches and coastal reserves in the long term. Ensuring that the existing foreshore reserve is retained (i.e. not rezoned for private development) will avoid introduction of new development and assets within vulnerable areas, and therefore avoid the costs of acquisition/compensation/interim protection being borne by future communities.

Where expansion of the foreshore reserve impacts currently developed properties, existing land uses can continue to operate under non-conforming use rights; once those rights expire – or the land is purchased, the land on the coast shall form part of a foreshore reserve. A staged approach according to risk levels is appropriate in determining which lots should be rezoned and at what time. Reservation of public land will require compensation and/or purchase.

Intensification planning

Planning for intensification of coastal development may be a necessary planning strategy for development types that are dependent on coastal locations. This includes:

- Coastal dependent industrial development (e.g. access to import/export facilities and ocean outfalls); and
- Boating and marina facilities

Intensification of development may also be used in existing coastal settlements where social or economic values (e.g. value of private land, heritage values) provide justification for interim protection works. In such instances, intensifying development (and therefore the cost benefit of interim protection) can assist to offset the costs of interim protection measures over long (50+ years) planning horizons. In commercial/residential examples, increasing density and intensity can increase the number of users (e.g. residents) that benefit from the infrastructure, therefore reduce the cost per user (and share these costs through

local area rates/special levies to fund the construction, maintenance and upgrading of the necessary temporary protection).

As population increases within a hazardous coastal zone, it is assumed that the intensification would support the ongoing protection of the land. Similar approaches have been undertaken in the Netherlands, where the high population density in vulnerable locations makes it viable to systematically protect in the long term as the assets become too valuable to lose or to retreat. This is particularly relevant for state significant industrial development which is dependent on coastal access and infrastructure. The intensification option is effectively a high cost, high reward option. However, the extreme investment of costs in assets and services within a vulnerable zone means that there is a high cost associated with protection. Essentially, ever increasing seawalls would be required to protect the development from ever relocating. For this to be financially viable, it requires significant density and a critical mass of people/economic development potential to support the protection elements in the infinite term.

An issue emerges as, despite the proviso that protection will continue in the long term, future climate change and evolving coastal processes are unknown. As such, future ways to protect the area, its land and assets, are also constantly changing. Despite the influx of communities and infrastructure through intensification making the land worthwhile to protect, as future climate change is unknown, it unsustainable to protect in the long term and as a result, should only be considered as a long term, but still an impermanent measure.

4.2.3 Retreat Strategies

Once a strategic decision to retreat has been made, additional responses are necessary to manage the infrastructure and financial impacts. Some preliminary responses may include the following options dependent on the primary issue/s relevant to the location:

- Strategic withdrawal of utilities/infrastructure
- Land acquisition (voluntary and compulsory, leaseback)
- Notifications on title

Strategic Withdrawal of Utilities/Infrastructure

Over time, strategic planning for utilities and infrastructure can identify ways to relocate and decommission infrastructure in areas at risk as assets become ready for renewal. With sufficient lead in, infrastructure providers are able to

consider the level of maintenance, upgrade, and renewal that is appropriate in areas of coastal risk.

New infrastructure should be located outside areas of coastal risk, commensurate with asset lifetimes. Alternative servicing strategies for coastal developments, such as design and installation of infrastructure perpendicular to the coast, can enable staged decommissioning of infrastructure assets over time, as risks are realised.

For infrastructure that may already be located within an identified future retreat location, not allowing for any future upgrading or installation of new infrastructure. The installation of infrastructure is to be limited to outside the identified risk zone, and preferably perpendicular to the coast, as opposed to parallel, where possible. .

Land acquisition and impermanent land tenure

There may be potential for compensation claims to be made where private land will be affected by erosion and inundation.

Acquisition of land, through compulsory acquisition or market purchase can be explored for private land located within an identified area where a retreat strategy applies. Where land is acquired ahead of coastal risks being experienced, there is opportunity to lease these landholdings to provide income streams, and continue the use and enjoyment of coastal land.

In new coastal development areas, the release of private land should consider leasehold rather than freehold sale, to avoid future pressures and costs to protect private coastal land.

Notification on Title

In all instances, an effective and appropriate planning response is to place a notification on title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area which has a retreat strategy applicable to it. This ensures all land holders and potential land purchases are aware of the risks, and assists to avoid an assumption that the land value will be retained in perpetuity through coastal protection works.

5. Conclusion

This options compendium offers a strategic adaptation pathway and appropriate interim and planning adaptation options to assist in the determination of the most appropriate response to coastal erosion and inundation risks along the Cockburn Sound and Owen Anchorage.

In response to the particular erosion and/or inundation risks along the Cockburn Coast, interim protection measures and supporting planning measures have been identified for each coastal management unit. The costs, benefits, and general suitability of these measures will be further considered through a multi-criteria assessment that explores the cost benefit of interim protection for assets and coastal management units against social, economic, and environmental criteria.

