Phase 7 Socio-Economic Appraisal of Adaptation Options for Coastal Hazards

Bundaberg Region Coastal Hazard Adaptation Strategy

Bundaberg Regional Council

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EXECUTIVE SUMMARY

Introduction

During Phase 7, detailed Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA) were applied to the shortlisted 'Modify' adaptation options, compared, and ranked. This provides a framework to inform prioritisation of adaptation options into the final CHAS Implementation and Action Plan.

The results in this report are guided by previous technical analyses including economic, social, and environmental consequences, infrastructure costs and the shortlisted 13 'Modify' adaptation options from Phase 6. This process is illustrated in Figure A. The priority settlements considered in the socio-economic appraisal are those identified as being exposed to intolerable risks from coastal hazards at some point in the future:

- Moore Park Beach
- Burnett Heads
- Bargara
- Innes Park/Coral Cove
- Coonarr
- Woodgate Beach and Walkers Point.

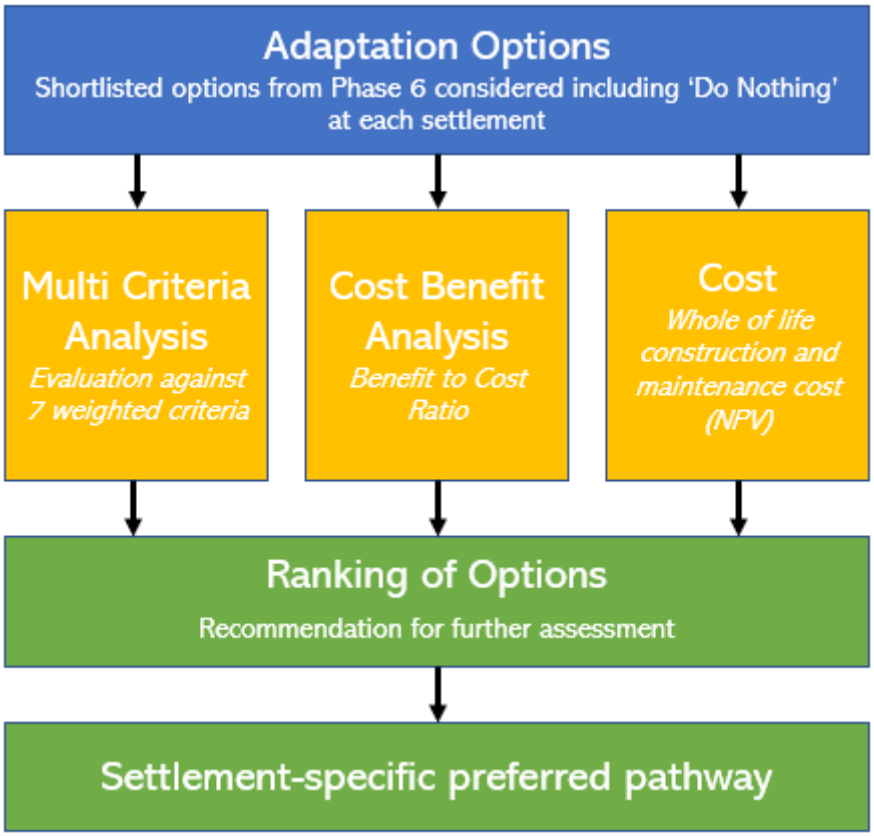

FIGURE A PHASE 7 SOCIO-ECONOMIC APPRAISAL PROCESS

Socio-economic appraisal

MCA was performed against key criteria, -each weighted with input from the Community Reference Group and Council. The evaluation criteria includes effectiveness of the option, adaptability over time, impact on beach access and amenity, technical viability of the option, impact on the natural environment and environmental values, approvals required and the cost of implementation and maintenance. Each of the shortlisted 'Modify' options were given a score which highlights the preferred adaptation pathway for implementation.

Adaptation option	MCA score	Cost estimate	Benefit estimate	Ratio
OPTIONS RECOMMENDED AS PREFERRED ADAPTATION PATHWAYS				
Moore Park Beach Beach Nourishment	77.3	$525,219	$3,830,002	7.3
Woodgate Beach Beach Nourishment	73.8	$1,072,437	$6,034,801	5.6
Moore Park Beach Seawall/Rockwall	67.4	$802,348	$3,830,002	4.8
Coonarr Beach Nourishment	63.8	$177,477	$675,539	3.8
Burnett Heads Storm Surge Barrier and Dyke	60.6	$80,273	$34,173	0.4
Coonarr Land use and tenure transition	59.6	$1,553,137	$693,254	0.4
Innes Park and Coral Cove Beach Nourishment	58.8	$11,595	$89,649	7.7
Bargara Beach Nourishment	58.4	$5,846	$225,164	38.5
OPTIONS NOT RECOMMENDED AS PREFERRED ADAPTATION PATHWAYS				
Coonarr Seawall / Rockwall	56.3	$511,532	$675,539	1.3
Woodgate Beach Seawall/Rockwall	46.1	$1,804,230	$6,034,801	3.3
Innes Park and Coral Cove Seawall/Rockwall	43.1	$28,987	$89,649	3.1
Bargara, Kellys Beach Seawall/Rockwall	40.3	$33,270	$225,164	6.8
Woodgate Beach Land use and tenure transition	37.7	$914,489	$217,441	0.2

CBA enables an assessment of the reduction in coastal hazard damages to property and infrastructure that could be afforded through implementation of the physical adaptation option. The reduction in damages is compared directly with the construction and maintenance cost to provide a Benefit-Cost Ratio (BCR), advising how economically beneficial it is to implement each option.

Net Present Value (NPV) is applied to enable direct comparison of adaptation options implemented over different planning horizons.

The results of the socio-economic appraisal of adaptation options are shown in the table below. The results show that soft-engineering approaches are preferable, namely beach nourishment to mitigate coastal erosion risks. This is the recommended adaptation approach for Moore Park Beach, Woodgate Beach, Coonarr, Innes Park and Kellys Beach, Bargara. This option was ranked higher than other hard-infrastructure options such as a seawall, as it is considered to have the same effectiveness as seawalls but scored much higher in its adaptability and impacts on beach access, amenity and environment. Being adaptable to changing sea level scenarios is important as the timing of these events is associated with a high degree of uncertainty.

The limitations of the socio-economic appraisal should be further assessed, together with the coordination of structural adaptation options and non-structural options, implementation timelines, governance considerations and coordination with internal and external CHAS supporting actions.

Discussion

Figure B summarises the preferred adaptation pathways for each settlement based on the analyses in this report and the screening process undertaken in Phase 6.

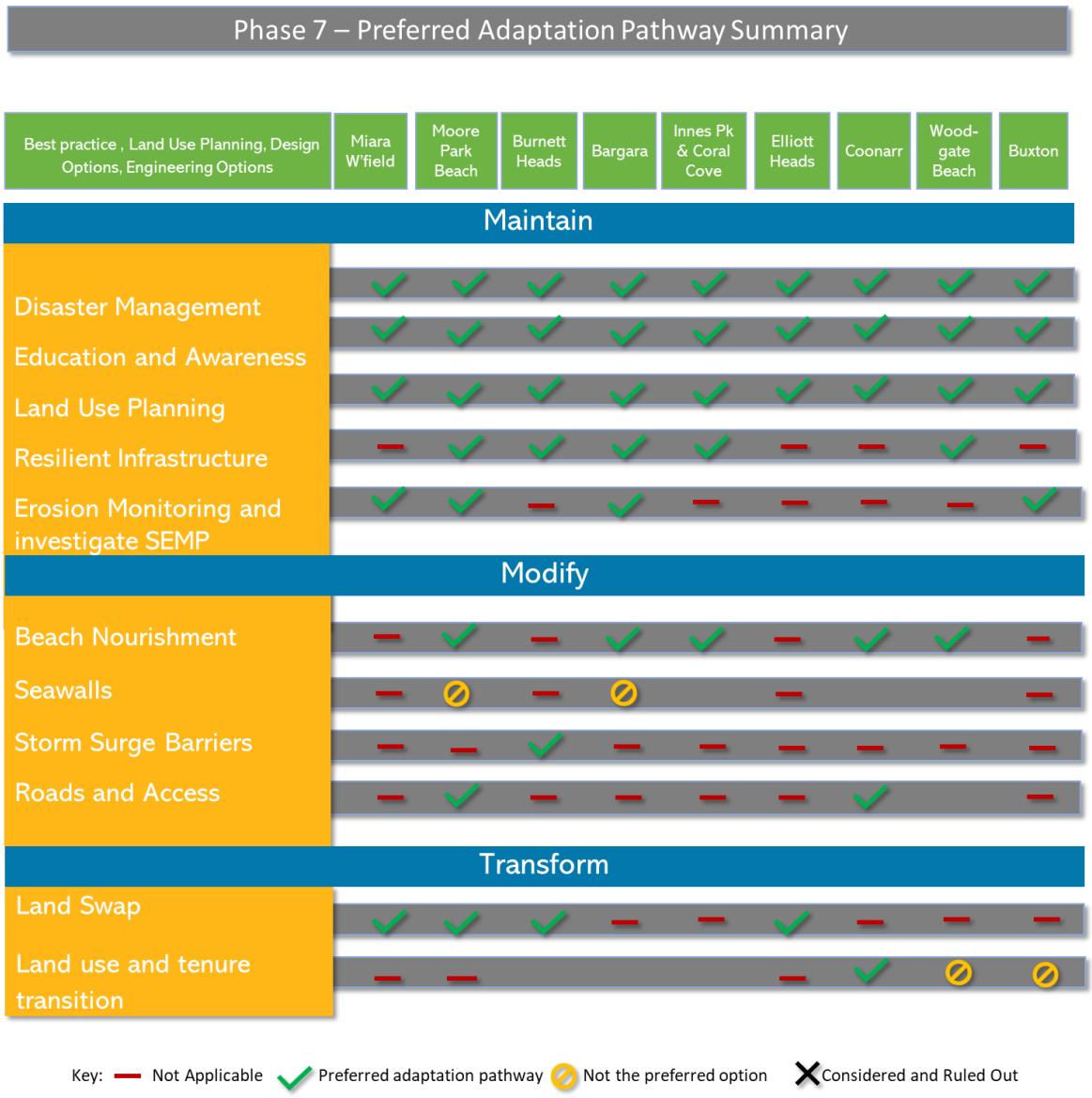

FIGURE B PREFERRED ADAPTATION PATHWAY SUMMARY

Adaptation options that have been recommended automatically into the CHAS Action Plan have in effect 'bypassed' the socio-economic appraisal of the MCA and CBA. These are adaptation options that are considered best-practice 'Maintain' options such as ongoing disaster management, education and awareness campaigns and land use planning to ensure the settlement vision and growth pattern are commensurate with the risk.

Some 'Modify' options have been recommended for implementation including raising of key access roads to lower the frequency of isolation risk to settlements. The raising of key access roads may result in a reduction to isolation risks during storm tide events, allow for easier access for emergency services and provide for simplified logistics during the post-event recovery phase. These have -not been considered in the socio-economic appraisal as they are do not reduce 'damages' in the same sense as a seawall or beach nourishment. Whether these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

It is intended that Council lead and facilitate the CHAS implementation, in coordination with existing capital works, and other projects. However best practice outcomes will be achieved if numerous stakeholders play a role in implementation. This means residents, business, community organisations, state agencies, and disaster management groups all have a role to play.

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1 INTRODUCTION

1.1 Background to Coastal Hazard Adaptation Planning

Over the last few years, the Queensland Coast (and specifically the Bundaberg Region) has experienced disasters which have resulted in significant economic costs and societal impacts. In response, Bundaberg Regional Council (Council) has pro-actively developed a unique perspective on the concepts of, approaches to, and challenges involved, in building resilience and undertaking activities to adapt to changing circumstances.

Current projections for Queensland's coastline by 2100 indicate:

- A projected sea level rise of 0.8 m
  - The projected sea-level rise of 0.8 metres by the year 2100 adopted by the Queensland Government is based on climate modelling for probable scenarios of world development as presented in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report released in 2014 (AR5).
  - A decision was made to continue with the previous 0.8 m sea-level rise planning value used in the Queensland Coastal Plan 2012 to maintain stability and certainty in the planning environment
- Tropical cyclones are projected to become less frequent, however tropical cyclones that do occur are expected to be more intense and may track further south.

The likely impacts associated with these changes mean that rising sea levels combined with storm tides are likely to cause accelerated erosion and increased risk of inundation. For settlements and infrastructure this is likely to result in damage to, and loss of, dwellings and infrastructure, with community-wide impacts. For ecosystems, sea level rise may lead to loss of habitat, and the salinisation of soils may cause changes to the distribution of plants and animals.

The impact of increasing coastal hazards will affect Queensland councils in the areas of:

- Litigation and legal liability;
- Community expectations;
- Land use planning and development assessments; and
- Asset and infrastructure planning and management.

In response to this, the QCoast2100 Program was developed to provide councils in Queensland with assistance to advance coastal hazard adaptation planning. The adaptation program will support all Queensland local governments impacted by existing and future coastal hazards to advance adaptation planning. The Program will facilitate the development of high-quality information enabling defensible, timely and effective local adaptation decision-making through access to tools, technical and expert support, and grants for eligible councils.

The CHAS program is delivered through eight phases (see Figure 1-1) and each of the phases can be categorised under three themes:

- Commit and Get Ready
  - Phase 1: Plan for life-of-project stakeholder communication and engagement (Completed 2017)
  - Phase 2: Scope coastal hazard issues for the area of interest (Completed 2017)
- Identify and Assess
  - Phase 3: Identify areas exposed to current and future coastal hazards (Completed 2019)
  - Phase 4: Identify key assets potentially impacted (Completed 2019)
  - Phase 5: Risk assessment of key assets in coastal hazard areas (Completed 2019)

- Plan, Respond and Embed
  - Phase 6: Identify potential adaptation options (Completed 2019)
  - Phase 7: Socio-economic appraisal of adaptation options (Current Phase)
  - Phase 8: Strategy development, implementation, and review.

FIGURE 1-1 CHAS PROGRAM PHASES

1.2 Description of Phase 7

In line with the CHAS Minimum Standards, this Phase will employ a community-based MCA to evaluate all viable options identified in Phase 6. This process is illustrated in Figure 1-2. This will allow ranking of the options in order of performance and selection of those with the best overall scores. The cost and effectiveness of these options will then be further evaluated through a CBA, which will generate a final list of preferred and cost-effective adaptation options.

When assessing adaptation options, it is of critical importance to obtain extensive “buy-in” from the community, Council, and stakeholders, particularly when structural mitigation works are required. To achieve this, the Community Reference Group (CRG) and Council were involved in the appraisal and selection of the adaptation options throughout Phases 6 and 7.

An MCA provides a qualitative framework to rank adaptation options based on their performance in reducing the risk to assets. The MCA undertaken for the Bundaberg CHAS compares the list of viable options against evaluation criteria that have been selected and weighted in collaboration with Council and the CRG. The evaluation criteria includes capital and maintenance cost, environmental and social impact, community acceptability, adaptability, effectiveness over time, legal and approval risks, and technical viability.

The CBA is then used to assess the cost-effectiveness of the viable options. It is commonly used to prioritise options and inform decision-making about alternative courses of action. A CBA can assist in identifying the option that achieves maximum value-for-money benefit for Council, while also accounting for social and environmental values according to their net economic benefit.

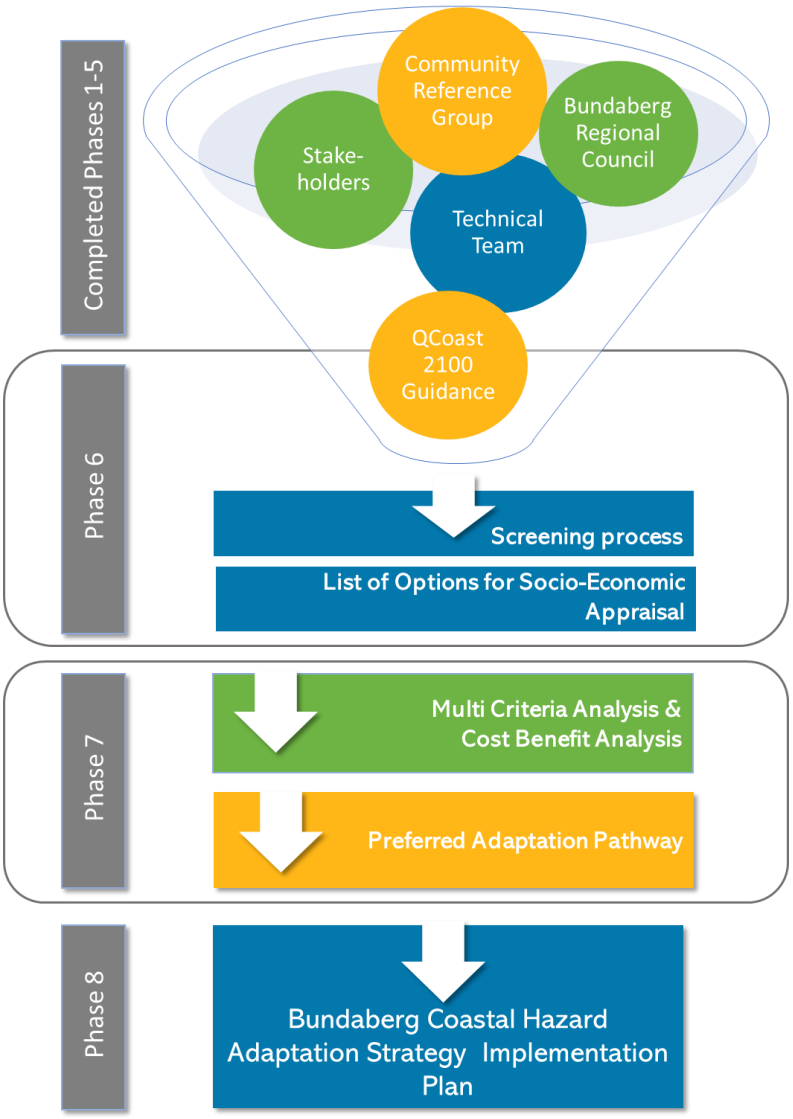

FIGURE 1-2 CHAS PHASES 6 AND 7 ADAPTATION OPTIONS PROCESS

1.3 Preferred Adaptation Pathways

Phase 7 refines the adaptation pathways presented in Phase 6, by selecting a settlement-specific 'preferred pathway'.

It is important to note that the preferred pathway represents the results of the CHAS Phases 6 and 7 in the determination of the desired options using the assumptions and data within this study. All viable adaptation options from the short list will remain 'on the table' for further investigation if required. The options identified in the CHAS represent the result of the high-level investigation and more detailed studies will be required such as a Shoreline Erosion Management Plan (SEMP). A SEMP will determine a site-specific approach to mitigate erosion over a 20-year timeframe and may consider the physical and structural options presented in this CHAS.

A true 'Adaptation Pathways' approach must include consideration of a governance framework that involves decision-making, implementation, monitoring and review. These will be explored further in Phase 8 with suggested approaches to include regularly monitoring of CHAS actions and ongoing governance via a steering committee. A preferred pathway as presented at the end of this report may evolve with regular monitoring and review of changes to the community, scientific and legislative context such as the thresholds that determine the risk profile. Other considerations that may change the preferred pathway include new science and adaptation approaches; emerging best-practice and learnings; community attitudes and aspirations and implementation progress.

2 OPTIONEERING PROCESS

2.1 Overview

The 'long-list' of options presented in Phase 6 were drawn from the following categories which have emerged from research by the CSIRO as an evolution to the traditional language of 'accommodate', 'defend' and 'retreat'. The need to avoid risk in the first instance is a mainstay of natural hazard policy.

- '**Maintain'** is an option usually applied where the risk requires action to reduce or maintain the current risk level. These include constant work in the areas of disaster management, land use planning, asset planning and maintenance, and community education and awareness programs. These activities do not remove the risk or the hazard.
- '**Modify'** options are generally proposed in settlements where the risk becomes intolerable and include physical options such as raising key access roads, seawalls, beach nourishment or storm surge barriers. The nature of the risk at some settlements means physical intervention against one hazard is not effective in protecting the entire community form all hazards. In some cases, defensive options may only be an interim adaptation method.
- '**Transform'** options are applied where risk is intolerable, these include land use and tenure transition and land swap. Land use and tenure transition is complex due to high capitalisation of coastal land and is generally only appropriate in certain circumstances when the land value becomes a true reflection of the risk level.

The following sections of this report explore which of the short-listed options are to be taken forward automatically into the Implementation Plan in Phase 8; or onto socio-economic appraisal to assist Council prioritising structural or physical options to reduce intolerable risks.

2.2 Screening

Shortlisting adaptation options automatically into the Implementation Plan has the effect of 'bypassing' the socio-economic appraisal of the MCA and CBA. These are adaptation options that are considered best-practice non-structural options such as ongoing disaster management, land use planning, community education and awareness, and monitoring erosion.

Other options that have been shortlisted include raising of key access roads to lower the frequency of isolation risk to settlements. The raising of key access roads may result in a reduction to isolation risks during storm tide events, allow for easier access for emergency services and provide for simplified logistics during the post-event recovery phase. These adaptation options will not provide any 'benefit' to property and infrastructure in the same way that a seawall or beach nourishment may reduce property damages over time. Therefore, for each of the settlements identified in Phase 5 as potentially exposed to isolation risks (Moore Park Beach, Coonarr and Woodgate) recommendations have been made to raise key access roads in Phase 6. It does not matter in terms of risk to life if secondary roads and causeways are simply left as they are, provided that there is one raised road for evacuation and emergency access. During the screening process, the most economically viable option has been shortlisted, however no further MCA/CBA will be undertaken for these options.

An overview of the screening process is summarised in Table 2-2, highlighting which options have been shortlisted (MCA and CBA not undertaken) and which ones were analysed further through the MCA and CBA process. Table 2-1 shows the symbology used in the screening summary.

Options within the 'Maintain' category have largely been shortlisted and will be automatically considered in the implementation plan whereas options within the 'Modify' and 'Transform' categories will require further appraisal. It is these options in priority settlements that have been taken forward to the MCA and CBA process.

TABLE 2-1 LEGEND FOR SCREENING SUMMARY TABLE

Symbology	Screening Description
	**Considered and requires assessment via MCA/CBA** Option to be included in the MCA to directly compare with other similar options. To be ranked and prioritised for consideration of the preferred pathway included in the implementation strategy.
	**Considered and short listed** Option will be taken automatically into the Implementation Plan in Phase 8.

TABLE 2-2 SCREENING SUMMARY TABLE

ADAPTATION OPTIONS	Miara, Norval Park, Winfield	Moore Park Beach	Burnett Heads	Bargara	Innes Park, Coral Cove	Elliott Heads	Coonarr	Woodgate Beach, Walkers Point	Buxton
MAINTAIN									
Disaster Management	✓	✓	✓	✓	✓	✓	✓	✓	✓
Education and Awareness Campaign	✓	✓	✓	✓	✓	✓	✓	✓	✓
Land Use Planning	✓	✓	✓	✓	✓	✓	✓	✓	✓
Resilient Infrastructure		✓	✓	✓	✓			✓	
Monitor Erosion	✓			✓			✓		✓
Site Specific Investigation				✓ Mon Repos Turtle Centre					
MODIFY									
Beach Nourishment/ Dune Reconstruction		✓ MCA		✓ MCA	✓ MCA	✓	✓ MCA	✓ MCA	
Seawall/Rockwall /Buried Seawall		✓ MCA		✓ MCA	✓ MCA		✓ MCA	✓ MCA	
Storm Surge Barrier			✓ MCA						
Road Raising			✓				✓	✓	
Causeway			✓					✓	
TRANSFORM									
Land Swap	✓ Miara Holiday park	✓ Moore Park Beach Surf Club & Tourist Park	✓ Lighthouse Tourist Park			✓ Elliott Heads Tourist Park			
Land Use and tenure transition							✓ MCA	✓ MCA	✓

2.3 Shortlisted Adaptation Options by Settlement

This section outlines the coastal hazard adaptation options that have been shortlisted and taken forward to the Implementation Plan in Phase 8.

2.3.1 Winfield, Miara and Norval Park

The risk profile for Winfield, Miara and Norval Park indicates that risk from both storm tide inundation and coastal erosion remains in the tolerable range under all sea level scenarios.