Informed by this compendium and a multi-criteria analysis, adaptation plans for the Cockburn Coast will ensure that at a minimum, the key challenges and opportunities are highlighted for any future development and/or redevelopment along the coastline. There is an importance in ensuring that the approach taken is one that is adaptive to changing conditions, and that the correct interim measures are put into place to enable an optimal response to changing coastal conditions.

i GCCM (2007) NGCBPS – EMP Baseline Data Assessment Vol 5: Summary of Narrowneck Reef Monitoring to May 2007. Griffith Centre for Coastal Management Research Report no. 63. Gold Coast, Australia.

ii GCCM (2007)

iii GCCM (2007)

iv Google Earth

v GCCM (2007)

vi Western Australian Planning Commission (2014) Coastal hazard risk management and adaptation planning guidelines. Perth, Government of Western Australia

vii Linham M.M., Nicholls R.J. (2010) Technologies for Climate Change Adaptation Coastal Erosion and Flooding. UNEP RISO.

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Appendix C – Coastal Adaptation Plans

Appendix D – Coastal Management Unit Preliminary Assessment Summary

CMU	Geographical limits		Compendium - Potential Interim Protection Options		Land uses within areas identified as at risk and decision on actions required								
	North	South	Inundation	Erosion	Primary Coastal Hazard Risk	Present	Intolerable Risk	Detail	2070	Intolerable Risk	Detail	2110	Intolerable Risk	Detail
1	South Mole	North boundary of South Beach	➢ Increase height of breakwaters, revetments and land backed wharfs ➢ Install flood levees ➢ Raise ground levels to reclaim land ➢ Install stormwater mgmt	➢ Install seawalls ➢ Undertake beach nourishment	Inundation	Parks and Recreation PP - Special Uses	No	Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented	Parks and Recreation PP - Special Uses Central City Area Railways and Road	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required	Parks and Recreation PP -Special Uses Central City Area Railways Urban	Yes	Review and build on initial retreat or interim protection actions
2	North boundary of South Beach	North boundary Pickled Fig Café	➢ Increase height of breakwaters, revetments and land backed wharfs ➢ Flood Levees	➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Parks and Recreation	No	Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented	Parks and Recreation Urban	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation Urban	Yes	Review and build on initial retreat or interim protection actions
3	North boundary of Pickled Fig Café	South extent of Robb Road	➢ Flood Levees	➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Parks and Recreation Railways and Road	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation Railways and Road Urban PP-Energy	Yes	Review and build on initial retreat or interim protection actions	Parks and Recreation Railways and Road Urban PP-Energy	Yes	Review and build on initial retreat or interim protection actions
4	South extent of Robb Road	Socrates Road/Pelinte View intersection	➢ Increase Height of Breakwaters & Revetments ➢ Raise ground levels to reclaim land	➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Inundation	Urban	No	Inundation only impacts roads and beach promenade during rare events	Urban	No	Inundation only impacts roads and beach promenade during rare events	Urban	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.
5	Socrates Road/Pelinte View intersection	South boundary of Coogee Beach Surf Life Saving Club		➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Parks and Recreation	No	Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented.	Parks and Recreation Urban	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation Urban Railway	Yes	Review and build on initial retreat or interim protection actions
6	South boundary of Coogee Beach Surf Life Saving Club	West boundary of Jervoise Bay Sailing Club		➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Parks and Recreation	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation	Yes	Review and build on initial retreat or interim protection actions	Parks and Recreation	Yes	Review and build on initial retreat or interim protection actions
7	West boundary of Jervoise Bay Sailing Club	West boundary of Woodman Point Facility		➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Parks and Recreation	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation	Yes	Review and build on initial retreat or interim protection actions	Parks and Recreation	Yes	Review and build on initial retreat or interim protection actions
8	West boundary of Woodman Point Facility	South boundary of AMC	➢ Increase Height of Breakwaters, Seawalls and Land Backed Wharfs.		Inundation	Industrial	No	Marine infrastructure requires access to water	Industrial	No	Marine infrastructure requires access to water	Industrial	Yes	Risk to nearshore assets becoming more significant. Some land backed wharf areas may need land raised