During Phase 6, non-physical adaptation options were considered in the 'Maintain' category and one site-specific option in the 'Transform' category. Table 2-3 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Winfield, Miara and Norval Park.

Given the risk is considered to remain in the tolerable range, this settlement has not been prioritised for actions in the 'Modify' category to address intolerable risks, therefore there are no adaptation options recommended for the socio-economic appraisal.

TABLE 2-3 SHORTLISTED OPTIONS IN WINFIELD, MIARA AND NORVAL PARK

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coastal hazard events.	Ongoing
Education and Awareness Campaign	Targeted engagement should be considered for specific at-risk properties.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts on properties mapped within the hazard.
Land Use Planning	Medium to short term planning to ensure the settlement pattern and vision are maintained for limited growth and urban services are not extended.	Ongoing.
Monitor Erosion at Colonial Cove	Council to implement ongoing baseline surveys to provide evidence for any future modification response. Further site investigation will be required in the form of SEMP for Colonial Cove.	Immediate
Modify		
No Modify Actions identified as part of this CHAS		
Transform		
Land Swap Miara Holiday Park	Relocate to new location at higher ground to remove risk to life and property in preparation for the 0.8 m permanent inundation.	0.4 m sea level rise

2.3.2 Moore Park Beach

Moore Park Beach has been identified as a priority area for adaptation to future coastal hazards. The main issues at Moore Park Beach relate to coastal erosion of the shorefront, permanent inundation causing isolation of communities, and the economic impacts of coastal hazard causing intolerable risk profile under a 0.4 m sea level rise scenario.

During Phase 6, non-physical options were considered in the 'Maintain' category and physical options in the 'Modify' and 'Transform' categories. Table 2-4 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Moore Park Beach.

To help mitigate the intolerable risks identified under a 0.4 m sea level rise scenario, two options have been identified in Moore Park Beach that are recommended for socio-economic appraisal. These will be addressed in Section 3 of this report:

- Beach Nourishment/Dune Reconstruction; and
- Seawall/Rockwall/Buried Seawall.

TABLE 2-4 SHORTLISTED OPTIONS IN MOORE PARK BEACH

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing
Education and Awareness Campaign	Moore Park Beach requires a bespoke campaign to inform residents of the nature of the risk and natural behaviours, including the implications for isolation.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts properties and how isolation occurs to the settlement.
Land Use Planning	Maintain a vision for low or no growth and the characteristics of a coastal township. Development capacity should not increase in future planning schemes.	Ongoing.
Resilient Infrastructure	Increased service to the community. Necessary for the ongoing function of settlement and should be implemented via Council's capital and maintenance works program.	Immediate
Modify – *for details on Beach Nourishment and Seawalls see Section 3 – Socio-Economic Appraisal*		
Raising Murdochs Linking Road (350 m incl minor drainage)	Prevents isolation of the settlement. Recommend raising be undertaken with other road upgrades elsewhere. Plan to construct prior to 0.8 m sea level rise to prevent isolation risk.	Between 0.4 m and 0.8 m sea level rise scenarios
Causeway Malvern Drive (800 m)	Malvern Drive is predicted to become inundated in a Highest Astronomic Tide (HAT) under a 0.8 m sea level rise conditions. Causeway will improve access / egress. Minimal road level increase required, inclusion of concrete protected causeway, excludes new bridge construction. Reduces isolation of the settlement.	Between 0.4 m and 0.8 m sea level rise scenarios
Causeway Moore Park Rd (800 m)	Moore Park Road becomes inundated at HAT in present day conditions. Causeway will improve access / egress. Minimal road level increase, inclusion of concrete protected causeway, excludes new bridge construction. Reduces isolation of the settlement.	Immediate
Transform		

Option	Description	Trigger for Action
Land Swap - Moore Park Beach Surf Club & Tourist Park	Continue plans to modify the surf club in the short term and relocate outside the erosion prone area.	Between the 0.2 m and 0.4 m sea level rise scenarios

2.3.3 Burnett Heads

Burnett Heads has been identified as an area subject to intolerable risks from storm tide inundation under a 0.8 m sea level rise scenario. Burnett Heads is not subject to isolation, but many highly critical services and properties are exposed to storm tide and permanent inundation. With some growth expected in the area and to continue servicing the community, new infrastructure and upgrades to existing services will need to be built with coastal hazard factored into the design.

During Phase 6, non-physical options were considered in the 'Maintain' category and physical options in the 'Modify' and 'Transform' categories. Table 2-5 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Burnett Heads.

To help mitigate the intolerable risks identified under a 0.8 m sea level rise scenario, the following option identified in Burnett Heads has been recommended for socio-economic appraisal. These will be addressed in Section 3 of this report:

- Storm Surge Barrier.

TABLE 2-5 SHORTLISTED OPTIONS IN BURNETT HEADS

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing
Education and Awareness Campaign	Targeted engagement should be considered for specific at-risk properties.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts on properties mapped within the hazard.
Land Use Planning	Maintain communication with the Port of Bundaberg throughout its development and ensure proposals for the State Development Area (SDA) are cognisant of risk exposure.	Ongoing.
Resilient Infrastructure	Increased service to the community. Necessary for the ongoing function of settlement and should be implemented via Council's capital and maintenance works program.	Immediate
Modify– *for details on Storm Surge Barrier see Section 3 – Socio-Economic Appraisal*		
No further options identified in the Modify category.		
Transform		
Land Swap - Lighthouse Tourist Park	Plan to transform the Burnett Heads Lighthouse Holiday Park away from areas exposed to sea-level rise and storm tide inundation. Risk to life and property would be removed in preparation for the 0.8 m permanent inundation.	Between the 0.4 m and 0.8 m sea level rise scenarios

2.3.4 Bargara

The settlement of Bargara is considered a high priority area for further investigation because it is subject to intolerable risks under a 0.8 m sea level rise scenario associated with coastal erosion risk to properties at Kellys Beach. Furthermore, Nielson Beach and the Bargara foreshore have been identified as areas that require further investigation as erosion events are occurring under present-day sea level conditions.

During Phase 6, non-physical options were considered in the 'Maintain' category and physical options in the 'Modify' category. No options have been considered in the 'Transform' category. Table 2-6 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Bargara.

To help mitigate the intolerable risks identified under a 0.8 m sea level rise scenario, the following options identified in Bargara have been recommended for socio-economic appraisal. These will be addressed in Section 3 of this report:

- Beach Nourishment; and
- Seawall/Rockwall.

TABLE 2-6 SHORTLISTED OPTIONS IN BARGARA

Option Category	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing
Education and Awareness Campaign	Targeted engagement should be considered for specific at-risk properties.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts on properties mapped within the hazard.
Land Use Planning	Maintain existing zoning pattern and ensure no intensification or increase in risk.	Ongoing.
Resilient Infrastructure	Increased service to the community. Necessary for the ongoing function of settlement and should be implemented via Council's capital and maintenance works program.	Immediate
Site Specific Investigation at Mon Repos Turtle Centre	In the short-term there is potential to build resilience of Mon Repos Turtle Centre via investigation in partnership with State Government – Queensland Parks and Wildlife Service.	Immediate
Monitoring Erosion – Bargara Foreshore and Nielson Beach	Council is currently monitoring erosion in Kellys Beach, Bargara Shorefront and Nielson Beach and will implement ongoing baseline surveys to provide evidence for any future modification response. Further site investigations will be required in the form of SEMPs.	Ongoing
Modify– *for details on Beach Nourishment and Seawall see Section 3 – Socio-Economic Appraisal*		
No further options identified in the Modify category.		
Transform		
No options identified in the Transform category.		

2.3.5 Innes Park and Coral Cove

The settlement of Innes Park is considered a high priority area for further investigation because it is subject to intolerable risks under a 0.8 m sea level rise scenario. Coral Cove is typified by a rocky foreshore, however, there are still assets and features mapped as being at risk to coastal erosion under a 0.8 m sea level rise scenario.

During Phase 6, non-physical options were considered in the 'Maintain' category and physical options in the 'Modify' category, no options have been considered in the 'Transform category. Table 2-7 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Innes Park and Coral Cove.

To help mitigate the intolerable risks identified under a 0.8 m sea level rise scenario, the following options identified in Innes Park have been recommended for socio-economic appraisal. These will be addressed in Section 3 of this report:

- Beach Nourishment; and
- Seawall/Rockwall.

TABLE 2-7 SHORTLISTED OPTIONS IN INNES PARK AND CORAL COVE

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing
Education and Awareness Campaign	Targeted engagement should be considered for specific at-risk properties.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts on properties mapped within the hazard.
Land Use Planning	Maintain a low-density settlement pattern and dominance of open space in all foreshore areas.	Ongoing.
Resilient Infrastructure	Increased service to the community. Necessary for the ongoing function of settlement and should be implemented via Council's capital and maintenance works program.	Immediate
Modify– *for details on Beach Nourishment and Seawall see Section 3 – Socio-Economic Appraisal*		
No further options identified in the Modify category.		
Transform		
No options identified in the Transform category.		

2.3.6 Elliott Heads

The settlement of Elliott Heads is not considered a high priority area for further investigation. The risk from both storm tide inundation and coastal erosion remains in the tolerable range under all sea level scenarios. Adaptation options are still required to maintain the current risk profile for the settlement.

During Phase 6, non-physical options were considered in the 'Maintain' category and options in the 'Transform' category, no options have been considered in the 'Modify' category. Table 2-8 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Elliott Heads.

TABLE 2-8 SHORTLISTED OPTIONS IN ELLIOTT HEADS

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing
Education and Awareness Campaign	Targeted engagement should be considered for specific at-risk properties.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts on properties mapped within the hazard.
Land Use Planning	Maintain existing zoning pattern and ensure no intensification or increase in risk.	Ongoing.
Modify		
No options identified in the Modify category.		
Transform		
Land Swap - Elliott Heads Tourist Park	In the medium term the Elliott Heads Tourist Park may consider modifying some operational practices with a long-term view of transforming or relocation. This measure will remove all risk to life and property if completed before 0.8 m permanent inundation.	Between the 0.4 m and 0.8 m sea level rise scenarios

2.3.7 Coonarr

The settlement of Coonarr is considered a high priority area for further investigation because it is subject to intolerable risks. The beachfront properties are exposed to isolation risks and damages associated with coastal erosion under a 0.2 m sea level rise scenario.

During Phase 6, non-physical options were considered in the 'Maintain' and 'Transform' categories and physical options in the 'Modify' category. Table 2-9 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Coonarr.

To help mitigate the intolerable risks identified under a 0.2 m sea level rise scenario, the following options identified in Coonarr have been recommended for socio-economic appraisal. These will be addressed in Section 3 of this report:

- Land Use and tenure transition of beach front properties;
- Beach Nourishment; and
- Seawall/Rockwall.

TABLE 2-9 SHORTLISTED OPTIONS IN COONARR

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing

Option	Description	Trigger for Action
Education and Awareness Campaign	Inform residents on the nature of the risk and natural behaviours, including the implications for isolation.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts properties and how isolation occurs to the settlement.
Land Use Planning	Maintain the settlement pattern for limited or no growth. Urban services are not expected to be extended.	Ongoing
Monitoring Erosion at Coonarr	Implement ongoing baseline surveys to provide evidence for any future modification response.	Ongoing
Modify– *for details on Beach Nourishment and Seawall see Section 3 – Socio-Economic Appraisal*		
Raise key access roads; Coonarr Beach Road (300m)	Build to the level of sea level rise. Coonarr Beach Rd becomes inundated at HAT in present day conditions.	Between now and the 0.2 m sea level rise scenario
Tran sform- *for details on Land use and tenure transition of properties see Section 3 – Socio-Economic Appraisal*		
No further options identified in the Transform category.		

2.3.8 Woodgate Beach and Walkers Point

Woodgate Beach and Walkers Point are considered a high priority area for further investigation as the settlements are subject to intolerable risk. The main issues at Woodgate Beach relate to coastal erosion of the shorefront under a 0.4 m sea level rise scenario and permanent inundation causing isolation of communities under a 0.8 m sea level rise scenario.

During Phase 6, non-physical options were considered in the 'Maintain' and 'Transform' categories and physical options in the 'Modify' category. Table 2-10 indicates the recommended coastal hazard adaptation options shortlisted for the implementation plan at Woodgate Beach and Walkers Point.

To help mitigate the intolerable risks identified under a 0.4 m sea level rise scenario, the following options identified in Woodgate Beach and Walkers Point have been recommended for socio-economic appraisal. These will be addressed in section 3 of this report:

- Land use and tenure transition of properties;
- Beach Nourishment; and
- Seawall/Rockwall.

TABLE 2-10 SHORTLISTED OPTIONS IN WOODGATE BEACH AND WALKERS POINT

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing
Education and Awareness Campaign	Inform residents on the nature of the risk and natural behaviours, including the implications for isolation.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts properties and how isolation occurs to the settlement.

Option	Description	Trigger for Action
Land Use Planning	Maintain a vision for low or no growth and the characteristics of a coastal township. Development capacity should not increase in future planning schemes.	Ongoing
Resilient Infrastructure	Increased service to the community. Necessary for the ongoing function of settlement. Implemented via Council's capital works program.	Immediate
Modify - *for details on Beach Nourishment and Seawall see Section 3 – Socio-Economic Appraisal*		
Raising Acacia Street (300 m)	Preferred over the causeway option as Acacia St is the key access road for Woodgate Beach community. Acacia St is likely to experience permanent inundation at 0.8 m sea level rise.	Between 0.4 m and 0.8 m sea level rise scenarios.
Raising Theodolite Creek Rd (300 m, minor drainage)	Preferred option as key access road for properties along Theodolite Creek Road. Theodolite Creek likely to be inundated permanently at 0.8 m sea level rise.	Between 0.4 m and 0.8 m sea level rise scenarios.
Raising Paperbark Court – First Ave (490 m)	Plan to construct prior to 0.8 m sea level rise to prevent isolation risk.	Between 0.4 m and 0.8 m sea level rise scenarios.
Recommend raising Walkers Point Road	In conjunction with Acacia St due to alternative egress via Heidke's Rd (unsealed road). Plan to construct prior to 0.8 m sea level rise to prevent isolation risk.	Between 0.4 m and 0.8 m sea level rise scenarios.
Transform - *for details on Land use and tenure transition of properties see Section 3 – Socio-Economic Appraisal*		
No further options identified in the Transform category.		

2.3.9 Buxton

The risk profile for Buxton indicates that risk from both storm tide inundation and coastal erosion remains in the tolerable range under all sea level scenarios. During Phase 6, non-physical adaptation options were considered in the 'Maintain' category and one option in the 'Transform' category. Table 2-11 shows all the recommended coastal hazard adaptation options shortlisted for the implementation plan in Buxton.

Given the risk is considered to remain in the tolerable range, this settlement has not been prioritised and investigated for physical measures in the 'Modify' category to address intolerable risks, therefore there are no adaptation options recommended for socio-economic appraisal.

TABLE 2-11 SHORTLISTED OPTIONS IN BUXTON

Option	Description	Trigger for Action
Maintain		
Disaster Management	Continue Council's community disaster preparedness and systematic responses to potential coast hazard events.	Ongoing

Option	Description	Trigger for Action
Education and Awareness Campaign	Education and Awareness; Targeted engagement should be considered for specific at-risk properties.	Event based – i.e. Council to monitor and review storm tide and erosion events impacts properties.
Land Use Planning	Maintain Buxton as a coastal character village with limited growth.	Ongoing
Monitoring Erosion at Buxton	Implement ongoing baseline surveys in the area of Wharf Street to provide evidence for any future modification response. Further site investigations will be required in the form of SEMPs.	Ongoing
Modify		
No further options identified in the Modify category.		
Transform		
Land Use and tenure transition	Consideration given to expanding the open space area on Wharf Street with strategic land use and tenure transition of properties. Risk to life and property is removed in preparation for the 0.8 m permanent inundation.	0.4 m sea level rise scenario.

2.4 Adaptation Options for socio-economic appraisal

The shortlisted options above aim to mitigate and reduce the risks from coastal hazard to the community across multiple sea level range scenarios. As described above, the settlements identified as being subject to intolerable risks have been prioritised for physical adaption options that will be evaluated in the MCA to rank the options in order of performance and selection of those with the best overall scores. The cost and effectiveness of these options will then be further evaluated through a CBA, which will generate a final list of preferred adaptation options known as the preferred pathway.

The priority settlements that are subject to intolerable risks in future sea level scenarios are:

- Moore Park Beach;
- Burnett Heads;
- Bargara;
- Innes Park and Coral Cove;
- Coonarr; and
- Woodgate Beach and Walkers Point.

In summary, the 13 physical adaptation options that have been selected for further analysis via a MCA and a CAB are shown in Table 2-12. A benchmark ‘Do Nothing’ option is included in the analysis for each settlement.

TABLE 2-12 ADAPTATION OPTIONS FOR SOCIO-ECONOMIC APPRAISAL

Priority Settlement	Adaptation Option	Rationale for Further Appraisal
Moore Park Beach	Seawall	Settlement subject to intolerable risk from permanent inundation, causing isolation under a 0.4 m sea level rise scenario. Properties subject to coastal erosion under a 0.4 m sea level rise scenario. Physical option may reduce the risk profile from the intolerable range.
	Beach Nourishment/ Dune Reconstruction	
	Do Nothing	Baseline option.
Burnett Heads	Storm surge barrier and tidal gate	Settlement subject to intolerable risk from storm tide inundation and permanent inundation under 0.8 m sea level rise scenario. Physical option may reduce the risk profile from the intolerable range.
	Do Nothing	Baseline option.
Bargara	Seawall	Settlement subject to intolerable risk from coastal erosion under 0.8 m sea level rise scenario. Physical option may reduce the risk profile from the intolerable range.
	Beach Nourishment/Dune Reconstruction	
	Do Nothing	Baseline option.
Innes Park and Coral Cove	Seawall	Settlement subject to intolerable risk from coastal erosion under 0.8 m sea level rise scenario. Physical option may reduce the risk profile from the intolerable range.
	Beach Nourishment/Dune Reconstruction	
	Do Nothing	Baseline option.
Coonarr	Seawall	Settlement subject to intolerable risk from permanent inundation causing isolation under a 0.2 m sea level rise scenario. Properties subject to coastal erosion under a 0.2 m sea level rise scenario. Physical option may reduce the risk profile from the intolerable range.
	Beach Nourishment/Dune Reconstruction	
	Land Use and tenure transition of properties on the Esplanade	
	Do Nothing	Baseline option.
Woodgate Beach and Walkers Point	Seawall	Settlement subject to intolerable risk from permanent inundation causing isolation under a 0.8 m sea level rise scenario. Properties and infrastructure subject to coastal erosion under a 0.4 m sea level rise scenario. 'Modify' and 'Transform' options may reduce the risk profile from intolerable range. Socio-economic appraisal of the land use and tenure transition option undertaken at the 0.4 m sea level rise scenario for consistency.
	Beach Nourishment/Dune Reconstruction	
	Land Use and tenure transition of properties in First Avenue	
	Do Nothing	Baseline option.

3 METHODOLOGY

3.1 Overview

As part of Phase 7, the adaptation options identified in Phase 6 were selected for further assessment using a MCA and CBA.

The process described in this section ensures transparency and repeatability for any potential future evaluation of options. The evaluation criteria and weighting process has been carefully undertaken and participants selected to ensure a balance of values and interests. This is evident by the selection of a team of multi-disciplinary Council officers from cross-departmental backgrounds, in addition to the CHAS Community Reference Group to undertake a workshop to weight the evaluation criteria.

In addition to the options ranked as a result of the MCA, each option was evaluated with a CBA. It is important to emphasise that the CBA solely assesses the economic performance of an option as it compares the costs of implementation (i.e. construction and maintenance) with the benefits that the option provides (i.e. reduction of damages to property). The BCR, MCA and costs need to be considered together when assessing which options to recommend as 'preferred pathways' for each settlement, that is the option that provides the optimum adaptation approach. This process is illustrated in Figure 3-1.

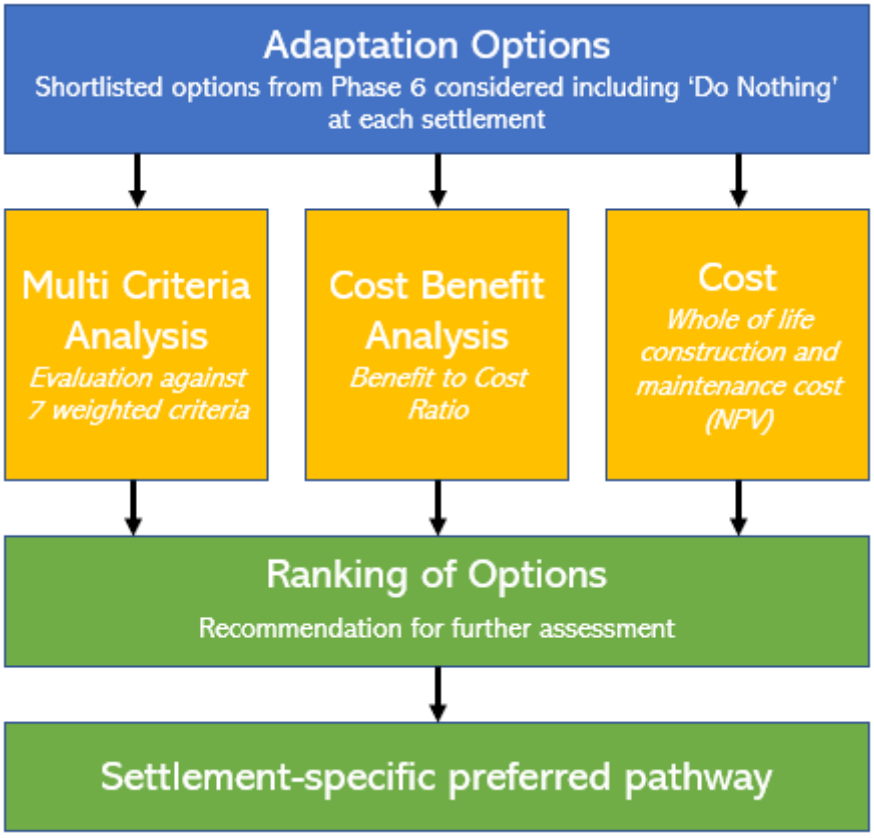

FIGURE 3-1 COMBINATION OF MCA, CBA, COST USED TO DETERMINE PREFERRED PATHWAY

3.2 Multi Criteria Analysis

The MCA provides a qualitative and semi-quantitative process by which to rank competing projects or adaptation options. This process is applied to the 13 adaptation options and six 'do nothing' options selected in Phase 6 and as discussed in Section 2.

3.2.1 Evaluation Criteria

The first step of the MCA undertaken was to identify suitable evaluation criteria in collaboration with Council and the community. These included, at a minimum, criteria that reflected cost, effectiveness, social and environmental impacts, and technical viability. A preliminary list of criteria was developed using the CHAS Minimum Standards and a review of the criteria used in the pilot CHAS for Townsville. The preliminary list was then reviewed and endorsed by the Council project team and by the Community Reference Group. The following Table 3-1 identifies the source of the evaluation criteria identified and amended to reflect a fit-for-purpose socio-economic appraisal for use in the Bundaberg CHAS.

Appendix C provides the MCA scores and the methodology of how each score is calculated. This section presents the normalised scores only. The raw scores presented in Appendix C given to each option are not comparable with other criteria because they use different units or scales (i.e.in some cases a higher figure indicates a good performance, in others it indicates a bad performance). These raw scores were normalised in terms of scale and range of 1 to 100, with a minimum-maximum normalisation process.

TABLE 3-1 SOURCE OF EVALUATION CRITERIA SELECTED FOR THE CHAS MCA

Description from CHAS Minimum Standards	Criteria used in Pilot CHAS (Townsville)	Criteria selected for Bundaberg CHAS
Capital cost and maintenance costs established in Phase 6.	1. Capital Cost	1. Cost: Present value of the whole of life cost (including capital and maintenance) over 50 years
	2. Operating and maintenance cost	
Environmental or social impact: to identify where the option may have trade-offs upon the surrounding environment, including beach amenity and access.	3. Impact on access to coastal areas for recreation (e.g. camping, fishing, swimming)	2. Impact on access to coastal areas for recreation (e.g. camping, fishing, swimming)
	4. Impact on natural coastal ecosystems	
	5. Indirect economic / industry impacts (e.g. tourism, fishing)	3. Impact on natural/cultural/landscape value
	6. Impact on cultural heritage and landscape	
Community acceptability, which is based upon general feedback from stakeholder engagement.	N/A	Not included: implicitly considered as part of the MCA weighting
Reversible/adaptable in the future, which is particularly relevant where there is considerable uncertainty and/or long time frames for a future impact.	7. Flexibility to respond to unexpected climate outcomes (upside / downside)	4. Flexibility to respond to unexpected climate outcomes (upside / downside), noting that risk of an option becoming inadequate is reduced by the use of triggers

Effectiveness over time: to consider where an option presents a long-term solution or a short-term solution that would require additional management action or upgrades in the future.	8. Severity of inundation on humans as well as buildings and community infrastructure	5. Effectiveness: Reduction of the risk to property (i.e. reduction in damages) and people (i.e. reduction of the population at risk)
To highlight the legislative and approval requirements (or impediments) to implementing an option within the current legal framework.	9. Complexity of implementation (technical, stakeholder / social, institutional)	6. Approvals: Complexity of obtaining the approval to initiate implementation
Technical viability, to highlight where certain options may or may not be technically feasible or would require significant engineering (or other) investigations and construction/implementation capabilities.		7. Technical viability

3.2.2 Weighting of Evaluation Criteria

Before mitigation options can be evaluated against the selected criteria, a weighting is applied to each criterion to represent its influence on the performance of each adaption option.

3.2.2.1 Council and Community Survey

In collaboration with Council and the Community Reference Group (CRG) an appropriate weighting has been 'workshopped' to prioritise MCA criteria using a 'pairwise comparison tool'. The tool known as an Analytic Hierarchy Process (AHP), (Saaty, 1984), directly compared each of the seven MCA evaluation criteria to one another. In this approach, criteria were compared in pairs, and a quantitative score ranging from 2 to 9 given to each pairwise comparison to indicate the extent to which one criterion was more (or less) important than the other. Criteria which were deemed equally important were scored with a 1. The results of the pairwise comparisons undertaken during the workshop are shown Table 3-2.

A second workshop was then held with the CRG. The seven criteria were listed on a board. Each member of the CRG was given several stickers and was asked to put these on the board next to their preferred criteria. Results were converted into weighting scores and are presented in Table 3-2.

The CRG's role is to validate Councils recommendations and methodology within a collaborative engagement framework. At the workshop, the CRG made recommendations to give further weighting to technical viability, cost and approvals and reduce the weighting of effectiveness and adaptability. The CRG agreed with the weightings applied to impact on access and impact on environment. As a result, due consideration has been given to the weighting applied by the community and the final weighting for the evaluation criteria agreed.

All possible permutations of criteria were considered, while the tool automatically detected any inconsistencies. On completion, the tool automatically calculated a numerical weight (ranging from 1 to 100) for each criterion.

TABLE 3-2 RESULTS OF PAIRWISE COUNCIL SURVEY AND COMMUNITY WEIGHTING WORKSHOP

Rank	MCA Criterion	Priority Weighting Council	Priority Weighting Community (number of votes)	Final Weighting
1	Effectiveness	34.1%	20% (16)	32%
2	Adaptability	22.5%	18% (14)	22%
3	Impact on Access	15.9%	14% (11)	15%
4	Technical Viability	11.0%	20% (16)	13%
5	Impact on Environment	9.3%	10% (8)	9%
6	Approvals	3.7%	8% (6)	5%
7	Cost	3.5%	11% (9)	4%
	TOTAL	100%	100% (80)	100%

3.3 Cost Benefit Analysis

In addition to the options ranking provided by the MCA, each option was evaluated via a CBA. It is important to emphasise that the CBA measures solely the economic performance of an option as it compares the costs of implementation (i.e. construction and maintenance) with the benefits that the option provides (i.e. reduction of damages to property).

Factors such as reduction of the risk to life are not considered in the CBA, because it would require assignment of a monetary value to human lives, which is considered controversial and not sufficiently supported by the relevant scientific literature. The results of the CBA should only be used as a guide to assess the economic profitability of the options and interpreted in conjunction with the MCA results. Figure 3-2 summarises the methodology of the CBA used in the CHAS.

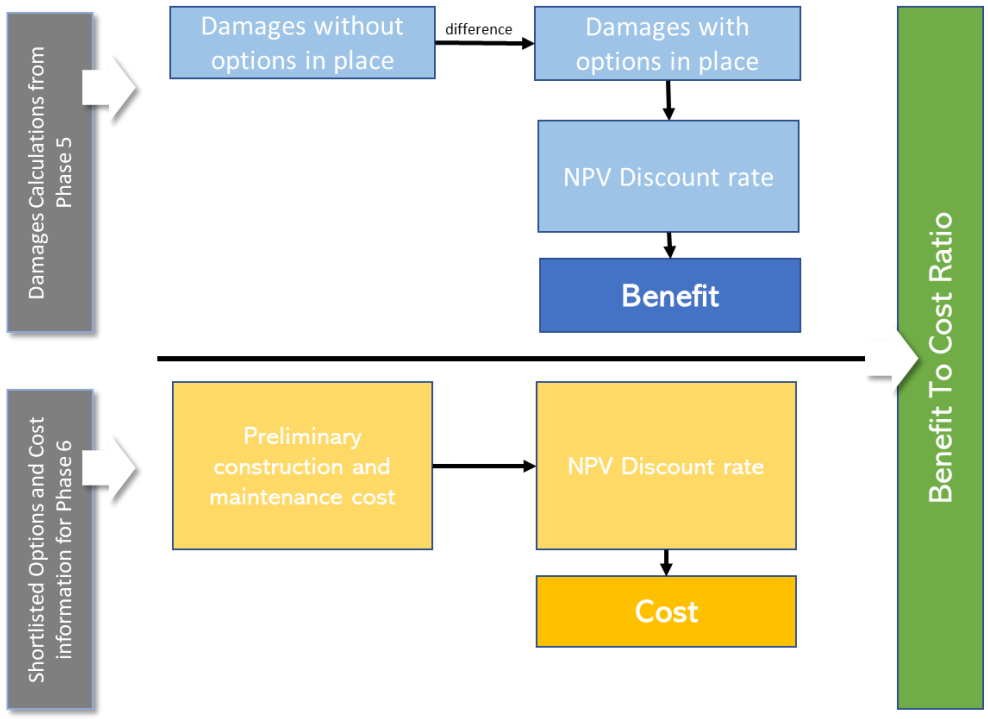

FIGURE 3-2 COST BENEFIT ANALYSIS METHODOLOGY

3.3.1 Net Present Value (NPV)

3.3.1.1 Definition

The discounted cash flow or net present value approach involves applying a discount rate to future cash flows over many years of income generated from a property to produce a NPV.

The Queensland Treasury offers the following explanation:

Discounting recognises that the use of money has a value. A dollar today is worth more than a dollar in five years' time. This concept is known as the time value of money. The time value of money means that cash inflows and outflows occurring in different time periods cannot simply be added together to determine the overall net cost or net benefit of a project. It is necessary to remove the effect of the time value of money (i.e. discount back) to enable all values to be compared equally (i.e. the present value).

For example, $100 received in two years' time has less value than $100 received today. $100 received today can be invested in the bank and the interest received, say at 10%, will grow the investment to $110 in one year and $121 in two years. The future value of $100 in two years' time is $121, based on a discount rate of 10%.

Similarly, the promised receipt of $100 in two years' time could be settled today for an equivalent payment of $82.64, as that is the sum of money which, if invested today at 10%, will yield $100 in two years' time. The present value of $100 received in two years' time is $82.64.

In the above manner, a single unit measure of net benefit or net cost is derived to enable meaningful comparison of options to be made. The process of discounting future financial cash flows (or economic costs and benefits) of a project is used to derive key decision indicators such as net present value (NPV) or benefit-cost ratios.

3.3.1.2 Application to the CHAS

For the purposes of this analysis, both preliminary construction costs and damage reduction benefits have been discounted to present day using a 7% 'base case' interest rate using the following formula:

NPV = Cash Flows x (1/(1+DF)^n))

where:

- DF =Discount Factor or required return (e.g. 7%)
- n =Number of years after present day (e.g. 80 years)
- Cash flows = construction cost or damages dollar figure in the time period.

Each option is assumed to be implemented at a certain sea level rise threshold, and so the relevant costs were discounted back to the present day (i.e. 2020) using the assumption of 1cm of average sea level rise per year out to 2100.

- Adaptation options, implemented by the 0.2 m sea level rise scenario, are discounted from year 20 (~2040),
- Adaptation options, implemented by the 0.4 m sea level rise scenario, are discounted from year 40 (~2060),
- Adaptation options, implemented by the 0.8 m sea level rise scenario, are discounted from year 80 (~2100).

Note that for the purpose of calculating NPV, 1 cm of average sea level rise per year (as a linear projection) has been assumed. This assumption is considered to fall within the likely range of sea level rise projections presented in the Intergovernmental Panel on Climate Change (IPCC).

NPV Construction Cost Example: Beach Nourishment and Dune Reconstruction in Moore Park Beach

The NPV for the construction cost of the beach nourishment adaptation option at Moore Park Beach is calculated as follows:

- DF = 7%
- n = 40 years
- Cash Flows = $4,574,080 (including maintenance over 50 year lifespan)
  - NPV = $4,574,080 x (1+0.07)^40
  - NPV = $305,458.81

The NPV for the maintenance component is calculated as follows:

- Maintenance value of $246,840 multiplied by sum of each dollar value from year 41 to year 80
- NPV = $219,760.81

Therefore, the total NPV for this option is

- $305,458.81 + $219,760.81
- $525,219.62

3.3.2 Cost

3.3.2.1 Preliminary Construction and Maintenance Costs

The preliminary costs have been developed for a 50 year whole of life cost and provide an indication of the level of capital and revenue expenditure for each physical adaptation option. The cost of each option was calculated over a life span of 50 years, by summing the present value of the capital (or construction) cost and the present value of the required maintenance.

The following assumptions are provided in the context of the preliminary cost calculations. Detailed costing including of individual adaptation options are provided in Appendix B. Section 4 provides individual costs for each adaptation option considered in the analysis.

- **Seawalls** do not typically require continuous maintenance; however, extreme storms can damage the structures and intervention may be required. A maintenance cost due to extreme storm damage has been included in the estimated whole of life cost. The maintenance cost assumed a 30% replacement of the seawall due to an extreme storm event every 10 years over 50-year lifetime.
- **Beach Nourishment** includes a sand nourishment campaign at a cost of 5% every year, therefore it is expected to be 'in place' for the 50-year life span.
- **Storm Surge Barrier** includes a maintenance cost of 10% of total construction costs per 5 years over a 50-year life span.

3.3.2.2 Limitation of NPV

As discussed, each option is discounted back to present day from the year it assumed to be implemented or constructed. Due to the planning horizon of the CHAS limited to 0.8 m sea level rise, any option assumed to be put in place 80 years from today **does not factor maintenance cost into the NPV** presented in the analysis.

3.3.3 Benefits

As part of Phase 5, a coastal hazard economic damages assessment was carried out that provides a strong basis for understanding the base case damages in the Bundaberg region. This economic consequence assessment included calculation of individual damages at each residential and commercial property. Damages with options in place have followed the same methodology. This was achieved through the following steps:

- The buildings and infrastructure affected by coastal erosion and storm tide inundation have been applied damages calculated by the different damage models
  - Storm tide inundation damages are based on inundation to buildings. These are typically predicted using “building fragility curves”. These are curves associating the intensity of the flood hazard to the damage level that this is expected to cause. The most used quantitative model for building damage from inundation and flooding are referred to as “stage-damage” curves as shown in the Appendix A. These define a relationship between peak water depth impacting the building and the resulting level of damage.
  - Coastal erosion damages to buildings within the erosion-prone areas are assumed to have their foundations undermined. As such, direct damages to these buildings were assumed to be equal to the total building and contents replacement value. It was also assumed that the damage from erosion would be permanent and no further erosion damage would be possible for any buildings affected by sea level rise, and as such, these buildings were discounted from the erosion damages assessment.
  - Sea level rise is a slow onset, permanent hazard in nature, and as such it was assumed to cause a complete loss of the building and land value. As with the coastal erosion assumptions, it is assumed that if a building were affected by sea level rise, no further damage from erosion or storm surge would be possible.
- The buildings and infrastructure affected by coastal hazards in the priority settlements were identified and NPV applied to the economic damages of the buildings and infrastructure from Phase 5. The base case damages presented as NPV are summarised in Table 3-3, this is to enable the calculation of benefits. The benefits of each adaptation option were calculated as the present value of the reduction of the damages to property. This equates to the damages without options in place minus the damages with the options in settlement.

TABLE 3-3 BASE CASE ECONOMIC DAMAGES – PRIORITY SETTLEMENTS

Settlement	Residential Damages (NPV)	Total Residential Damages (inc 15% infrastructure and 25% intangibles) NPV	Non-Residential Damages (NPV)	Total Non-Residential Damages (inc 15% infrastructure and 25% intangibles) NPV	Total Base Case Damages (NPV)
Moore Park Beach	$19,353,351	$27,094,692	$1,730,267	$2,422,374	**$29,517,065**
Burnett Heads	$31,339,766	$43,875,672	$3,235,120	$4,529,168	**$48,404,840**
Bargara	$23,623,065	$33,072,291	$696	$974	**$33,073,265**
Innes Park and Coral Cove	$987,964	$1,383,149	$0	$0	**$1,383,149**
Coonarr	$495,182	$693,254	$0	$0	**$693,254**
Woodgate Beach and Walkers Point	$11,930,336	$16,702,470	$2,003,481	$2,804,873	**$19,507,343**

3.3.4 Benefit Cost Ratio

A Benefit to Cost Ratio (BCR) has been calculated for each of the selected adaptation options. Options with a BCR greater than 1 are considered economically worthwhile, however it is important to consider these results in conjunction with the MCA appraisal. Further investigation may be required to refine the economic analysis during the feasibility assessment of a chosen adaptation option.

3.3.5 Sensitivity Test

The CBA was complemented by a sensitivity analysis. Specifically, a new set of BCRs has been calculated using a discount rate of 4% and 10%, in addition to the standard value of 7%. Queensland Treasury does not provide specific recommendations on the discount rates to be used, however, recent guidelines from Infrastructure Australia, (March 2018) recommends the use of 4%, 7% and 10%. The results of the sensitivity test are presented in the Appendix A.

The sensitivity to variations in costs and benefits was also assessed by looking at the following two scenarios:

- Best case scenario (costs reduced by 10%, benefits increased by 10%); and
- Worst case scenario (costs increased by 10%, benefits reduced by 10%).

4 RESULTS OF SOCIO-ECONOMIC APPRAISAL

The MCA evaluation process measures the performance of each adaptation option against each of the seven evaluation criteria. The full qualitative and semi-quantitative assessment of each adaptation option against the selected criteria is presented in this section. Each physical adaptation option is summarised to give an overview of site-specific details, costing, and further analysis of suitability of the option.

This section details the appraisal of the adaptation options and is ordered geographically north to south.

The full socio-economic appraisal results are provided in Appendix A.

High resolution mapping is also provided in Appendix D.

4.1 Base Line Options “Do Nothing”

It is standard practice in economic evaluation to benchmark each option against a baseline ‘do nothing’ option, so that the evaluated scores and value for money of other options are directly comparable to current service provision. In this case a 'do nothing' option was considered for each settlement. Table 4-1 summarises the baseline MCA scores for each settlement.

TABLE 4-1 SUMMARY OF BASELINE MCA SCORES FOR PRIORITY SETTLEMENTS

Criteria	Objective	Moore Park Beach	Burnett Heads	Bargara	Innes Park and Coral Cove	Coonarr	Woodgate Beach and Walkers Point
Effectiveness	Reduce erosion and storm risks to property and people	0.0	0.0	0.0	0.0	0.0	0.0
Adaptability	Ability to be adapted based on unexpected climate trends	100.0	100.0	100.0	100.0	100.0	100.0
Beach Impact	Minimise impact on beach access and amenity	69.3	100.0	0.0	0.0	0.0	23.0
Env. Impact	Minimise impact to the environment	50.2	29.0	76.0	83.0	99.0	88.0
Tech. viability	Adaptation options that are technically viable	100.0	100.0	100.0	100.0	100.0	100.0
Approval	Minimise difficulty in obtaining required permits	100.0	100.0	100.0	100.0	100.0	100.0
Cost	Cost-effective adaptation options implemented	100.0	100.0	100.0	100.0	100.0	100.0
Final MCA Score (Baseline)		**56.9**	**58.8**	**49.8**	**50.8**	**52.8**	**54.9**

4.2 Moore Park Beach – Beach Nourishment with Dune Reconstruction

4.2.1 Description of Option

The proposed adaptation option extends along the ocean fronting area of intolerable risk for 2.2 km. The treatment should extend offshore for a minimum width of 34 m. It is noted that the area becomes less populated north of Palm View Drive and a reduced length of 1.2 km should be considered. Note that there is no “holding structure” in place (e.g. groyne or headland etc.) so the sand placed will disperse over time, hence the inclusion of annual maintenance of sand renourishment factored into the cost estimate.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

Despite the screening process identifying some minor adverse impacts it was deemed partially effective if no regular re-nourishment is undertaken. To counter this, it has been assumed a 50-year program of re-nourishment is included in the whole of life cost of this option.

Negative impacts of depositing additional sand on the foreshore at Moore Park Beach are considered to be minimal, assuming the sand is installed outside of the turtle nesting hatching season. In addition, sand should not placed over rocky foreshores or seagrass beds, should be of a similar particle size to the sand already on the beach and placed gradually, allowing vegetation to colonise. It has been assumed the sand is sourced from offshore and will not result in the depletion of sand on nearby beaches.

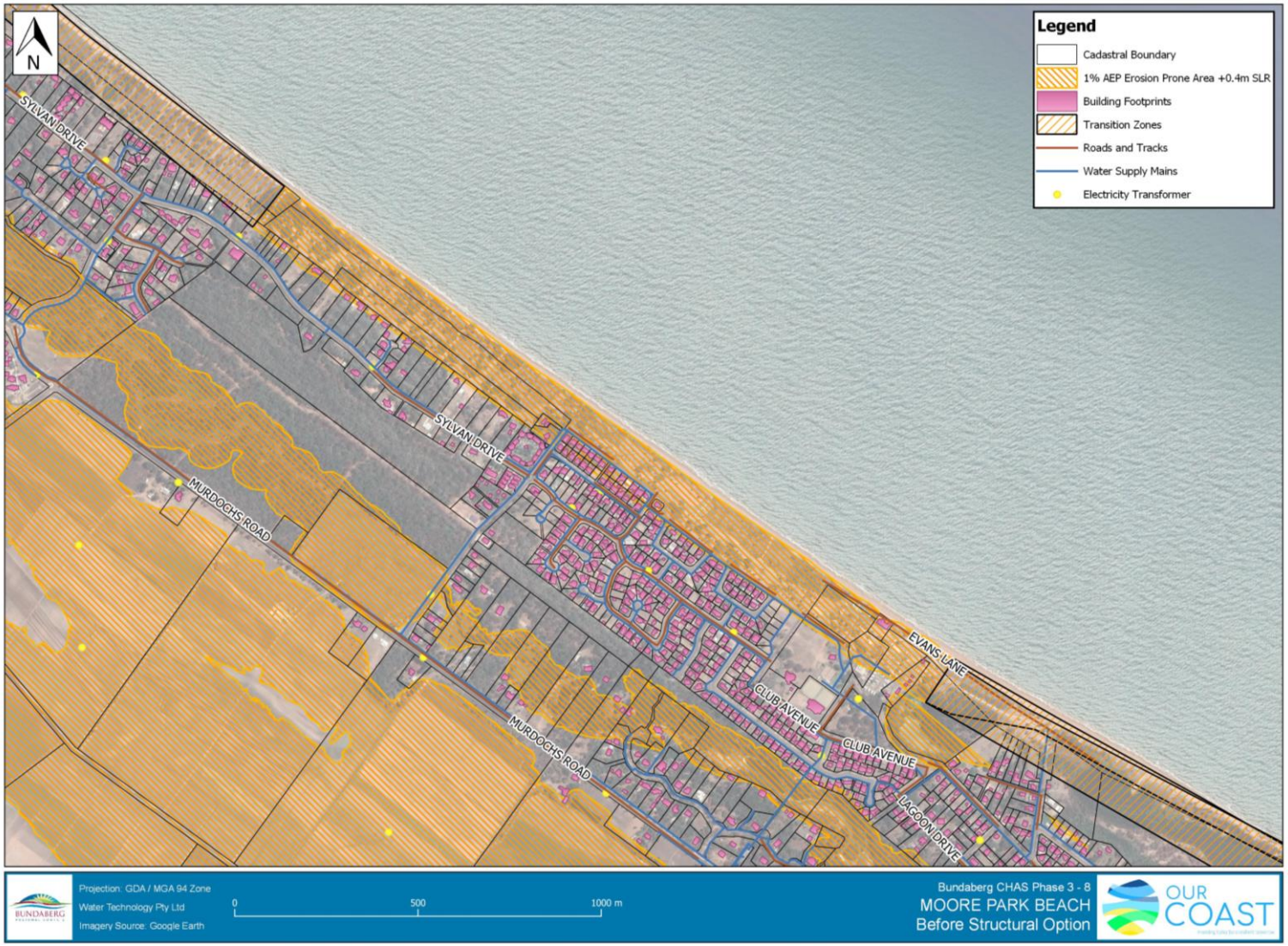

FIGURE 4-1 MOORE PARK BEACH – UNMITIGATED COASTAL HAZARD (0.4 M SEA LEVEL RISE EROSION PRONE AREA)

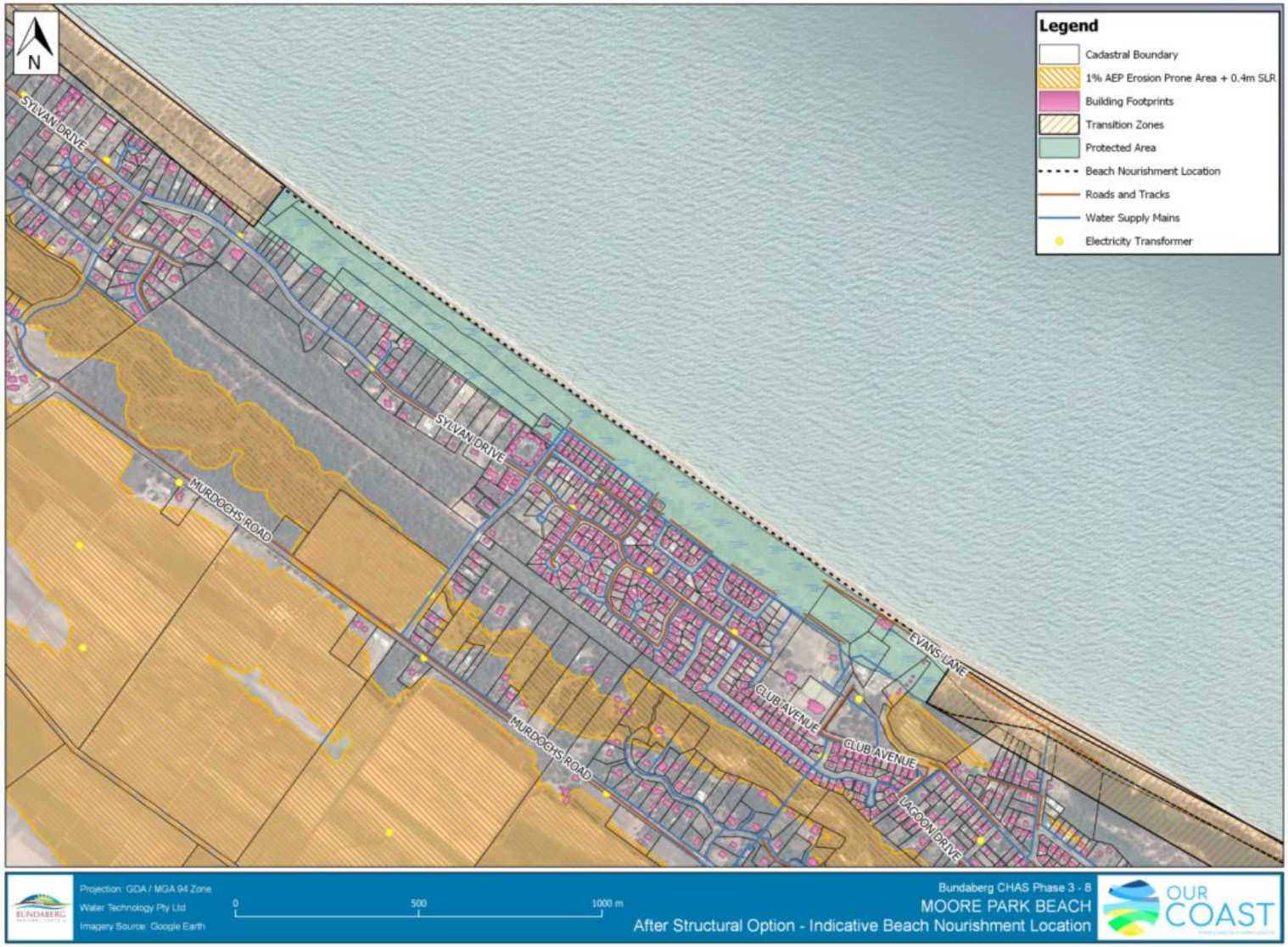

FIGURE 4-2 MOORE PARK BEACH – BEACH NOURISHMENT GENERAL LOCATION AND BENEFITS

4.2.2 Benefits

Beach nourishment and dune reconstruction in Moore Park Beach is effective against erosion and inundation, if built high enough, and can also be effective against sea level rise. Dune planting increases effectiveness compared to beach nourishment alone. This option:

- Would prevent further coastal erosion for the lifetime of the program of nourishment for the mapped erosion prone area;
- Would prevent approximately $3.8million (NPV) of damages in Moore Park Beach in the time period between a 0.4 m sea level rise scenario and 0.8 m sea level rise scenario; and,
- Does not address inundation from the creeks and wetlands behind the dune or would not be effective against storm tide inundation to property.