CMU	Geographical limits		Compendium - Potential Interim Protection Options			Land uses within areas identified as at risk and decision on actions required								
	North	South	Inundation	Erosion	Primary Coastal Hazard Risk	Present	Intolerable Risk	Detail	2070	Intolerable Risk	Detail	2110	Intolerable Risk	Detail
9	South boundary of AMC	South boundary of Naval Base Shacks camp ground			Neither	Parks and Recreation	No	* Caravan camp facilities are located very close to edge of cliff. See assumption register	Parks and Recreation	No	* Caravan camp facilities are located very close to edge of cliff. See assumption register	Parks and Recreation	No	* Caravan camp facilities are located very close to edge of cliff. See assumption register
10	South boundary of Naval Base Shacks camp ground	South boundary of Kwinana Power Station	➢ Increase Height of Breakwaters, Seawalls, and land.	➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Parks and Recreation and Industry	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation Industry	Yes	Potential for major impacts on every foreshore property. Review and build on initial retreat or interim protection actions	Parks and Recreation Industry	Yes	Potential for major impacts on every foreshore property. Review and build on initial retreat or interim protection actions
11	South boundary of Kwinana Power Station	South boundary of Kwinana Bulk Jetty	➢ Increase Height of Breakwaters, Seawalls, and land.	➢ Install seawalls ➢ Install detached breakwaters ➢ Increase groyne density ➢ Undertake beach nourishment	Erosion	Industry PP -Water Authority	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Industry PP -Water Authority	Yes	Potential for major impacts on every foreshore property. Review and build on initial retreat or interim protection actions	Industry PP -Water Authority	Yes	Review and build on initial retreat or interim protection actions
12	South boundary of Kwinana Bulk Jetty	LGA boundary at coastline		➢ Upgrade existing infrastructure ➢ Install detached breakwaters & nourishment ➢ Install seawalls	Erosion	Parks and Recreation Port Installations (Industrial)	No	Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented.	Parks and Recreation Port Installations (Industrial)	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation Port Installations (Industrial)	Yes	Review and build on initial retreat or interim protection actions
13	LGA boundary at coastline	Wanliss Street		➢ Install seawalls ➢ Install detached breakwaters ➢ Install groynes ➢ Undertake beach nourishment and dune stabilisation	Erosion	Parks and Recreation	No	Some loss of foreshore reserve and beach assets expected. Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented.	Parks and Recreation	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation	Yes	Review and build on initial retreat or interim protection actions. If no actions were made, then may be close to losing nearly all of foreshore reserve by this point
14	Wanliss Street	Railway Terrace		➢ Install seawalls ➢ Install detached breakwaters ➢ Install groynes ➢ Undertake beach nourishment and dune stabilisation	Erosion	Parks and Recreation	No	Some loss of foreshore reserve and beach assets expected. Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented.	Parks and Recreation Urban	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required. Potential for loss of park, road and road reserve but no urban lots affected.	Parks and Recreation Urban	Yes	Review and build on initial retreat or interim protection actions.

CMU	Geographical limits		Compendium - Potential Interim Protection Options			Land uses within areas identified as at risk and decision on actions required								
	North	South	Inundation	Erosion	Primary Coastal Hazard Risk	Present	Intolerable Risk	Detail	2070	Intolerable Risk	Detail	2110	Intolerable Risk	Detail
15	Railway Terrace	Hymus Street	➢ Install seawalls or flood levees / sea dykes	➢ Install seawalls ➢ Install detached breakwaters ➢ Install groynes ➢ Undertake beach nourishment and dune stabilisation	Erosion and Inundation	Parks and Recreation Urban	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required. Areas affected include foreshore road within urban zone and adjacent houses.	Parks and Recreation Urban	Yes	Review and build on initial retreat or interim protection actions.	Parks and Recreation Urban	Yes	Review and build on initial retreat or interim protection actions.
16	Hymus Street	Causeway		➢ Install seawalls ➢ Install detached breakwaters ➢ Install groynes ➢ Undertake beach nourishment and dune stabilisation	Erosion	Port Installations (URBAN)	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Port Installations (URBAN)	Yes	Review and build on initial retreat or interim protection actions.	Parks and Recreation Port Installations (URBAN)	Yes	Review and build on initial retreat or interim protection actions.
17	Causeway	Western boundary of Point Peron Recreational Camp		➢ Upgrade existing infrastructure ➢ Install seawalls ➢ Install detached breakwaters ➢ Install groynes ➢ Undertake beach nourishment and dune stabilisation	Erosion	Parks and Recreation PP Special Use (URBAN)	No	Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented. *no housing infrastructure at risk	Parks and Recreation PP Special Use (URBAN)	Yes	Risk to nearshore assets becoming intolerable as protection of dunes reduces. Retreat or Interim Protection is required.	Parks and Recreation PP Special Use (URBAN) Waste Water Facility	Yes	Review and build on initial retreat or interim protection actions.
18	Western boundary of Point Peron Recreational Camp	End of peninsula	➢ Install seawalls or flood levees / sea dykes ➢ Raise land levels	➢ Upgrade existing infrastructure ➢ Install seawalls ➢ Install detached breakwaters ➢ Install groynes ➢ Undertake beach nourishment and dune stabilisation	Erosion and Inundation	Parks and Recreation PP Special Use (URBAN)	No	Risk to nearshore assets is increasing but not yet intolerable. Accommodation measures should be implemented. *no housing infrastructure at risk	Parks and Recreation PP Special Use (URBAN)	Yes	Risk to nearshore assets becoming intolerable. Retreat or Interim Protection is required.	Parks and Recreation PP Special Use (URBAN)	Yes	Review and build on initial retreat or interim protection actions.

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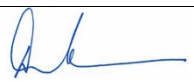
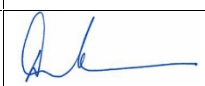
0	B Grace C Thompson L McKenzie	D Horn		D Horn		24.06.2016
1	B Grace C Thompson L McKenzie B. Benjamin	D Horn		D Horn		30.10.2016

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