TABLE 4-2 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to Current Condition (NPV)
Moore Park Beach – Beach Nourishment	$29,517,065	$25,687,063	**$3,830,002**

4.2.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $4.5million this includes sand sourcing study, designs, approvals and a 40% contingency. The preliminary cost estimate is detailed in Table 4-3. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-3 PRELIMINARY COST ESTIMATE – MOORE PARK BEACH BEACH NOURISHMENT

Option	Length/Dimension	Implementation Cost[1]	Initial cost per linear cubic metre	Annual Maintenance[2]	NPV (7%)
Moore Park Beach Nourishment / Dune Reconstruction	Length: 2.2 km Extent offshore: 34 m Area: 74,800 m^3	$4,574,080	$2,079	$246,840	$525,220

4.2.4 Benefit to Cost Ratio – BCR

The BCR for beach nourishment with dune reconstruction at Moore Park Beach would be approximately 7.29. That is, the benefits of this option would be about 7 times the estimated cost.

[1] Implementation costs include sand sourcing study, initial survey, design and approval costs and 40% contingency

[2] Annual maintenance to undertake a sand renourishment campaign of 5% of implementation cost every year along the at-risk foreshore including 10% contingency

TABLE 4-4 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit Cost Ratio (BCR)
$3,830,002	$525,220	7.29

4.2.5 MCA – Summary

Table 4-5 summarises the performance of the Moore Park Beach Nourishment / Dune construction option against the seven weighted criteria.

TABLE 4-5 MCA SUMMARY FOR BEACH NOURISHMENT AT MOORE PARK BEACH

Criteria	Objective	Performance – 0.4 m Sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Estimated to provide $3.8 million (NPV) of damage reduction and has a reduction of population at risk of 4.86.	66.6	32%	21.3
Adaptability	Ability to be adapted based on unexpected climate trends	Highly adaptable, as is a temporary mitigation that requires ongoing implementation.	78.0	22%	17.2
Beach Impact	Minimise impact on beach access and amenity	Positive impact on long-term amenity and minimal or very temporary impacts to access.	100.0	15%	15.0
Env. Impact	Minimise impact to the environment	Temporary impacts to water quality by increasing sediment in the water column and impact tidal flushing of the small creeks to the south of the nourishment area.	91.5	13%	11.9
Tech. Viability	Adaptation options that are technically viable	Widely used solution to mitigate coastal erosion, with minimal technical concerns.	81.8	9%	7.4
Approval	Minimise difficulty in obtaining required permits	Several conservation significant species known to occur. Additional investigations and impact assessments likely.	30.0	5%	1.5
Cost	Cost-effective adaptation options implemented	Requires ongoing maintenance however, the overall cost is comparatively low compared to other structural options.	70.9	4%	2.8
Total Score					**77.1**
MCA ranking compared to other options:		**1st**			

4.3 Moore Park Beach – Seawall, Rockwall or Buried Seawall

4.3.1 Description of Option

The proposed seawall or rockwall treatment extends along the ocean fronting area of intolerable risk for 2.2 km. Planning of this option ought to commence at 0.2 m sea level rise in preparation for 0.4 m coastal erosion hazard. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

The screening process identified some minor adverse impacts such as loss of beach in front of the seawall and the creation of a hard barrier to beach access. Despite these potential downsides, a seawall is effective against erosion and is often constructed as a buried seawall with nourishment to provide amenity and satisfy state approvals.

Construction of a seawall at Moore Park Beach provides a hard line of defence with very limited residual risk for erosion to occur landwards of the seawall. A combination of seawall with beach nourishment should be considered as a layered approach to any future planning process.

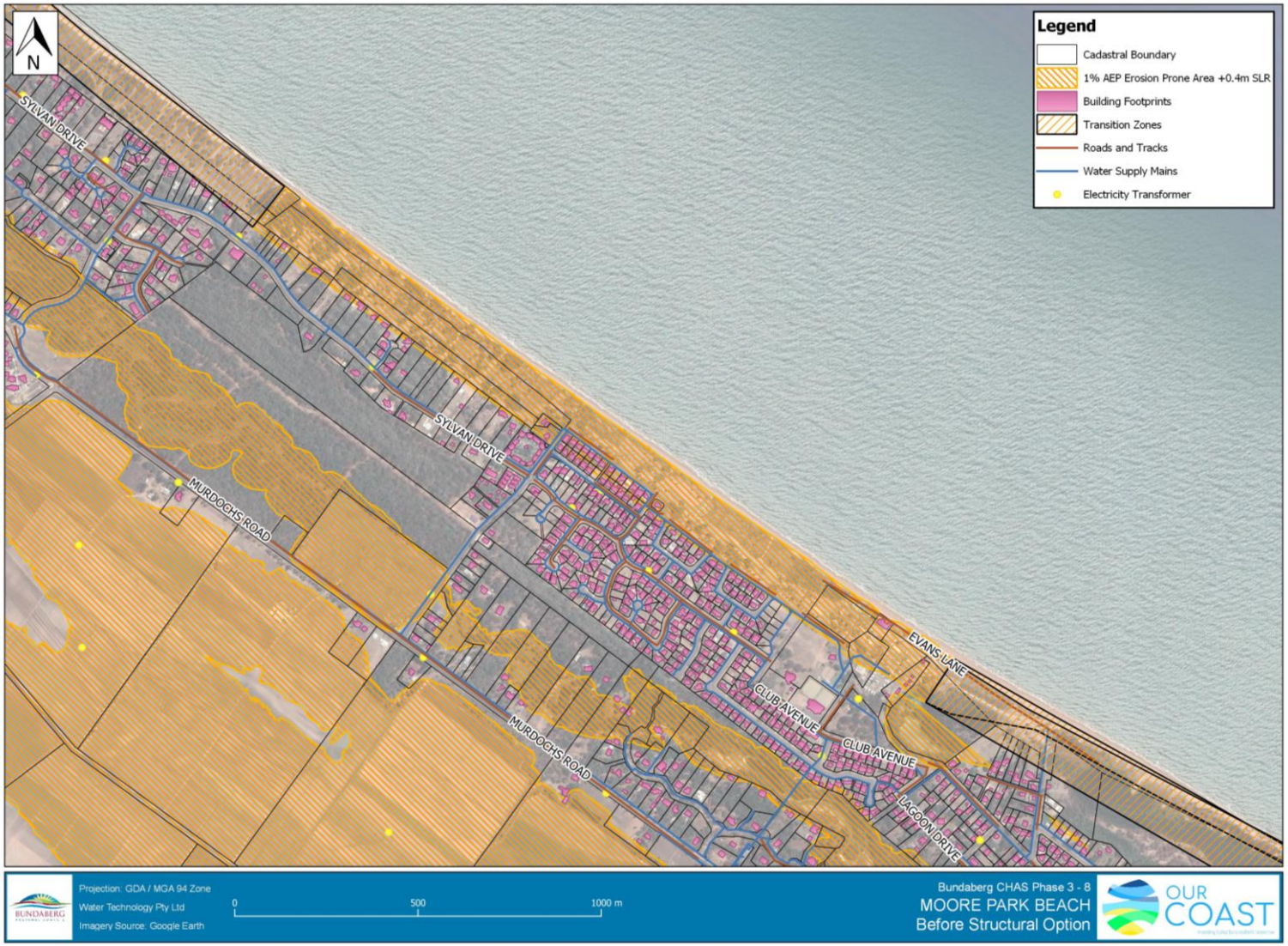

FIGURE 4-3 MOORE PARK BEACH – UNMITIGATED COASTAL HAZARD (0.4 M SEA LEVEL RISE EROSION PRONE AREA)

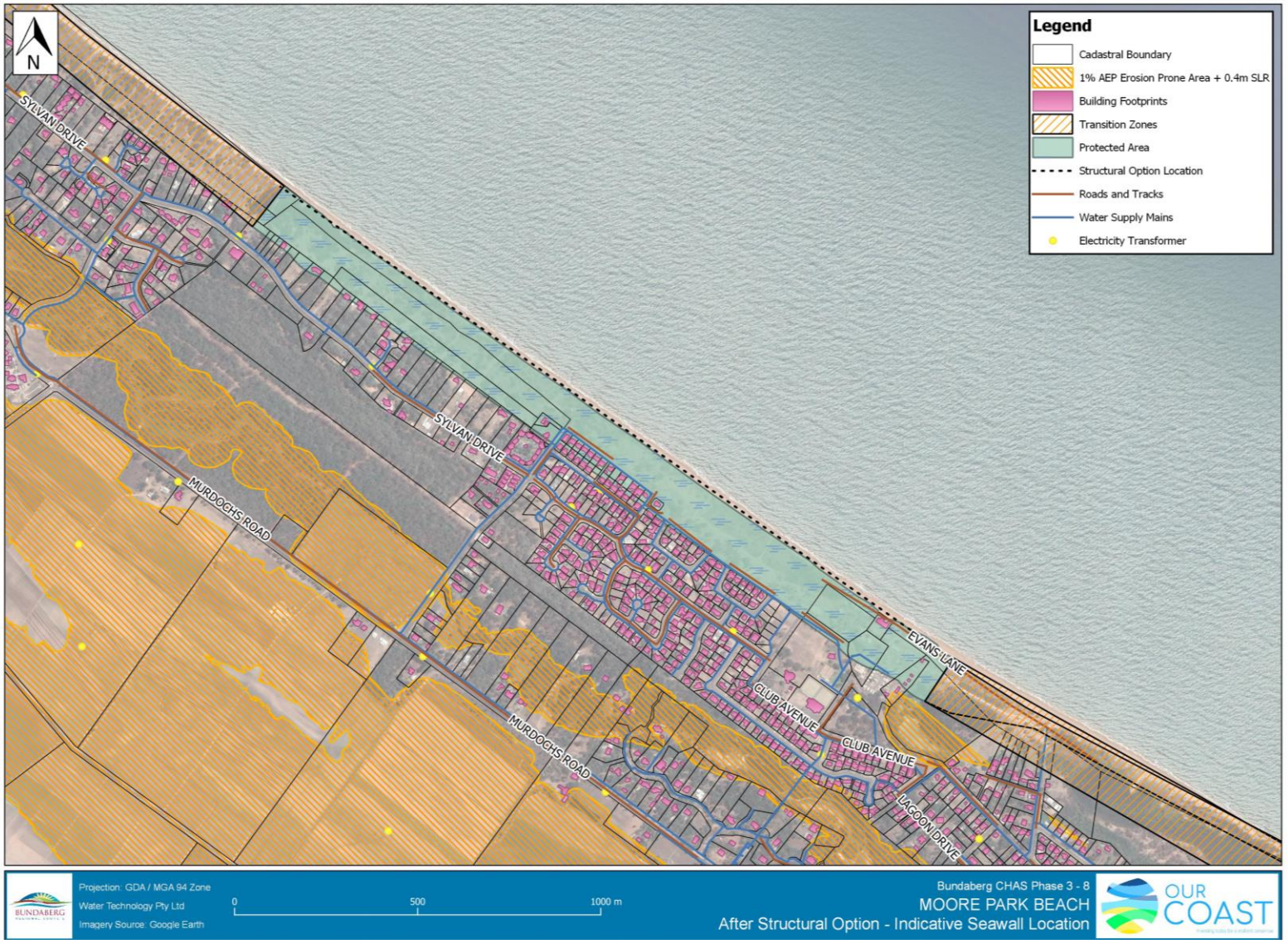

FIGURE 4-4 MOORE PARK BEACH – SEAWALL/ROCKWALL/BURIED SEAWALL GENERAL LOCATION AND BENEFITS

4.3.2 Benefits

A seawall or rockwall in Moore Park Beach is effective against erosion and inundation and can also be effective against sea level rise. There are design options such as a buried seawall in combination with beach nourishment that allow for beach access and amenity.

- Would prevent further coastal erosion for the lifetime of the asset for the mapped erosion prone area;
- Would prevent approximately $3.8million (NPV) of damages in Moore Park Beach in the time period between a 0.4 m sea level rise scenario and 0.8 m sea level rise scenario; and,
- Does not address inundation from the creeks and wetlands behind the dune and would not be effective against storm tide inundation to property.

TABLE 4-6 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Moore Park Beach – Seawall	$29,517,065	$25,687,063	$3,830,002

4.3.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $11.8million this includes survey, designs and approvals and 40% contingency. The preliminary cost estimate is detailed in Table 4-7. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-7 PRELIMINARY COST ESTIMATE – MOORE PARK BEACH SEAWALL

Option	Seawall Length	Initial Cost [3]	Maintenance Cost [4]	Discounted from year	Whole of Life Cost NPV (7%)
Moore Park Beach Seawall	2.2 km	$11,786,866	$3,536,060	40	$1,014,986

4.3.4 Benefit to Cost Ratio – BCR

The benefit-cost ratio for beach nourishment with dune reconstruction at Moore Park Beach would be approximately 3.77. That is, the benefits of this option would be almost 4 times the estimated cost.

TABLE 4-8 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit Cost Ratio (BCR)
$3,830,002	$1,014,986	3.77

[3] Initial costs include initial survey, design and approval costs
[4] Includes a maintenance cost that is assumed at 30% replacement cost of the seawall due to extreme storm event every 10 years over 50-year lifetime

4.3.5 MCA – Summary

Table 4-9 summarises the performance of the adaptation option of a seawall construction at Moore Park Beach against the seven weighted criteria.

TABLE 4-9 MCA SUMMARY FOR SEAWALL FOR MOORE PARK BEACH

Criteria	Objective	Performance – 0.4 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Estimated to provide $3.8 million (NPV) of damage reduction and has a reduction of population at risk of 4.86.	66.6	32%	21.3
Adaptability	Ability to be adapted based on unexpected climate trends	Seawalls are generally more difficult to adapt, even if they are made of sandbags and there would be a higher cost involved which is proportional to the length of the wall. In this case the option considered is 2.2 km in length so this option is not readily adaptable.	56.6	22%	12.3
Beach Impact	Minimise impact on beach access and amenity	Impact of the Moore Park Beach seawall on beach access and amenity is proportionally low because there is a high natural to urbanised beach ratio. So, there is less impact on the beach in populated areas.	69.3	15%	10.4
Env. Impact	Minimise impact to the environment	Moore Park Beach is a significant beach for turtle nesting, however currently, foredune erosion can reduce success rates. Seawalls at Moore Park Beach are likely to be located as far landward as possible. Where seawalls are placed further landward, the dune would be able to retreat landward, providing the opportunity for turtles to nest.	91.5	13%	11.9
Tech. Viability	Adaptation options that are technically viable	Established/proven design principles exist for treatment. Will require individual design requirements	81.8	9%	7.4
Approval	Minimise difficulty in obtaining required permits	Several conservation significant species known to occur. Additional investigations and impact assessments likely.	81.8	5%	1.5
Cost	Cost-effective adaptation options implemented	Overall cost is comparatively high compared to other structural options.	30.0	4%	3.0
Total Score					**67.8**
MCA ranking compared to other options:		**3rd**			

4.4 Burnett Heads – Storm Surge Barrier and Dyke

4.4.1 Description of Option

The indicative location of the treatment includes 300 m earth dyke in association with Buss and Moffatt Streets plus an 80 m storm surge barrier to protect properties immediately south west of the wetland area is shown in Figure 4-5. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA analysis as a possible adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

The screening process identified the high cost of this option as well as the potential for many adverse impacts to the amenity and degradation to the wetland ecosystem. As such an alternative location of the storm surge barrier has been discussed in a location that protects the developed area of the west of Burnett Heads but ensures the existing wetland ecosystem remains tidally inundated.

The storm surge barrier is an effective measure for properties affected by storm tide inundation and sea level rise.

Properties that are potentially affected by permanent inundation due to sea level rise were considered in the damage calculations, these economic consequences were not considered to be catastrophic as part of the risk assessment and did not ‘push’ the risk profile above the intolerable threshold. A combination of permanent inundation and storm tide inundation results in the ‘trigger’ for intolerable risk to be reached after a 0.8 m sea level rise scenario. However, the damages expected from permanent inundation could be reduced if a storm surge barrier is constructed before a 0.8 m sea level rise scenario, thus providing a more favourable BCR to this adaptation option.

It is recommended that Council investigate the implementation of this option in conjunction with any future road infrastructure upgrades in the vicinity of Buss Moffatt Streets and undertake a further CBA by bringing the timing of implementation forward from ‘year 80’, as assumed in this analysis.

Earlier implementation of this option may provide a greater BCR, this should be considered in any future planning process.

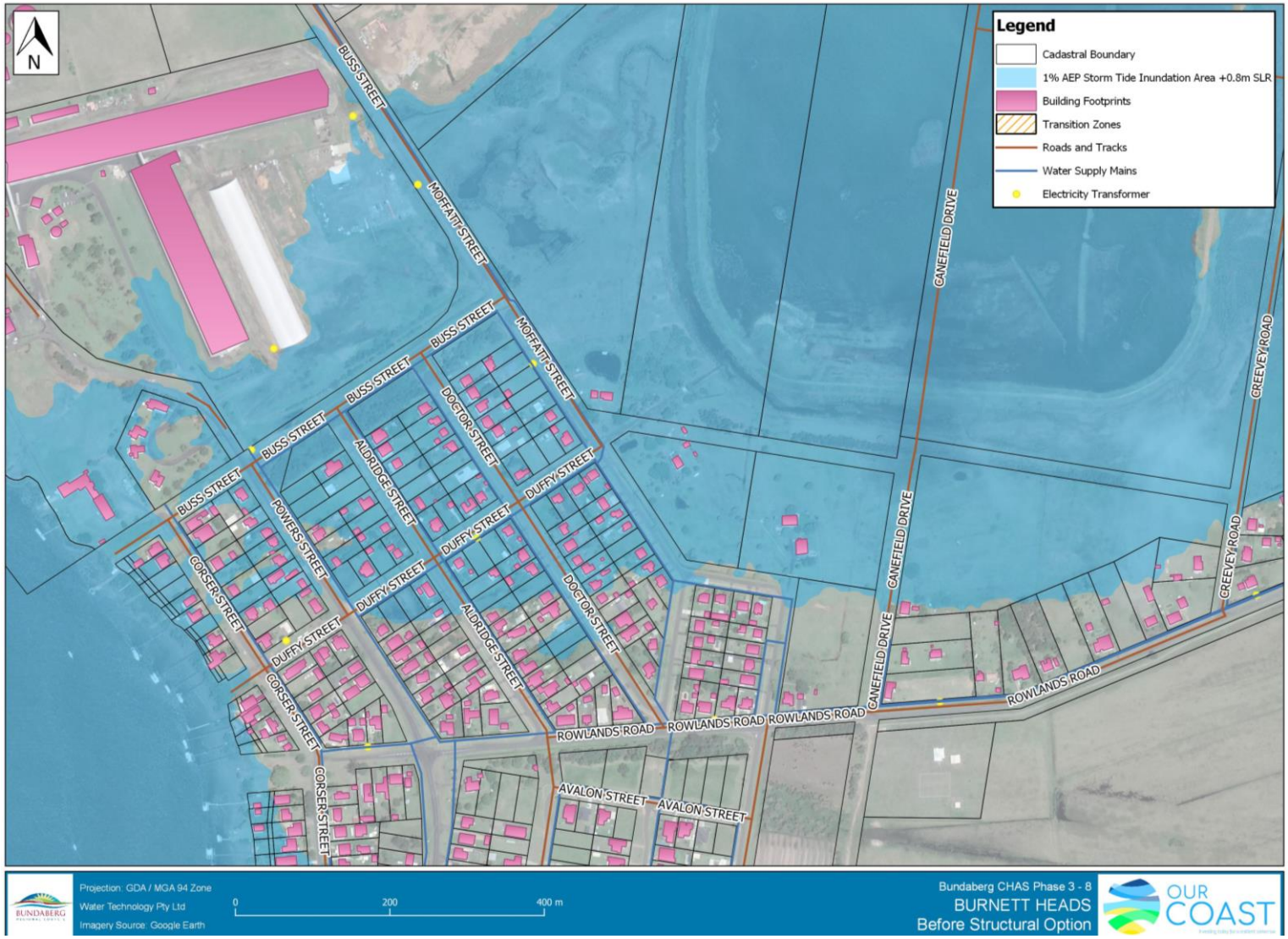

FIGURE 4-5 BURNETT HEADS – UNMITIGATED COASTAL HAZARD (0.8 M SEA LEVEL RISE 1% AEP STORM TIDE INUNDATION)

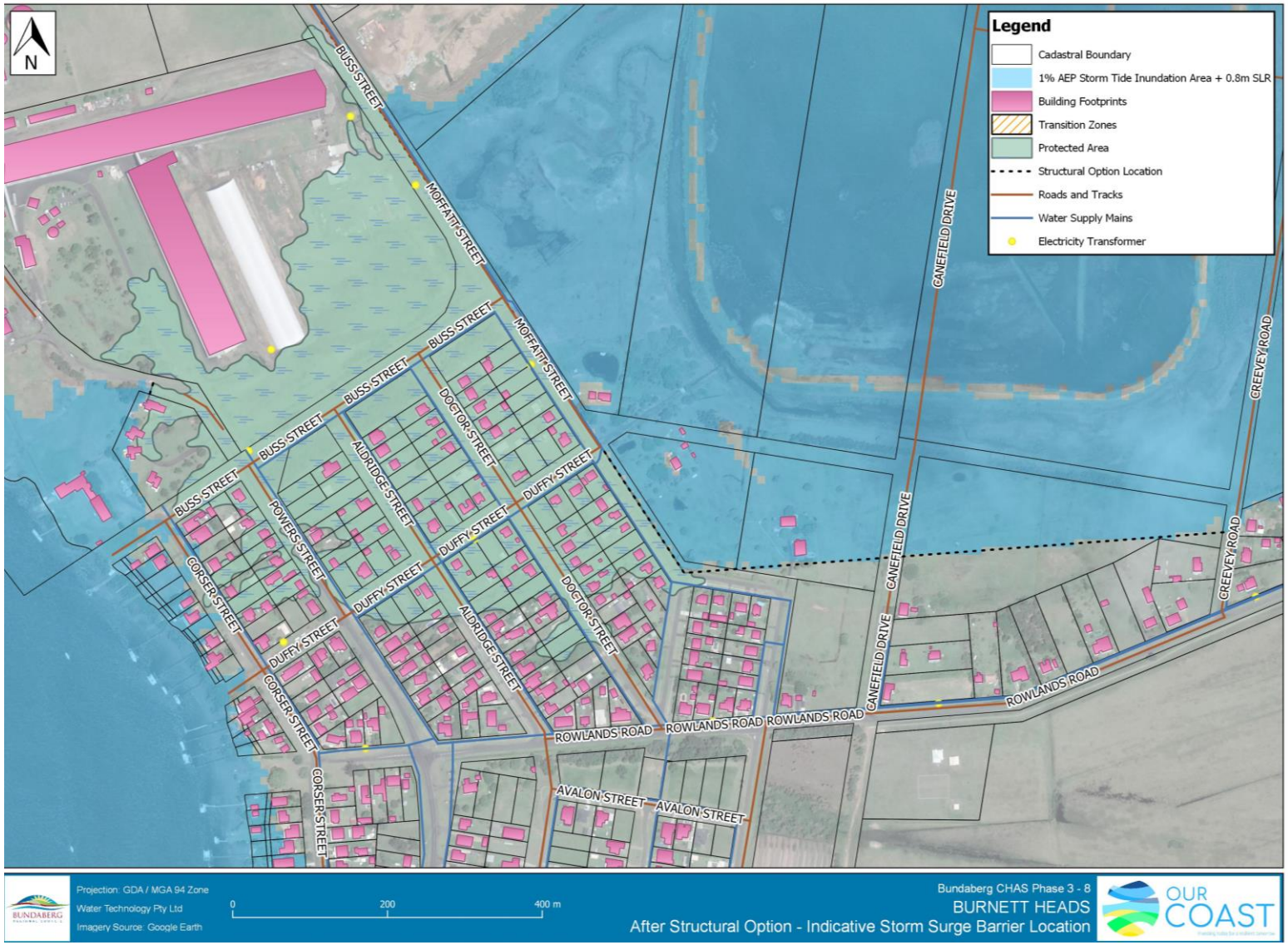

FIGURE 4-6 BURNETT HEADS – STORM SURGE BARRIER AND DYKE – GENERAL LOCATION AND BENEFITS

4.4.2 Benefits

A storm surge barrier in Burnett Heads would be effective against storm tide inundation and can also be effective against sea level rise. A barrier is effective against wave force and inundation and can be designed in combination with road and transport corridor upgrades. This option is assumed to be designed to 1% AEP 0.8 m sea level rise scenario and would:

- Prevent inundation to the mapped storm tide inundation 0.8 m sea level rise scenario;
- Prevent approximately $34,174 (NPV) of damages in Burnett Heads after the 0.8 m sea level rise scenario. This value appears small due to the discount factor over 80 years; and,
- Reduce the number of people at risk by 130.

TABLE 4-10 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Burnett Heads – Storm Surge Barrier	$48,404,840	$48,370,666	$34,174

4.4.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $18 million this includes survey, designs and approvals. The preliminary cost estimate is detailed Table 4-11. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-11 PRELIMINARY COST ESTIMATE – BURNETT HEADS STORM SURGE BARRIER

Settlement	Dimension	Rate[5]	Initial Cost [6]	Total preliminary cost	Discounted from year	Whole of Life Cost NPV (7%)
Burnett Heads	3.1 km Earth dyke	$3,000/m	$9,300,000	$ 18,000,000	80	$80,273
	80 m Storm Surge Barrier	n/a	$8,700,000			

4.4.4 Benefit to Cost Ratio – BCR

The benefit-cost ratio for a storm surge barrier and dyke construction at Burnett Heads would be approximately 0.43. That is, the cost of this option would be almost double the estimated benefits. As discussed, the damages expected from permanent inundation could be reduced if a storm surge barrier is constructed before a 0.8 m sea level rise scenario, thus providing a more favourable BCR to this adaptation option.

TABLE 4-12 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$34,174	$80,273	0.43

[5] Assuming 30m3 fill
[6] Initial costs include initial survey, design and approval costs

4.4.5 MCA – Summary

TABLE 4-13 MCA SUMMARY FOR A STORM SURGE BARRIER AT BURNETT HEADS

Criteria	Objective	Performance – 0.8 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Highly effective against storm tide inundation. Reduces the risk to 130 people. May realise improved benefit to cost ratio if implemented earlier.	99.7	32%	31.9
Adaptability	Ability to be adapted based on unexpected climate trends	A storm surge barrier in Burnett Heads is difficult to adapt as it involves a large land footprint and a relatively large civil construction program of works. It will be designed to certain storm tide inundation event and to alter the design would be an expensive operation.	38.0	22%	8.4
Beach Impact	Minimise impact on beach access and amenity	This option is not located on the beach and therefore has no impact on beach amenity or access. Will need to be designed to ensure continued use of the wetlands for the community.	100.0	15%	15.0
Env. Impact	Minimise impact to the environment	The area of estuarine wetlands and waterways in the vicinity of the proposed works will likely increase over time. There will be negative impacts to the aquatic ecology of this area unless regular tidal ingress and egress to the estuarine wetlands is maintained.	0.0	13%	0.0
Tech. Viability	Adaptation options that are technically viable	Requires large land footprint for earth dyke and may impact local community.	0.0	9%	0.0
Approval	Minimise difficulty in obtaining required permits	Moderately difficult to gain approvals. Habitat for conservation of significant bird species (threatened and marine/migratory). Waterway provides connectivity to regionally significant artificial ponds. Marine plants likely to be impacted by the works. Survey for marine plants required. Offsets likely	30.0	5%	1.5
Cost	Cost-effective adaptation options implemented	Low benefit to cost ratio and relatively expensive option. Alternative design locations and options to implement via transport corridor upgrades can bring overall cost down.	95.6	4%	3.8
Final score					60.6
MCA ranking compared to other options:		**5th**	**(out of 19)**		

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4.5 Bargara (Kellys Beach) – Beach Nourishment with Dune Reconstruction

4.5.1 Description of Option

Beach nourishment aims to reduce the onset of coastal erosion and the risk of storm tide inundation. To increase effectiveness of this adaptation option, dune re-construction and re-vegetation should be included.

A long-term beach nourishment strategy requires continuous monitoring of shoreline changes to identify timing of renourishment campaigns, which can be conducted through remote sensing cameras or traditional survey methods.

Details of beach nourishment at Bargara includes input of sand along a 1.4km stretch of beach, extending a minimum of 14 m offshore. The analysis assumes that beach nourishment is periodically topped-up for the lifespan of the asset.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

The screening process identified some minor adverse impacts upon tidal flushing of Money's Creek and the lagoon up to The Causeway, however beach nourishment of Kellys Beach is viewed effective against erosion risk to properties adjacent to the beach. Typically, Council does not fund projects to protect private property or infrastructure and it will be advised that, collectively, private property owners investigate the feasibility of protecting their assets. A combination of seawall with beach nourishment could be considered as part of any project planning.

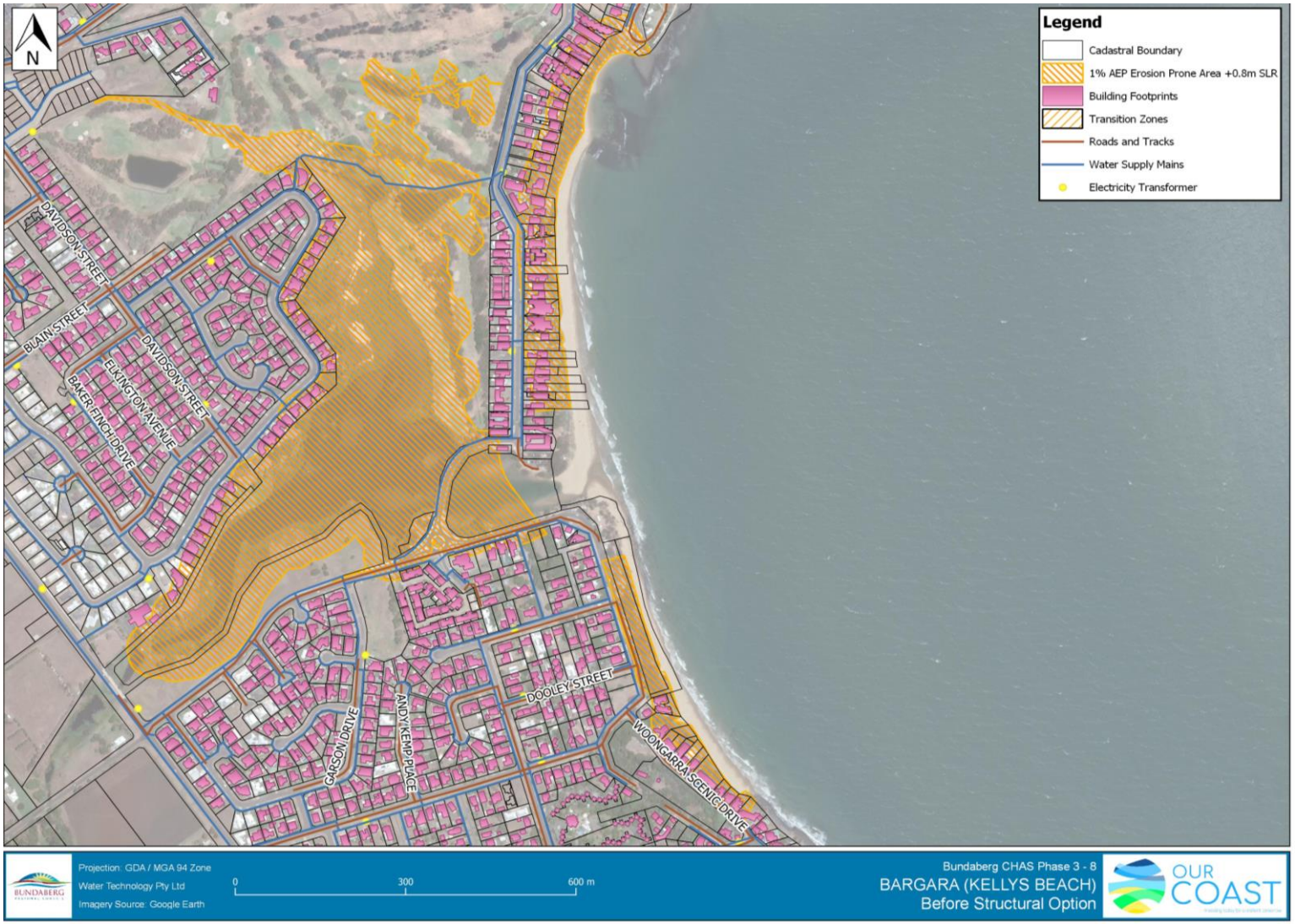


FIGURE 4-7 KELLYS BEACH, BARGARA – UNMITIGATED COASTAL HAZARD (0.8 M SEA LEVEL RISE – EROSION PRONE AREA)

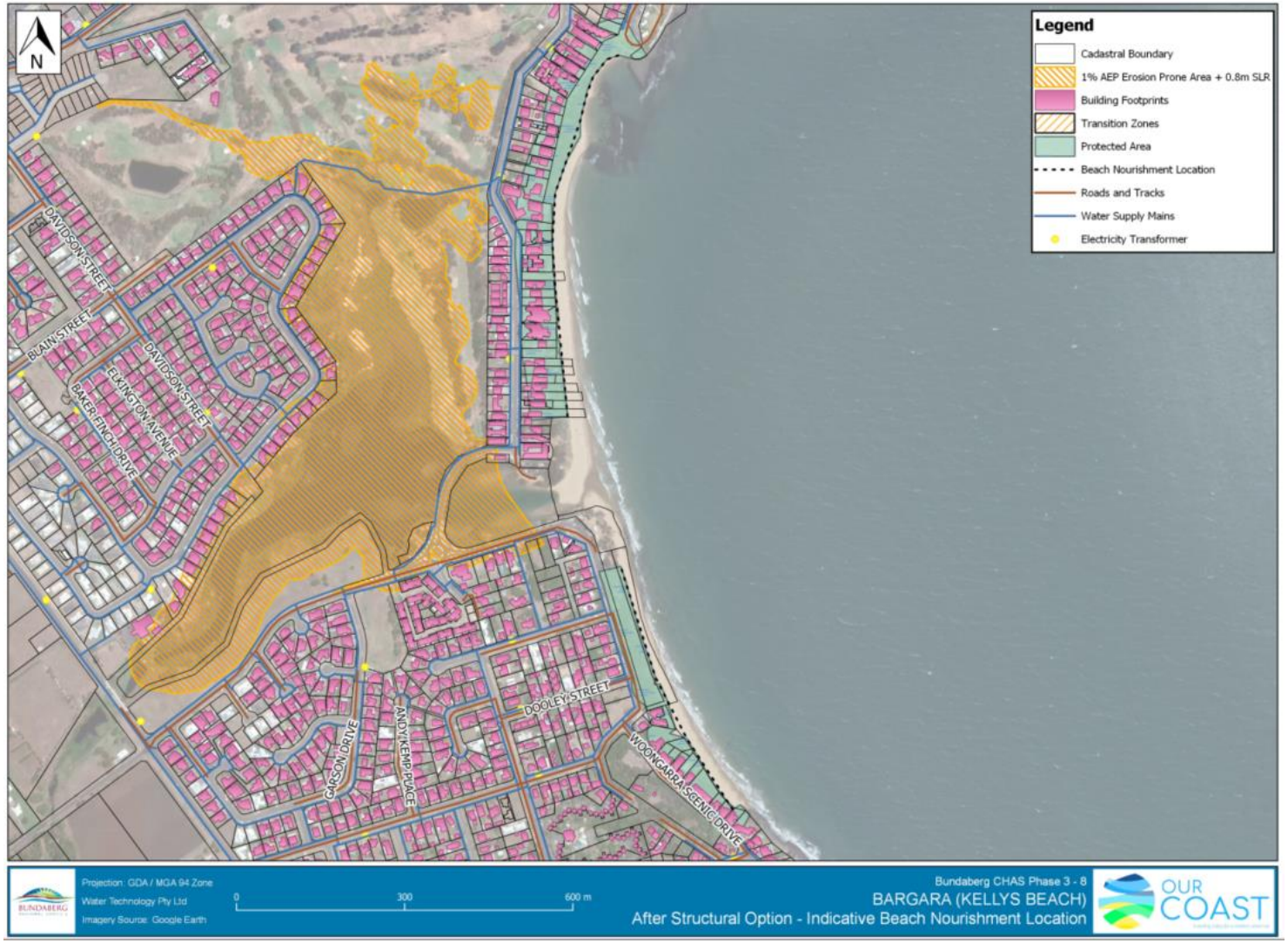


FIGURE 4-8 KELLYS BEACH BARGARA – BEACH NOURISHMENT GENERAL LOCATION AND BENEFITS

4.5.2 Benefits

Beach nourishment on Kellys Beach would be effective against coastal erosion and can also be effective against inundation. It will not address inundation from the creeks and lagoon behind the dunes. If regular re-nourishment is continued, as assumed in the analysis, this option would:

- Prevent coastal erosion to private property after the 0.8 m sea level rise scenario;
- Prevent approximately $225,165 (NPV) of damages in Bargara after the 0.8 m sea level rise scenario; and
- Create a natural solution that does not impact on beach amenity.

TABLE 4-14 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Kellys Beach - Beach Nourishment / Dune Reconstruction	$33,073,265	$32,848,100	$225,165

4.5.3 Cost Estimate

The initial implementation costs of beach nourishment at Kellys Beach, Bargara is approximately $1.3 million with annual maintenance costs of $64,680. NPV has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios. Beach nourishment at Bargara is an adaptation option responding to 0.8 m sea level rise, which is assumed to be put in place 80 years from today. As this option is assumed to be implemented at 0.8 m sea level rise, no maintenance is considered in the NPV.

TABLE 4-15 PRELIMINARY COST ESTIMATE – KELLYS BEACH, BARGARA BEACH NOURISHMENT

Option	Length/Dimension	Implementation Cost[7]	Initial cost linear cubic metre	Annual Maintenance[8]	Discounted from year	NPV (7%)
Kellys Beach - Beach Nourishment / Dune Reconstruction	Length: 1.4 km Extent offshore: 14 m Area: 19,600 m3	$1,310,960	$936	$64,680	80	$5,846

4.5.4 Benefit to Cost Ratio – CBA

When assessing the financial cost and benefit of beach nourishment at Kellys Beach, the benefit to cost ratio was found to be 38.5 and offer benefits of approximately $225,000, meaning the savings achieved through reducing damages is more than 38 times the cost of installation. This benefit-cost ratio is the highest of all adaptation options assessed during this study. However, these benefits do not consider ongoing maintenance required as the option is implemented after 0.8 m sea level rise. Furthermore, the benefits afforded by this option are concentrated to highly capitalised private assets on Kellys Beach.

[7] Implementation costs include sand sourcing study, initial survey, design and approval costs and 40% contingency
[8] Annual maintenance to undertake a sand renourishment campaign of 5% of implementation cost every year along the at-risk foreshore including 10% contingency

TABLE 4-16 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$225,165	$5,846	38.51

4.5.5 MCA – Summary

TABLE 4-17 MCA SUMMARY FOR BEACH NOURISHMENT AT KELLYS BEACH, BARGARA

Criteria	Objective	Performance – 0.8 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Effective adaptation option for properties fronting Kellys Beach. Can be more effective when paired with dune revegetation and the use of a hard-structural option (e.g. seawall).	3.9	32%	1.2
Adaptability	Ability to be adapted based on unexpected climate trends	Highly adaptable, a single sand replenishment episode would be considered a temporary mitigation that requires ongoing implementation. The renourishment campaign can readily be adjusted with changing sea level scenarios.	86.0	22%	18.9
Beach Impact	Minimise impact on beach access and amenity	Positive impact on long-term amenity and minimal or very temporary impacts to access.	100.0	15%	15.0
Env. impact	Minimise impact to the environment	Likely adverse impact upon tidal flushing of Money's Creek and Kellys Creek	82.2	13%	10.7
Tech. viability	Adaptation options that are technically viable	Beach nourishment is a widely used solution to mitigate coastal erosion, with minimal technical concerns.	81.8	9%	7.4
Approval	Minimise difficulty in obtaining required permits	Commonwealth and state matters of environmental significance present. Previous records of conservation significant species (threatened and migratory/marine bird species and marine turtles) present. Offsets likely and many approvals required.	25.0	5%	1.3
Cost	Cost-effective adaptation options implemented	Beach nourishment requires ongoing maintenance; however, the overall cost is comparatively low compared to other structural options.	99.7	4%	4.0
Total score					58.4
MCA ranking compared to other options:		**9th**	**(out of 19)**		

4.6 Bargara (Kellys Beach) – Seawall, Rockwall or Buried Seawall

4.6.1 Description of Option

The proposed seawall or rockwall treatment extends along the ocean fronting area of intolerable risk for 1.4 km. Planning of this option ought to commence at 0.4 m sea level rise in preparation for 0.8 m coastal erosion hazard. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

The screening process identified some minor adverse impacts such as loss of beach in front of the seawall for the public and the creation of a hard barrier to beach access. Despite these potential downsides, a seawall at Kellys Beach would be an effective measure to protect private residences that front the shoreline. Typically, Council does not fund projects to protect private property or infrastructure and it will be advised that, collectively, private property owners investigate the feasibility of protecting their assets. A combination of a seawall with beach nourishment could be considered as part of any project planning.

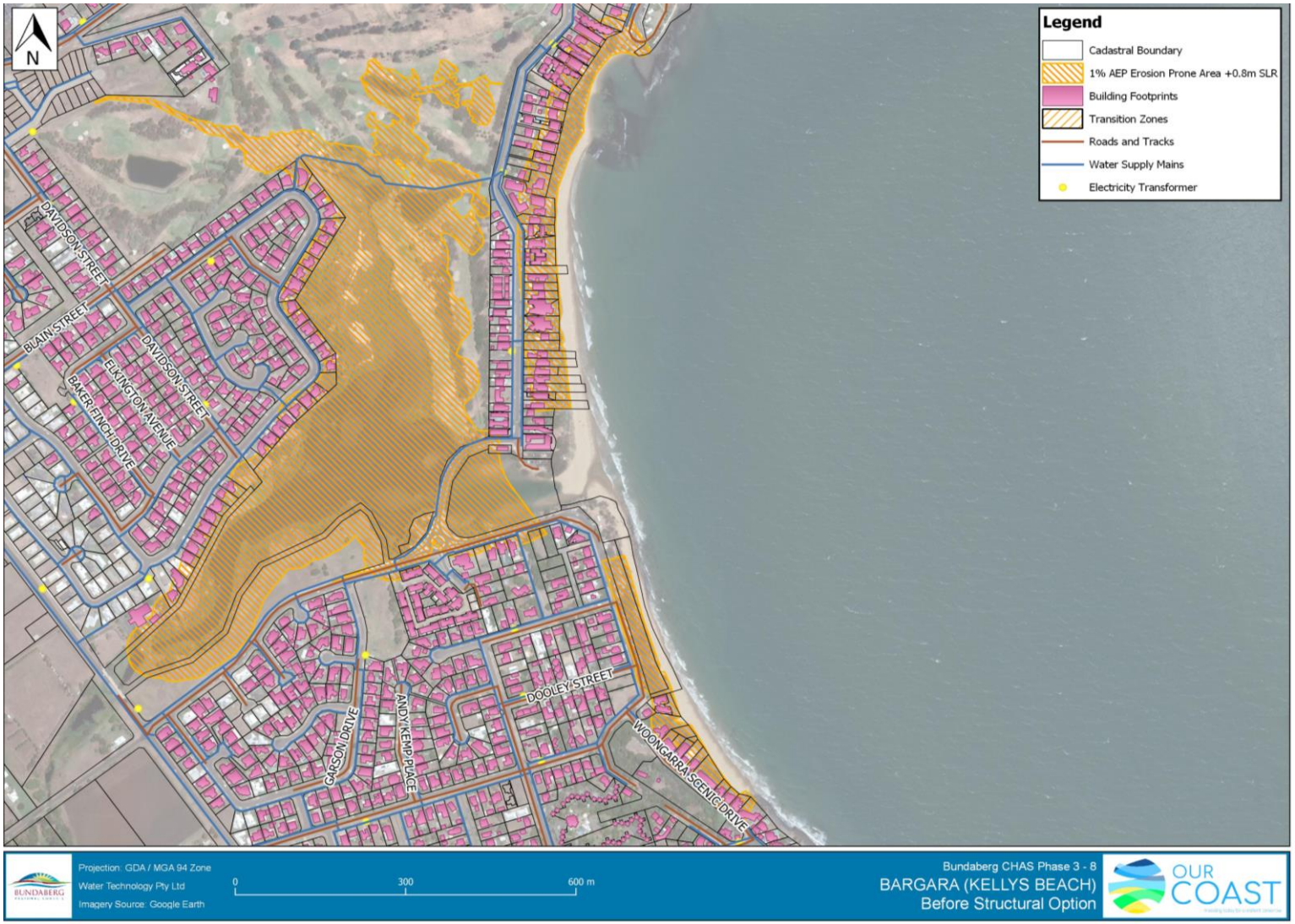


FIGURE 4-9 KELLYS BEACH, BARGARA – UNMITIGATED COASTAL HAZARD (0.8 M SEA LEVEL RISE – EROSION PRONE AREA)

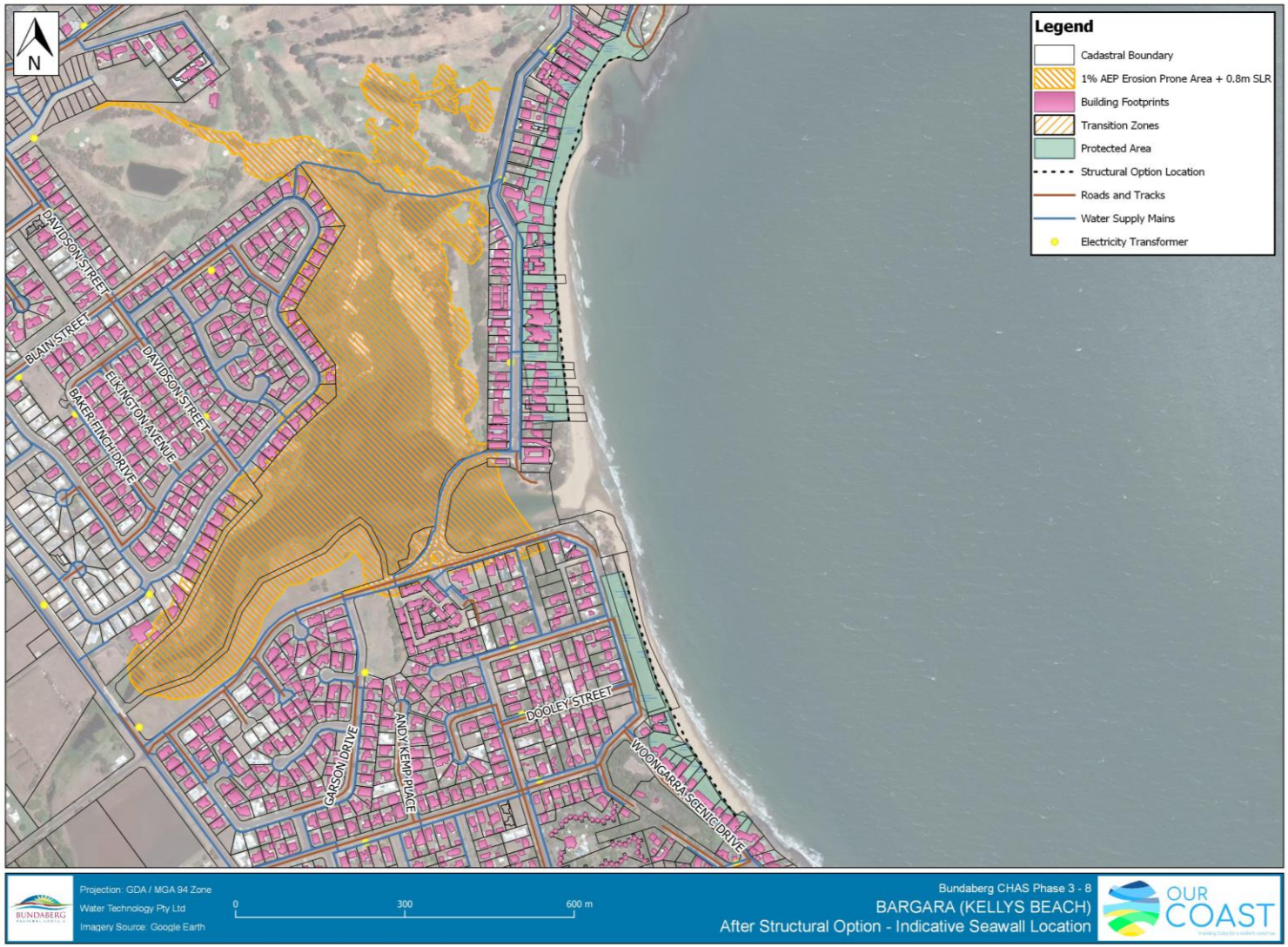


FIGURE 4-10 KELLYS BEACH, BARGARA – SEAWALL/ROCKWALL/BURIED SEAWALL – GENERAL LOCATION AND BENEFITS

4.6.2 Benefits

A seawall or rockwall at Kellys Beach is effective against erosion and inundation and can also be effective against sea level rise. There are design options, such as a buried seawall in combination with beach nourishment, that allow for beach access and amenity. This option would:

- Prevent further coastal erosion for the lifetime of the asset for the mapped erosion prone area;
- Would prevent approximately $225,165 (NPV) of damages to private property in Kellys Beach after the 0.8 m sea level rise scenario; and,
- Does not address inundation from the creeks and wetlands behind the dune and would not be effective against storm tide inundation to property.

TABLE 4-18 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Kellys Beach, Bargara – Seawall/Rockwall	$33,073,265	$32,848,100	$225,165

4.6.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $7.4 million, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-19. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-19 PRELIMINARY COST ESTIMATE – KELLYS BEACH, BARGARA SEAWALL

Option	Seawall Length	Initial Cost [9]	Maintenance Cost [10]	Discounted from year	Whole of Life Cost NPV (7%)
Kellys Beach, Bargara – Seawall, Rockwall	1.4km	$7,460,400	$2,238,120	80	$33,271

4.6.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of a seawall or rockwall constructed at Kellys Beach, the benefit to cost ratio was found to be 6.77 and offers benefits of approximately $225,000, meaning the savings achieved through reducing damages is more than 6 times the cost of installation. It is important to note the benefits afforded by this option are concentrated to highly capitalised private assets on Kellys Beach.

TABLE 4-20 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$225,165	$33,271	6.77

[9] Initial costs include initial survey, design and approval costs
[10] Includes a maintenance cost that is assumed at 30% replacement cost of the seawall due to extreme storm event every10 years over 50-year lifetime

4.6.5 MCA – Summary

TABLE 4-21 MCA SUMMARY FOR A SEAWALL AT BARGARA

Criteria	Objective	Performance – 0.8 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Estimated to provide $33,271 (NPV) of damage reduction to private property fronting Kellys Beach.	3.9	32%	1.2
Adaptability	Ability to be adapted based on unexpected climate trends	Seawalls are generally more difficult to adapt, even if they are made of sandbags and there would be a higher cost involved which is proportional to the length of the wall. In this case the option considered is 1.4km in length so this option is somewhat adaptable.	72.0	22%	15.8
Beach Impact	Minimise impact on beach access and amenity	Impact of a seawall on Kellys Beach on beach access and amenity is high because the beach is 100% an 'urbanised beach' where people access the beach and surf. Therefore, high impact on the beach access and amenity.	0.0	15%	0.0
Env. Impact	Minimise impact to the environment	This is a significant beach for turtle nesting, the seawall is likely to be placed at the top of HAT, resulting in loss of turtle nesting habitat.	62.4	13%	8.1
Tech. Viability	Adaptation options that are technically viable	Established/proven design principles exist for treatment. Will require individual design requirements	81.8	9%	7.4
Approval	Minimise difficulty in obtaining required permits	Several conservation and significant species known to occur. Additional investigations and impact assessments likely.	25.0	5%	1.3
Cost	Cost-effective adaptation options implemented	Overall cost is comparatively low compared to other structural options.	98.2	4%	3.9
Total score					37.7
MCA ranking compared to other options:		**19th**	**(out of 19)**		

4.7 Innes Park and Coral Cove - Beach Nourishment with Dune Reconstruction

4.7.1 Description of Option

Indicative location of the beach nourishment extends for whole of Innes Park beach pocket north and south of Palmers Creek. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal of the adaptation option. Beach nourishment aims to reduce the onset of coastal erosion, by reducing the risk of storm tide inundation when combined with dune reconstruction. Dune reconstruction can aid the process of beach nourishment, and separate regeneration planting can occur to increase effectiveness of this adaptation option. Note that there is a “holding structure” to the north of Innes Park in the rocky headland which will prevent sand dispersing over time. Nonetheless annual maintenance of sand renourishment has been factored into the cost estimate as sand losses will still occur to the south and offshore.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

Negative impacts of depositing additional sand on the foreshore at Innes Park are considered to be minimal, however can affect tidal flushing of Palmers Creek affecting water quality and ecology.

FIGURE 4-11 INNES PARK – UNMITIGATED COASTAL HAZARD – 0.8 M SEA LEVEL RISE (EROSION PRONE AREA)

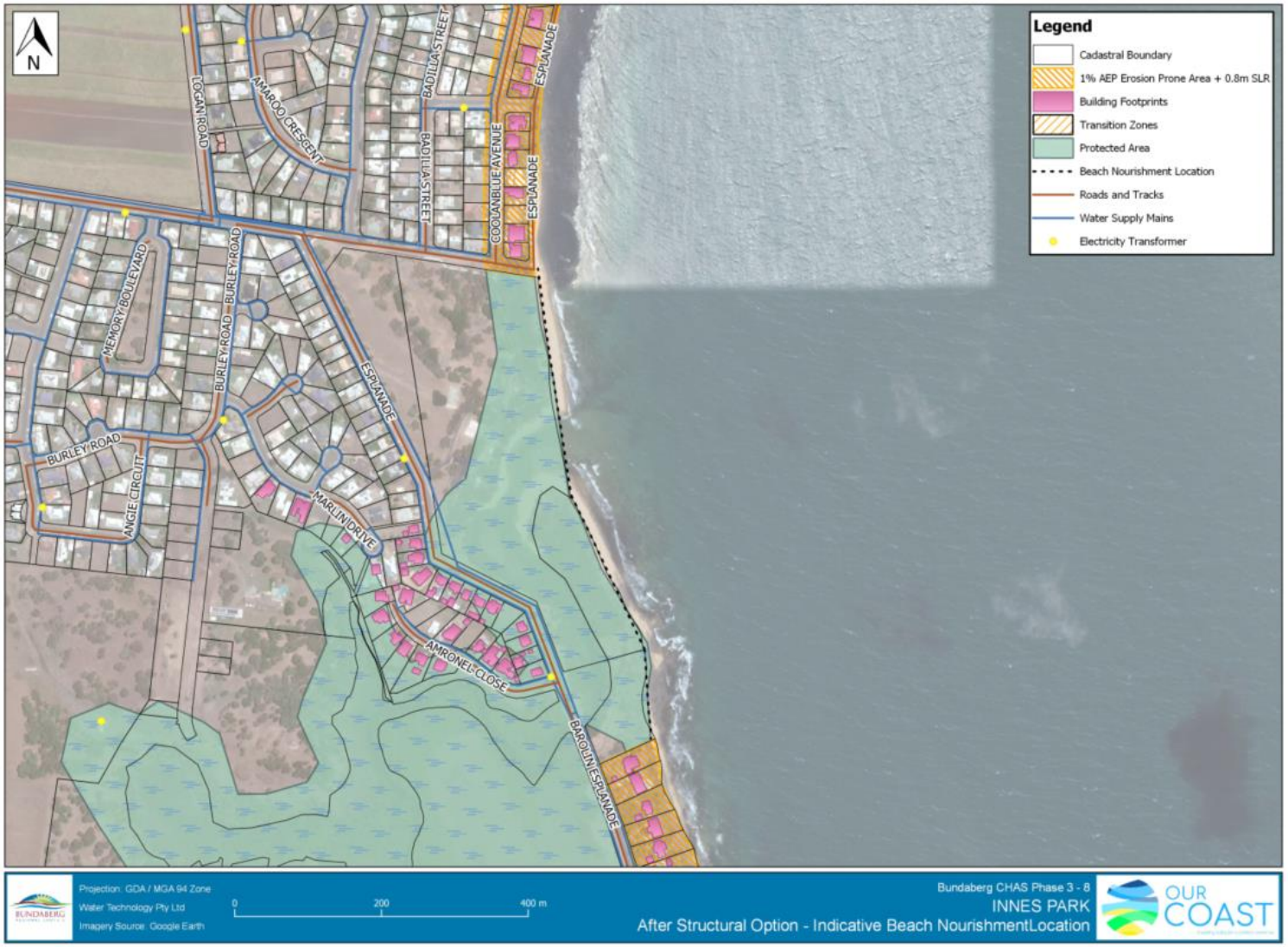


FIGURE 4-12 INNES PARK – BEACH NOURISHMENT GENERAL LOCATION AND BENEFITS

4.7.2 Benefits

Beach nourishment on the foreshore at Innes Park would be effective against coastal erosion on properties and infrastructure. It is noted that much of the foreshore to the north is protected by rock foreshore. If regular re-nourishment is continued, as assumed in the analysis, this option would:

- Prevent coastal erosion to public infrastructure and population at risk after the 0.8 m sea level rise scenario;
- Prevent approximately $89,649 (NPV) of damages in Innes Park after the 0.8 m sea level rise scenario; and,
- Create a natural solution that does not impact on beach amenity.

TABLE 4-22 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Innes Park - Beach Nourishment / Dune Reconstruction	$1,383,149	$1,293,500	$89,649

4.7.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $2.6 million, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-23. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-23 PRELIMINARY COST ESTIMATE – INNES PARK BEACH NOURISHMENT

Option	Length / Dimension	Implementation Cost[11]	Initial cost linear cubic metre	Annual Maintenance[12]	Discounted from year	NPV (7%)
Innes Park	Length: 1 km extent offshore: 34 m area: 34,000m^2	$2,600,000	$2,600	$134,000	80	$11,595

4.7.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of beach nourishment at Innes Park, the benefit to cost ratio was found to be 7.73 and offers benefits of approximately $89,649, meaning the savings achieved through reducing damages is more than 7 times the cost of installation.

[11] Implementation costs include sand sourcing study, initial survey, design and approval costs and 40% contingency

[12] Annual maintenance to undertake a sand renourishment campaign of 5% of implementation cost every year along the at-risk foreshore including 10% contingency

TABLE 4-24 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$89,649	$11,596	7.73

4.7.5 MCA – Summary

TABLE 4-25 MCA SUMMARY FOR BEACH NOURISHMENT AT INNES PARK AND CORAL COVE

Criteria	Objective	Performance – 0.8 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Comparatively not as effective as reducing damages nor does it reduce the risk to people from inundation.	1.5	32%	0.5
Adaptability	Ability to be adapted based on unexpected climate trends	Highly adaptable, as one sand replenishment is a temporary mitigation that requires ongoing implementation. The renourishment campaign can readily be adjusted with changing sea level scenarios.	90.0	22%	19.8
Beach Impact	Minimise impact on beach access and amenity	Positive impact on long-term amenity and minimal or very temporary impacts to access.	100.0	15%	15.0
Env. Impact	Minimise impact to the environment	Likely adverse impact upon tidal flushing of Palmer's Creek	87.8	13%	11.4
Tech. Viability	Adaptation options that are technically viable	Beach nourishment is a widely used solution to mitigate coastal erosion, with minimal technical concerns.	81.8	9%	7.4
Approval	Minimise difficulty in obtaining required permits	Commonwealth and State matters of environmental significance present. Previous records of conservation significant species (threatened and migratory/marine bird species and marine turtles) present. Offsets likely and many approvals required.	15.0	5%	0.8
Cost	Cost-effective adaptation options implemented	Overall cost is comparatively low compared to other structural options.	99.4	4%	4.0
Total score					58.8
MCA ranking compared to other options:		**8th**	**(out of 19)**		

4.8 Innes Park and Coral Cove - Seawall, Rockwall or Buried Seawall

4.8.1 Description of Option

The indicative location of a seawall or rockwall treatment extends along the whole of Innes Park beach pocket north and south of Palmers Creek (approximately up to 1 km). This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal of the adaptation option. Planning of this option ought to commence at 0.4 m sea level rise in preparation for coastal erosion hazard in a 0.8 m sea level rise scenario. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (Working Group and Project Control Group).

The screening process identified some minor adverse impacts such as loss of beach in front of the seawall and the creation of a hard barrier to beach access. Furthermore, despite reductions in damages to property and infrastructure the relative effectiveness of a seawall at Innes Park is low in comparison to other modify options due to the relatively low reduction in damages. This is due to the lower number of properties protected by the option.

FIGURE 4-13 INNES PARK – UNMITIGATED COASTAL HAZARD – 0.8 M SEA LEVEL RISE (EROSION PRONE AREA)

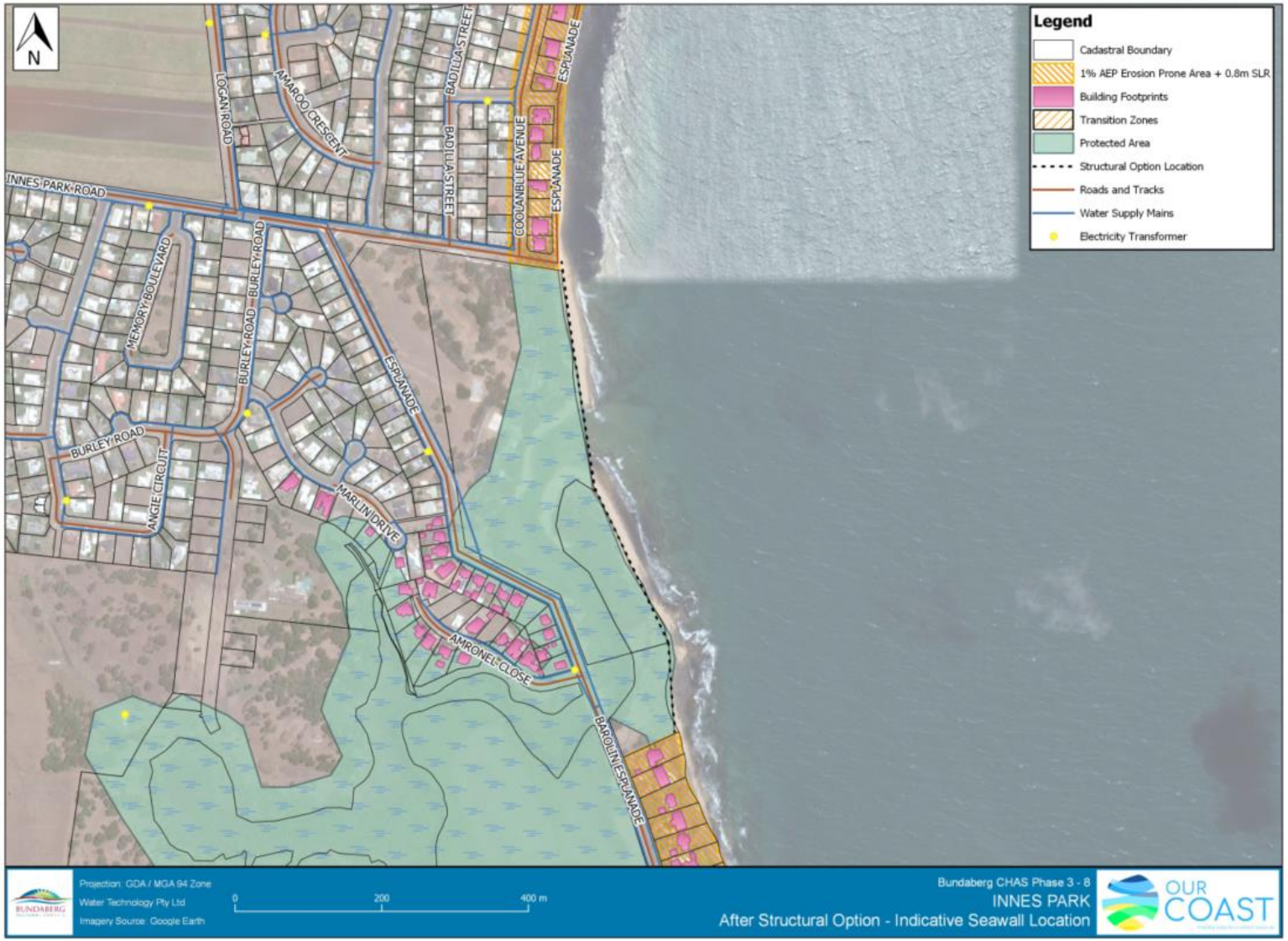


FIGURE 4-14 INNES PARK – SEAWALL/ROCKWALL/BURIED SEAWALL – GENERAL LOCATION AND BENEFITS

4.8.2 Benefits

A seawall or rockwall at Innes Park would be comparatively ineffective against erosion and inundation. This is in part due to the lower reduction in damages compared to elsewhere.

There are design options such as a buried seawall in combination with beach nourishment that allow for beach access and amenity. This option would:

- Prevent further coastal erosion for the lifetime of the asset for the mapped erosion prone area;
- Prevent approximately $89,649 (NPV) of damages to Innes Park after the 0.8 m sea level rise scenario; and,
- Not reduce population at risk to inundation.

TABLE 4-26 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Innes Park – Seawall/Rockwall	$1,383,149	$1,293,500	$89,649

4.8.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $5.4 million, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-27. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-27 PRELIMINARY COST ESTIMATE – INNES PARK SEAWALL

Option	Seawall Length	Initial Cost [13]	Maintenance Cost [14]	Discounted from year	Whole of Life Cost NPV (7%)
Innes Park – Seawall, Rockwall	1km	$5,357,000	$1,607,100	80	$23,890

4.8.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of constructing a seawall at Innes Park, the benefit to cost ratio was found to be 3.09 and offers benefits of approximately $89,649, meaning the savings achieved through reducing damages is more than 3 times the cost of installation.

TABLE 4-28 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$89,649	$28,988	3.09

[13] Initial costs include initial survey, design and approval costs
[14] Includes a maintenance cost that is assumed at 30% replacement cost of the seawall due to extreme storm event every10 years over 50-year lifetime

4.8.5 MCA – Summary

TABLE 4-29 MCA SUMMARY FOR SEAWALL AT INNES PARK AND CORAL COVE

Criteria	Objective	Performance – 0.8 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Comparatively not as effective at reducing damages nor does it reduce the risk to people from inundation.	1.5	32%	0.5
Adaptability	Ability to be adapted based on unexpected climate trends	Seawalls are generally more difficult to adapt, even if they are made of sandbags and there would be a higher cost involved which is proportional to the length of the wall. In this case the option considered is 1km in length, so this option is somewhat adaptable.	80.0	22%	17.6
Beach Impact	Minimise impact on beach access and amenity	Impact of a seawall on access to the beach at Innes Park is high because the beach is 100% an 'urbanised beach' where people access the beach and surf. Therefore, high impact on the beach access and amenity.	0.0	15%	0.0
Env. Impact	Minimise impact to the environment	Innes Park is not noted as an important breeding area, turtles may occasionally nest on the sandy beaches on the extreme northern end of the proposed location. As with other seawalls, impacts need to be minimised to important ecological features, such as the rocky reefs along the foreshore of Innes Park, by locating them as far landward as possible.	78.4	13%	10.2
Tech. Viability	Adaptation options that are technically viable	Established/proven design principles exist for treatment. Will require individual design requirements	81.8	9%	7.4
Approval	Minimise difficulty in obtaining required permits	Several conservation and significant species known to occur. Additional investigations and impact assessments likely.	15.0	5%	0.8
Cost	Cost-effective adaptation options implemented	Overall cost is comparatively low compared to other structural options.	98.4	4%	3.9
Total score					40.3
MCA ranking compared to other options:		**18th**	**(out of 19)**		

4.9 Coonarr – Beach Nourishment with Dune Reconstruction

4.9.1 Description of Option

Indicative location of the beach nourishment and seawall treatments extend 400 m in front of the Esplanade at Coonarr. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal of both physical options. The treatment should extend offshore for a minimum width of 13 m. Note that there is no “holding structure” in place (e.g. groyne or headland, etc.) so the sand placed will disperse over time hence the inclusion of annual maintenance of sand renourishment is factored into the cost estimate.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

Negative impacts of depositing additional sand on the foreshore of Coonarr are minimal, assuming the sand is placed outside of the turtle nesting hatching season and does not impact on tidal waterways south of the nourishment area.

Coonarr beach nourishment would protect the properties and infrastructure of the small settlement and should be considered along with the other adaptation options for this settlement. Typically, Council does not fund projects to protect private property or infrastructure and it will be advised that, collectively, private property owners investigate the feasibility of protecting their assets.

Given the potential intolerable risk at 0.2 m sea level rise, there is a clear priority for immediate implementation of disaster management planning, an education and awareness campaign, land use planning and continued monitoring of erosion at Coonarr. However, the timing of projected impacts means that planning for a range of additional options needs to commence immediately, focusing on beach nourishment, land use and tenure transition and road raising.

The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

FIGURE 4-15 COONARR – UNMITIGATED COASTAL HAZARD – 0.2 M SEA LEVEL RISE (EROSION PRONE AREA)

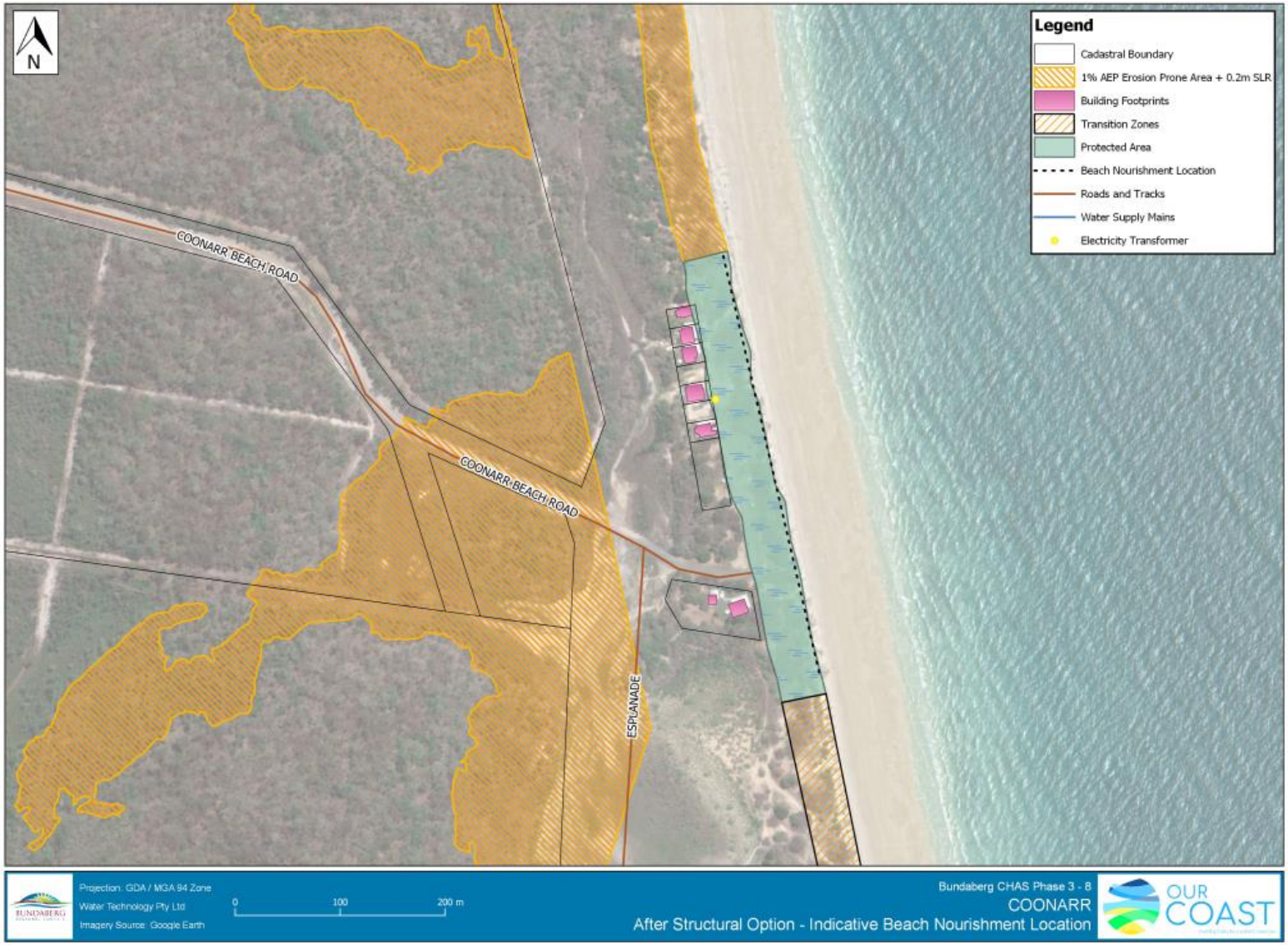


FIGURE 4-16 COONARR – BEACH NOURISHMENT – GENERAL LOCATION AND BENEFITS

4.9.2 Benefits

Beach nourishment on the foreshore in Coonarr would be effective against coastal erosion on properties and infrastructure. If regular re-nourishment is continued, as assumed in the analysis, this option would:

- Prevent coastal erosion to public infrastructure and private properties after the 0.2 m sea level rise scenario;
- Prevent approximately $675,539 (NPV) of damages in Coonarr after the 0.2 m sea level rise scenario; and,
- Create a natural solution that does not impact on beach amenity.

TABLE 4-30 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Coonarr - Beach Nourishment / Dune Reconstruction	$693,254	$17,715	$675,539

4.9.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $449,960, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-31. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-31 PRELIMINARY COST ESTIMATE – COONARR BEACH NOURISHMENT

Town	Length/ Dimensions	Implementation Cost[15] (inc. 40% contingency)	Initial Cost m^2 / m	Annual Maintenance[16]	Discounted from year	NPV
Coonarr	length: 400 m extent offshore: 13 m area: 5200 m^2	$449,960	$1,125	$17, 160	20	$177,477

4.9.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of beach nourishment at Coonarr, the benefit to cost ratio was found to be 3.81 and offers benefits of approximately $675,539, meaning the savings achieved through reducing damages is almost 4 times the cost of installation.

TABLE 4-32 BCR CALCULATION

Option Benefit Relative to Current Condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$675,539	$177,477	3.81

[15] Implementation costs include sand sourcing study, initial survey, design and approval costs
[16] Annual maintenance to undertake a sand re-nourishment campaign is 5% each year along the at-risk foreshore (inc. 10% contingency)

4.9.5 MCA – Summary

TABLE 4-33 MCA SUMMARY FOR BEACH NOURISHMENT AT COONARR

Criteria	Objective	Performance – 0.2 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Effective adaptation option, albeit to only a small community and minor infrastructure. It is the protection offered that scores this option lower comparatively to other locations.	11.5	32%	3.7
Adaptability	Ability to be adapted based on unexpected climate trends	Beach nourishment is highly adaptable, as is a temporary mitigation that requires ongoing implementation.	96.0	22%	21.1
Beach Impact	Minimise impact on beach access and amenity	Beach nourishment has a positive impact on long-term amenity and minimal or very temporary impacts to access.	100.0	15%	15.0
Env. Impact	Minimise impact to the environment	Very minimal. There are some shallow reefs offshore at Coonarr, and seagrass further offshore. It is likely that modelling is required to ensure that sand is not displaced over these habitats.	100.0	13%	13.0
Tech. Viability	Adaptation options that are technically viable	Beach nourishment is a widely used solution to mitigate coastal erosion, with minimal technical concerns.	72.7	9%	6.5
Approval	Minimise difficulty in obtaining required permits	Several conservation and significant species known to occur. Additional investigations and impact assessments likely.	15.0	5%	0.8
Cost	Cost-effective adaptation options implemented	Beach nourishment requires ongoing maintenance; however, the overall cost is comparatively low compared to other structural options.	90.2	4%	3.6
Total score					63.7
MCA ranking compared to other options:		**4th**	**(out of 19)**		

4.10 Coonarr - Seawall, Rockwall or Buried Seawall

4.10.1 Description of Option

The location of the seawall treatment extends 340 m in front of the Esplanade at Coonarr. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal of both physical options. It is noted that the area protected is a very small community with 5 properties and minor infrastructure. Typically, Council does not fund projects to protect private property or infrastructure and it will be advised that, collectively, private property owners investigate the feasibility of protecting their assets.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (Working Group and Project Control Group).

A seawall at Coonarr would be similarly as effective as beach nourishment in protecting property and infrastructure that front the shoreline, however, the screening process identified some minor adverse impacts such as loss of beach in front of the seawall and the creation of a hard barrier to beach access.

Given the potential intolerable risk at 0.2 m sea level rise, there is a clear priority for immediate implementation of disaster management planning, an education and awareness campaign, land use planning and continued monitoring of erosion at Coonarr. However, the timing of projected impacts means that planning for a range of additional options needs to commence immediately, focusing on beach nourishment, land use and tenure transition and road raising.

The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

FIGURE 4-17 COONARR – UNMITIGATED COASTAL HAZARD – 0.2 M SEA LEVEL RISE (EROSION PRONE AREA)

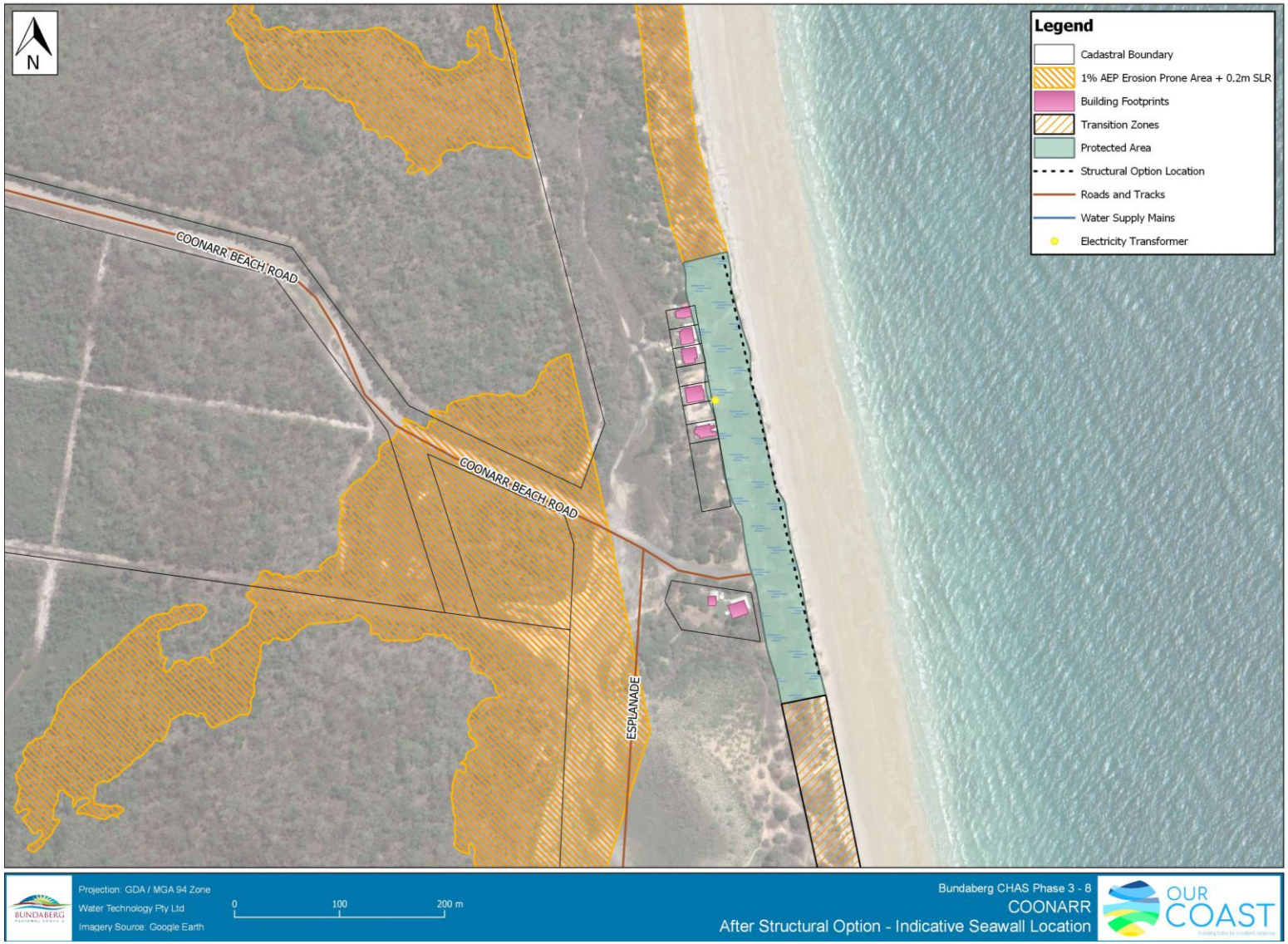


FIGURE 4-18 COONARR – SEAWALL/ROCKWALL/BURIED SEAWALL – GENERAL LOCATION AND BENEFITS

4.10.2 Benefits

Construction of a seawall or rockwall on the foreshore in Coonarr would be comparatively ineffective against coastal erosion on properties and infrastructure. This option would:

- Prevent coastal erosion to public infrastructure and properties after the 0.2 m sea level rise scenario;
- Prevent approximately $675,539 (NPV) of damages in Coonarr after the 0.2 m sea level rise scenario;

and,
- Not prevent storm tide inundation or prevent isolation risk from inundation behind the dunes.

TABLE 4-34 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Coonarr – Seawall/Rockwall	$693,254	$17,715	$675,539

4.10.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $1.8 million, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-35. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-35 PRELIMINARY COST ESTIMATE- COONARR SEAWALL

Options	Seawall Length	Initial Cost [17]	Maintenance Cost [18]	Discounted from year	NPV
Coonarr – Seawall, Rockwall or Buried Seawall	340m	$1,837,200	$551,160	20	$617,036

4.10.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of a constructed seawall at Coonarr, the benefit to cost ratio was found to be 1.09 and offers benefits of approximately $675,539, meaning the savings achieved through reducing damages is almost equal to the cost of installation.

TABLE 4-36 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$675,539	$617,036	1.09

[17] Initial costs include initial survey, design and approval costs
[18] Annual maintenance to undertake a sand re-nourishment campaign is 5% each year along the at-risk foreshore (inc. 10% contingency)

4.10.5 MCA – Summary

TABLE 4-37 MCA SUMMARY FOR SEAWALL AT COONARR

Criteria	Objective	Performance – 0.2 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Effective adaptation option, albeit to only a small community and minor infrastructure. It is the scale of protection offered compared to other options that scores the option comparatively lower.	11.5	32%	3.7
Adaptability	Ability to be adapted based on unexpected climate trends	Seawalls are generally more difficult to adapt. In this case the option considered is just 340m in length, so this option is considered adaptable.	93.2	22%	20.5
Beach Impact	Minimise impact on beach access and amenity	Impact of the seawall on beach access and amenity is proportionally low because there is a high natural to urbanised beach ratio, so there is less impact on the beach in populated areas.	60.5	15%	9.1
Env. Impact	Minimise impact to the environment	While turtles nest on this beach, nests are fewer in number in Coonarr than at Moore Park Beach and Bargara.	97.1	13%	12.6
Tech. Viability	Adaptation options that are technically viable	Established/proven design principles exist for treatment. Will require individual design requirements	72.7	9%	6.5
Approval	Minimise difficulty in obtaining required permits	Several conservation and significant species known to occur. Additional investigations and impact assessments likely.	15.0	5%	0.8
Cost	Cost-effective adaptation options implemented	Overall cost is comparatively low compared to other structural options.	71.6	4%	2.9
Final Score					56.0
MCA ranking compared to other options:		**11th**	**(out of 19)**		

4.11 Coonarr – Land use and tenure transition

4.11.1 Description of Option

Potential transition of the tenure and land use of the small group of residential dwellings on Coonarr beach front.

There are nine lots in the area at risk from coastal erosion, these experience potential isolation risk after 0.2 m sea level rise. One lot is zoned open space, two vacant lots and six dwellings. Risk can be mitigated by transitioning the use of the residential property to ensure no intensification of uses as low asset value supports the ability to transform.

Lots that contain residential dwellings present a challenge as it is reasonable to assume that property owners may expect a pre-hazard market value for a beach front property. Pre-hazard values have been used in this socio-economic appraisal, however with incremental sea level rise, this market value is likely to be adversely impacted as a result of the identified coastal hazards associated with permanent inundation causing isolation and coastal erosion of the beach front properties.

Given the potential intolerable risk at 0.2 m sea level rise, there is a clear priority for immediate implementation of disaster management planning, an education and awareness campaign, land use planning and continued monitoring of erosion at Coonarr. However, the timing of projected impacts means that planning for a range of additional options needs to commence immediately, focusing on beach nourishment, land use and tenure transition and road raising.

The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

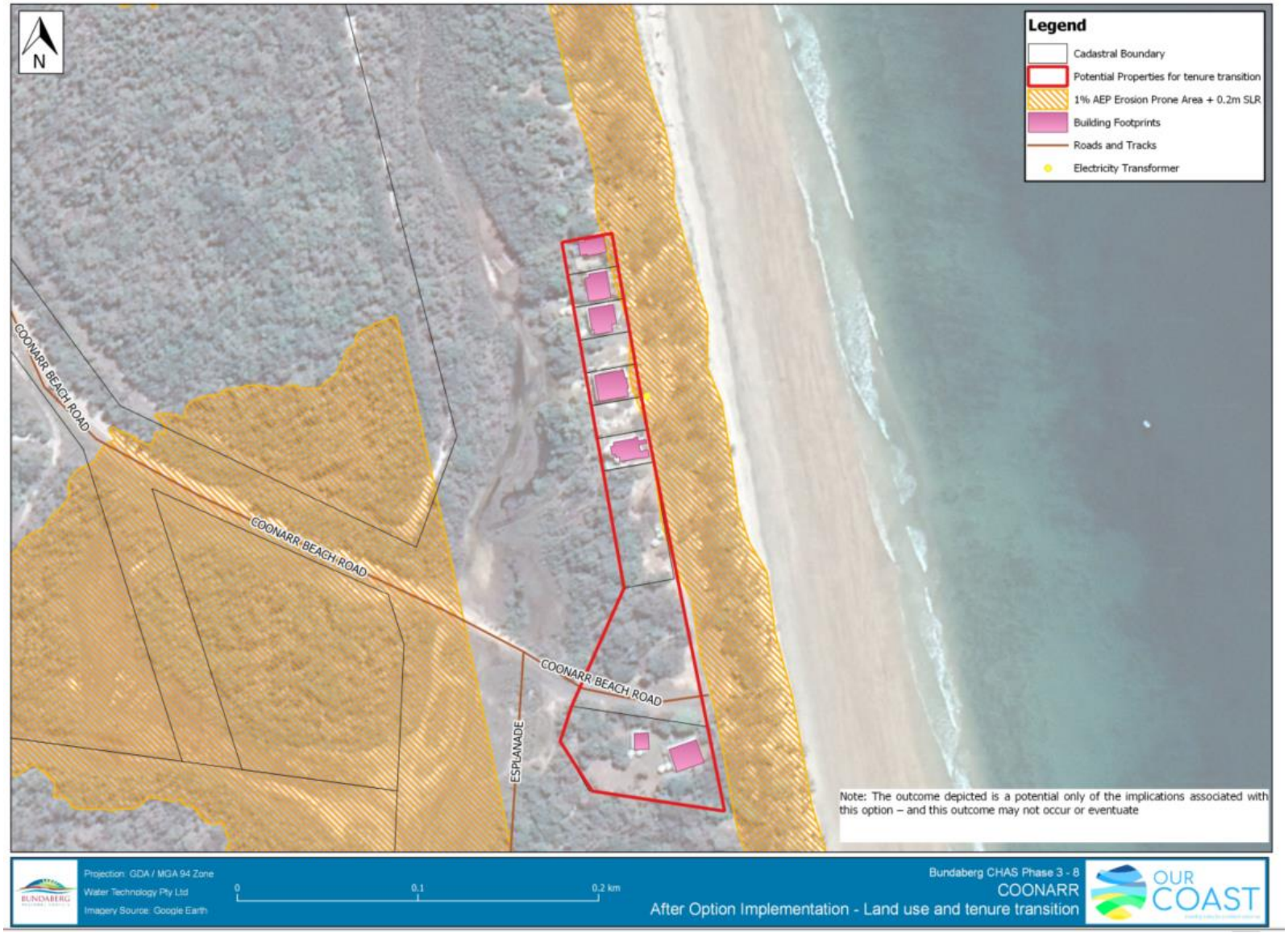


FIGURE 4-19 COONARR – LAND USE AND TENURE TRANSITION

4.11.2 Benefits

Land use and tenure transition of the residential properties would be fully effective by removing people and property from the risks of coastal erosion including damages and potential isolation issues. The lots have the potential to be turned into open space and an enjoyable recreational area for local residents. The social impact of removing homes individually from small communities such as this could be potentially significant on social cohesion and sense of place.

This option would:

- Remove properties from the risks associated from permanent inundation and coastal erosion in the 0.2 m sea level rise scenario and all future sea level rise scenarios; and,
- Prevent approximately $693,254 (NPV) of damages in Coonarr after the 0.2 m sea level rise scenario.

TABLE 4-38 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Coonarr – Land Use and tenure transition	$693,254	$0	$693,254

4.11.3 Cost Estimate

The cost estimates indicate that the value of land and properties in Coonarr is approximately $1,553,137, this assumes an average lot size of 1,000sqm and at a value of $50/m^2. The cost estimate is detailed in Table 4-31. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-39 PRELIMINARY COST ESTIMATE – COONARR LAND

Settlement Option	Lots	Property Value	Land Value[19]	Initial Cost	NPV
Coonarr - Land Use and tenure transition	5	$1,050,164 (DS)	$50/m^2	$6,010,152	$1,553,137
	1	$459,333 (SS)			

4.11.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of a transitioning the use of properties at Coonarr, the benefit to cost ratio was found to be 0.45. That is the benefits achieved are almost half the current market value of the properties.

TABLE 4-40 BCR CALCULATION

Option Benefit Relative to Current Condition	NPV of Total Whole of Life Cost	Benefit Cost Ratio (BCR)
$693,254	$1,553,137	0.45

[19] It was then assumed an average lot area of 1,000 m^2.

4.11.5 MCA – Summary

TABLE 4-41 MCA SUMMARY FOR LAND USE AND TENURE TRANSITION AT COONARR

Criteria	Objective	Performance – 0.2 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Land use and tenure transition is completely effective at removing the risk to people at risk from hazards. The economic benefits are not comparatively as high as other options, which brings the score down slightly.	11.6	32%	3.7
Adaptability	Ability to be adapted based on unexpected climate trends	Land use and tenure transition is adaptable to different climate trends. The decision is reversable, i.e. can be rented back if trends slow down.	96.6	22%	21.3
Beach Impact	Minimise impact on beach access and amenity	Land use and tenure transition, retreat or do-nothing options imply migration of the beach backwards with significant loss of beach amenity (beach would erode in most instances). These cases were given the same impact coefficient of their equivalent seawall case. There is an exception in Coonarr, because if all the properties are bought back then there is no longer an urbanised part of the beach, so the value of beach accessibility is lower.	60.0	15%	9.0
Env. Impact	Minimise impact to the environment	Estuarine and wetland ecosystems along Coonarr Creek to the south of the creek mouth will increasingly inundate. Likely that estuarine wetlands will migrate landward, putting at risk endangered ecosystems.	98.7	13%	12.8
Tech. Viability	Adaptation options that are technically viable	Will require acquisition of land, which is considered to have a high impact on project viability.	72.7	9%	6.5
Approval	Minimise difficulty in obtaining required permits	Land use and tenure transition to less intensive uses will likely require no approvals, agreement from homeowners.	100.0	5%	5.0
Cost	Cost-effective adaptation options implemented	An expensive option compared to others in this location.	13.9	4%	0.6
Total score					58.9
MCA ranking compared to other options:		**6th**	**(out of 19)**		

4.12 Woodgate Beach –Beach Nourishment with Dune Reconstruction

4.12.1 Description of Option

The proposed adaptation option of beach nourishment extends from the boat ramp to south of Twelfth Ave (approximately 5 km) to protect the Esplanade Road. The treatment should extend offshore for a minimum width of 34 m. It is noted that there is no “holding structure” in place (e.g. groyne or headland, etc.) so the sand placed will disperse over time hence the inclusion of annual maintenance of sand renourishment is factored into the cost estimate.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and through detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

Negative impacts of depositing additional sand on the foreshore at Woodgate Beach are considered to be minimal, assuming the sand is installed outside of the turtle nesting/hatching season. In addition, implementation must ensure that tidal flushing at Theodolite Creek is not impacted by drifting sand.

Given the potential isolation risk at 0.8 m sea level rise, there is a need for careful strategic planning of whether to continue to protect properties in the Woodgate Beach settlement. Council have started the process of implementing the actions from the Woodgate Beach Shoreline Erosion Management Plan (Water Technology, 2018) which includes a buried seawall and beach nourishment in the vicinity of the boat ramp to cater for localised erosion issues over the next 10 to 20 years. The location of the options considered in this CHAS extend further south along the Woodgate Beach shoreline.

The timing of future impacts means that planning for a range of additional options needs to commence after the lifespan of the SEMP, focusing on beach nourishment, land use and tenure transition and road raising.

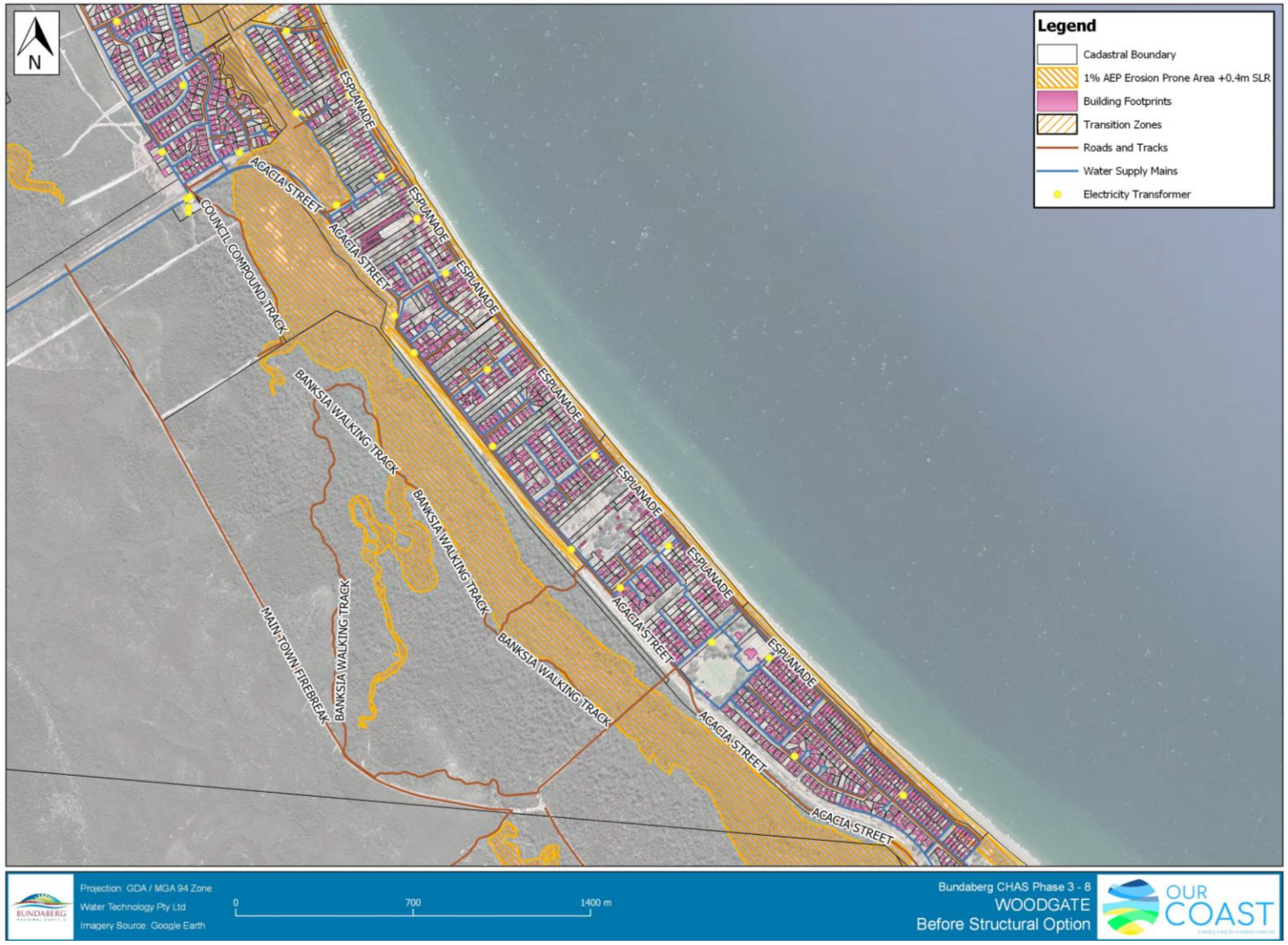


FIGURE 4-20 WOODGATE BEACH - UNMITIGATED COASTAL HAZARD – 0.4 M SEA LEVEL RISE (EROSION PRONE AREA)

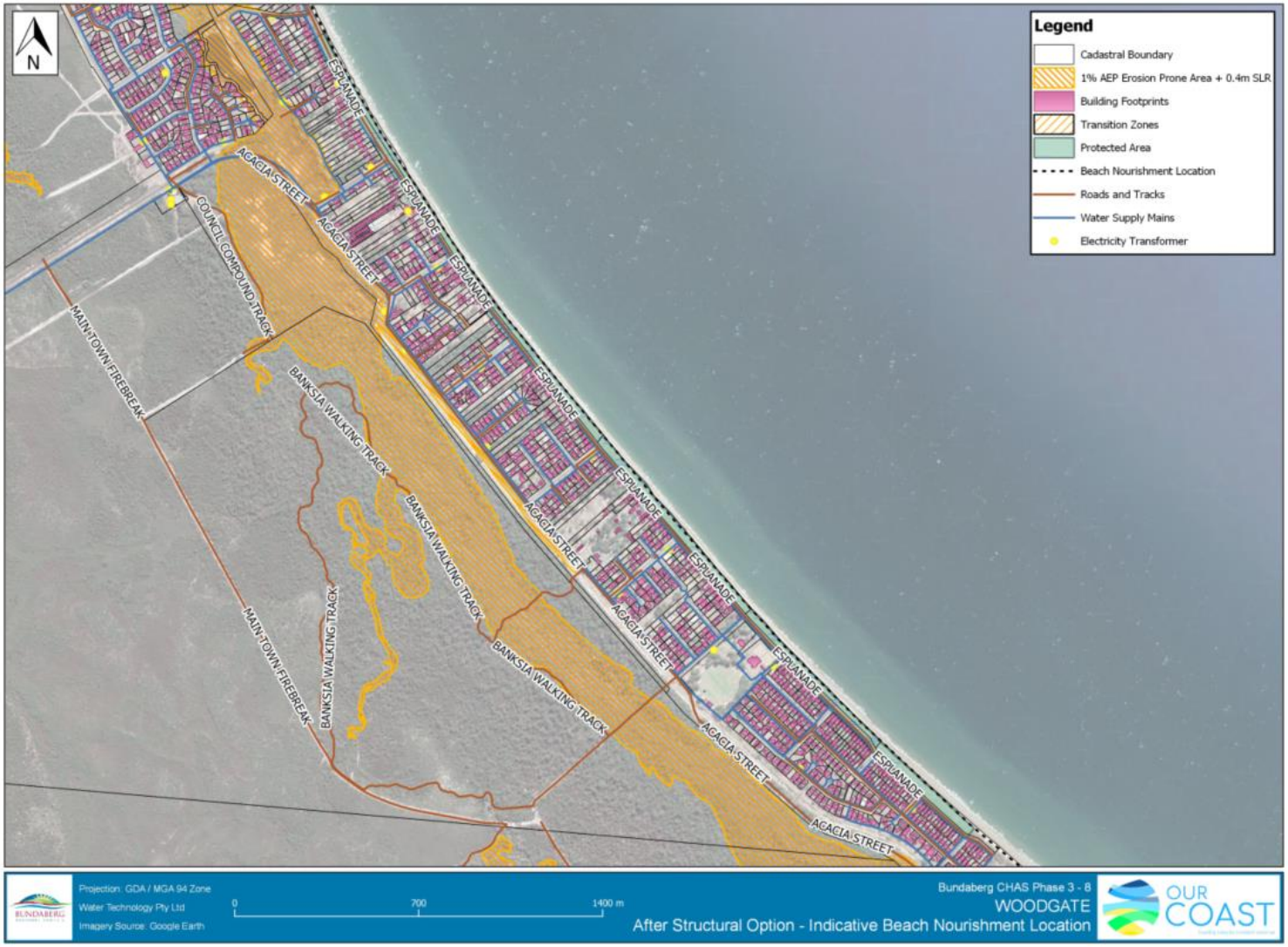


FIGURE 4-21 WOODGATE BEACH – BEACH NOURISHMENT - GENERAL LOCATION AND BENEFITS

4.12.2 Benefits

Beach nourishment on the foreshore at Woodgate Beach is likely to be effective against coastal erosion on properties and infrastructure. If regular re-nourishment is continued, as assumed in the analysis, this option would:

- Prevent coastal erosion to public infrastructure and properties after the 0.4 m sea level rise scenario;.
- Prevent approximately $6 million (NPV) of damages in the Woodgate Beach settlement after the 0.4 m sea level rise scenario; and,
- Create a natural solution that does not impact on beach amenity.

TABLE 4-42 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Woodgate Beach - Beach Nourishment / Dune Reconstruction	$19,507,343	$13,472,541	$6,034,801

4.12.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $9million, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-43. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-43 PRELIMINARY COST ESTIMATE – WOODGATE BEACH NOURISHMENT

Settlement /Option	Length/ Dimensions	Implementation Cost[20] (inc. 40% contingency)	Initial Cost linear cubic metre	Annual Maintenance[21]	Discounted from year	NPV
Woodgate Beach – Beach Nourishment / Dune Reconstruction	length: 5 km extent offshore: 34 m area: 155,000m^2	$9,240,000	$1,848	$511,500	40	$1,072,437

4.12.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of beach nourishment at Woodgate Beach, the benefit to cost ratio was found to be 5.63 and offers benefits of approximately $6million meaning the savings achieved through reducing damages is almost 6 times the cost of installation.

[20] Implementation costs include sand sourcing study, initial survey, design and approval costs
[21] Annual maintenance to undertake a sand re-nourishment campaign is 5% each year along the at-risk foreshore (inc. 10% contingency)

TABLE 4-44 BCR CALCULATION

Option Benefit Relative to current condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$6,034,801	$1,072,437	5.63

4.12.5 MCA – Summary

TABLE 4-45 MCA SUMMARY FOR BEACH NOURISHMENT AT WOODGATE BEACH

Criteria	Objective	Performance – 0.4 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Estimated to provide $6million (NPV) of damage reduction and has a reduction of population at risk of 1.2. Highly effective in reducing the coastal erosion to the Woodgate Beach settlement.	100.0	32%	32.0
Adaptability	Ability to be adapted based on unexpected climate trends	Very adaptable, as beach nourishment is a temporary mitigation that requires ongoing implementation.	50.0	22%	11.0
Beach Impact	Minimise impact on beach access and amenity	Positive impact on long-term amenity and minimal or very temporary impacts to access.	100.0	15%	15.0
Env. Impact	Minimise impact to the environment	Temporary impacts to water quality by increasing sediment in the water column and impact tidal flushing of the Theodolite Creek to north of the nourishment area.	54.9	13%	7.1
Tech. Viability	Adaptation options that technically are viable	Widely used solution to mitigate coastal erosion, with minimal technical concerns.	72.7	9%	6.5
Approval	Minimise difficulty in obtaining required permits	Several conservation significant species known to occur. Additional investigations and impact assessments likely.	0.0	5%	0.0
Cost	Cost-effective adaptation options implemented	Requires ongoing maintenance however, and due to the scale of the option the overall cost is comparatively high compared to other structural options.	40.6	4%	1.6
					73.3
MCA ranking compared to other options:		**2nd**	**(out of 19)**		

4.13 Woodgate Beach – Seawall, Rockwall or Buried Seawall

4.13.1 Description of Option

The indicative location of the seawall adaptation option on Woodgate Beach extends from the boat ramp to south of Twelfth Ave (approximately 5 km) to protect the Esplanade Road. Planning of this option ought to commence at 0.2 m sea level rise in preparation for 0.4 m coastal erosion hazard. This extent has been used in the estimation of reduction in damages as part of the socio-economic appraisal.

As identified in Phase 5, there is potential isolation risk to the Woodgate Beach community after a 0.8 m sea level rise scenario, therefore there is a need for careful strategic planning of whether to continue to protect properties in the Woodgate Beach settlement. Council have started the process of implementing the actions from the Woodgate Shoreline Erosion Management Plan (SEMP) which includes a buried seawall and beach nourishment in the vicinity of the boat ramp to cater for localised erosion issues over the next 10 to 20 years.

The timing of future impacts means that planning for a range of additional options needs to commence after the lifespan of the SEMP, focusing on beach nourishment, land d road raising.

Through the optioneering process shortlisted in Phase 6, this option was progressed into the MCA and CBA as a viable adaptation option. This was further developed with reference to the compendium of options, and though detailed discussion and consultation with the community (through the Community Reference Group) and with Council (working group and Project Control Group).

The screening process identified some minor adverse impacts such as loss of beach in front of the seawall and the creation of a hard barrier to beach access. Despite these potential downsides, a seawall would be effective against erosion and is often constructed as buried seawalls with nourishment to provide amenity and satisfy state approvals.

A combination of seawall with beach nourishment should be considered as part of any future planning process.

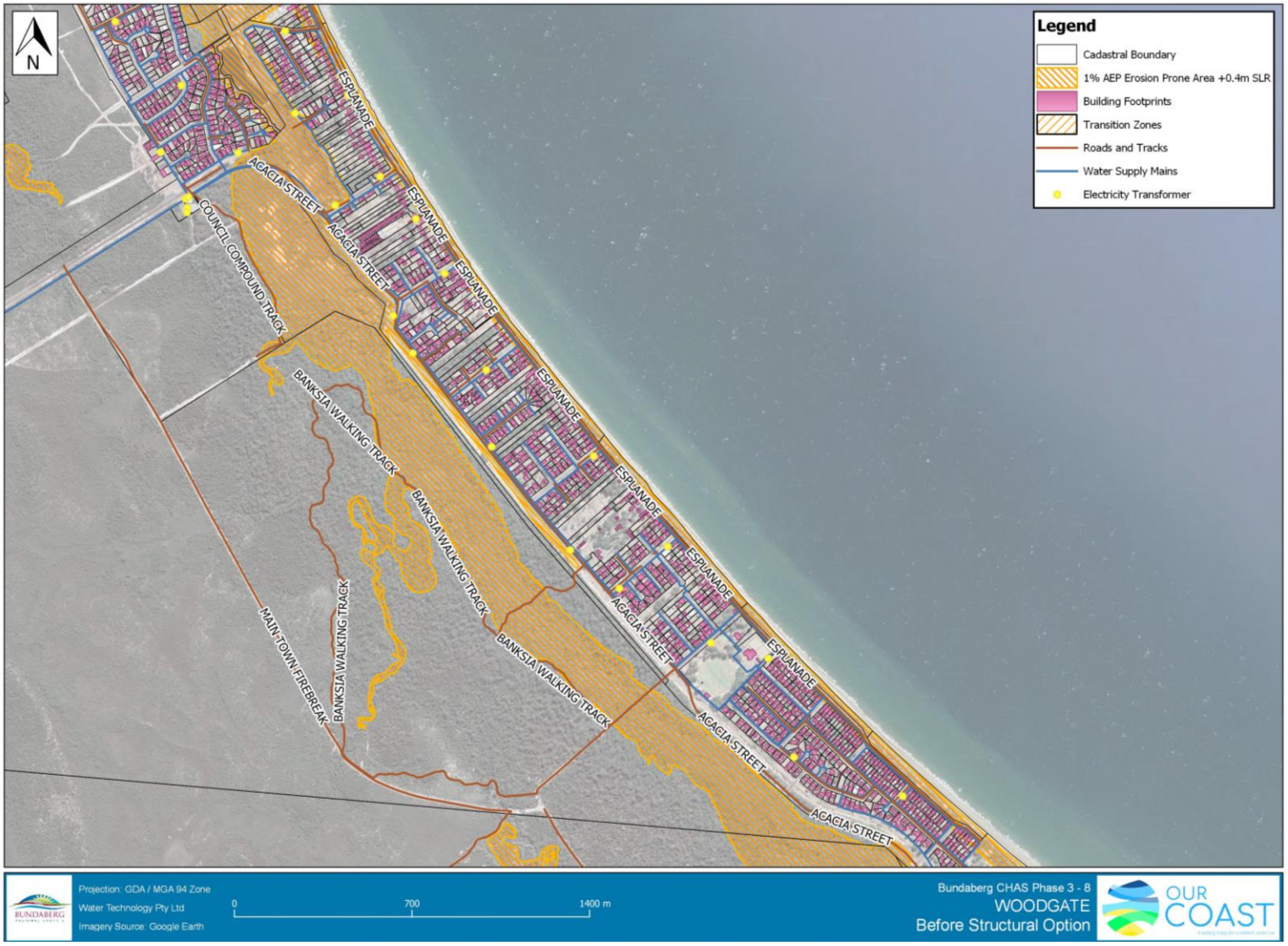


FIGURE 4-22 WOODGATE BEACH - UNMITIGATED COASTAL HAZARD – 0.4 M SEA LEVEL RISE (EROSION PRONE AREA)

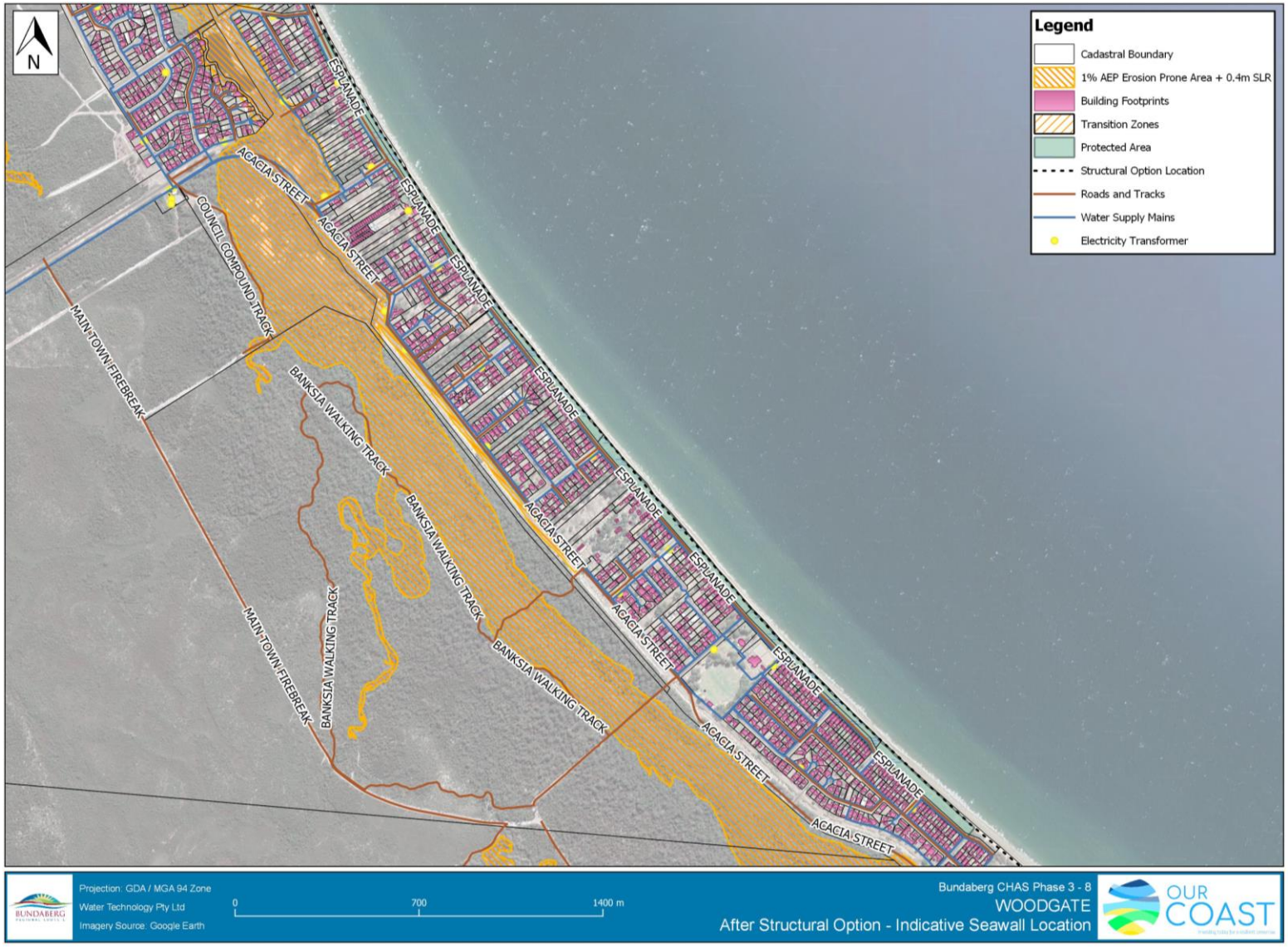


FIGURE 4-23 WOODGATE BEACH – SEAWALL/ROCKWALL/BURIED SEAWALL – GENERAL LOCATION AND BENEFITS

4.13.2 Benefits

A constructed seawall or rockwall in front of the Esplanade at Woodgate Beach is likely to be very effective against coastal erosion on properties and infrastructure. This option would:

- Prevent coastal erosion to public infrastructure and properties after the 0.4 m sea level rise scenario; and,
- Prevent approximately $6 million (NPV) of damages in the Woodgate Beach settlement after the 0.4 m sea level rise scenario.

TABLE 4-46 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit relative to current condition (NPV)
Woodgate Beach – Seawall/Rockwall or Buried Seawall	$19,507,343	$13,472,541	$6,034,801

4.13.3 Cost Estimate

The cost estimates indicate that the initial construction of this option would cost approximately $26million, this includes survey, designs and approval. The preliminary cost estimate is detailed in Table 4-47. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-47 PRELIMINARY COST ESTIMATE - WOODGATE BEACH SEAWALL

Options	Seawall Length	Initial Cost [2]	Maintenance Cost	Discounted from year	NPV
Woodgate Beach	5km	$26,505,000	$7,951,500	40	$2,282,388

4.13.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of a constructed seawall in Woodgate Beach, the benefit to cost ratio was found to be 2.64 and offers benefits of approximately $6 million (NPV), meaning the savings achieved through reducing damages is over two and half times the cost of installation.

TABLE 4-48 BCR CALCULATION

Option Benefit Relative to Current Condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$6,034,801	$2,282,388	2.64

[22] Initial costs include initial survey, design and approval costs

4.13.5 MCA – Summary

TABLE 4-49 MCA SUMMARY FOR SEAWALL AT WOODGATE BEACH

Criteria	Objective	Performance – 0.4 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Estimated to provide $6 million (NPV) of damage reduction and has a reduction of population at risk of 1.2. Highly effective in reducing the coastal erosion to the Woodgate Beach settlement.	100.0	32%	32.0
Adaptability	Ability to be adapted based on unexpected climate trends	Seawalls are generally more difficult to adapt, proportional to the length of the wall. In this case the option considered is 5km in length, so this option is not readily adaptable.	0.0	22%	0.0
Beach Impact	Minimise impact on beach access and amenity	Negative impact on beach access and amenity due to highly urbanised beach where people regularly access the beach and surf. Therefore, option likely to have a high impact on the beach access and amenity.	23.3	15%	3.5
Env. Impact	Minimise impact to the environment	While turtles nest on this beach, nests are in lower numbers than elsewhere, beach and dune would gradually erode up to the seawall, and turtle nesting habitat would be lost. Also, potential impact on seagrass offshore of nourishment area.	8.0	13%	1.0
Tech. Viability	Adaptation options that are technically viable	Widely used solution to mitigate coastal erosion, with minimal technical concerns.	72.7	9%	6.5
Approval	Minimise difficulty in obtaining required permits	High ecological value waters (wetland) present, Permit required for works in Great Sandy Marine Park. Potential offset liability. Several conservation significant species known to occur. Many permits, additional investigations and impact assessments likely.	0.0	5%	0.0
Cost	Cost-effective adaptation options implemented	Overall cost is comparatively high compared to other structural options.	0.0	4%	0.0
Total score					43.1
MCA ranking compared to other options:		**17th**	**(out of 19)**		

4.14 Woodgate Beach – Land use and tenure transition

4.14.1 Description of Option

Potential transition of the tenure and land use of the small group of residential dwellings in First Avenue that are potentially impacted by isolation in the 0.4 m sea level rise scenario.

This location was chosen due to the current access route via the Esplanade and Second Ave and must be considered in combination with the adaptation options to build a causeway at Paperbark Court. There are 14 lots with residential dwellings in the area chosen for investigation. Risks can be mitigated in the short term by transitioning the use of other vacant lots to ensure no intensification of uses as low asset value supports the ability to transform.

As discussed, there is a need for careful strategic planning of whether to continue to protect properties in the Woodgate Beach settlement due to the potential isolation risk from the main route, Acacia Street, under a 0.8 m sea level rise scenario. The timing of future impacts means that planning for a range of additional options needs to commence after approximately 0.4 m sea level rise focusing on land use and tenure transition and road raising.

The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

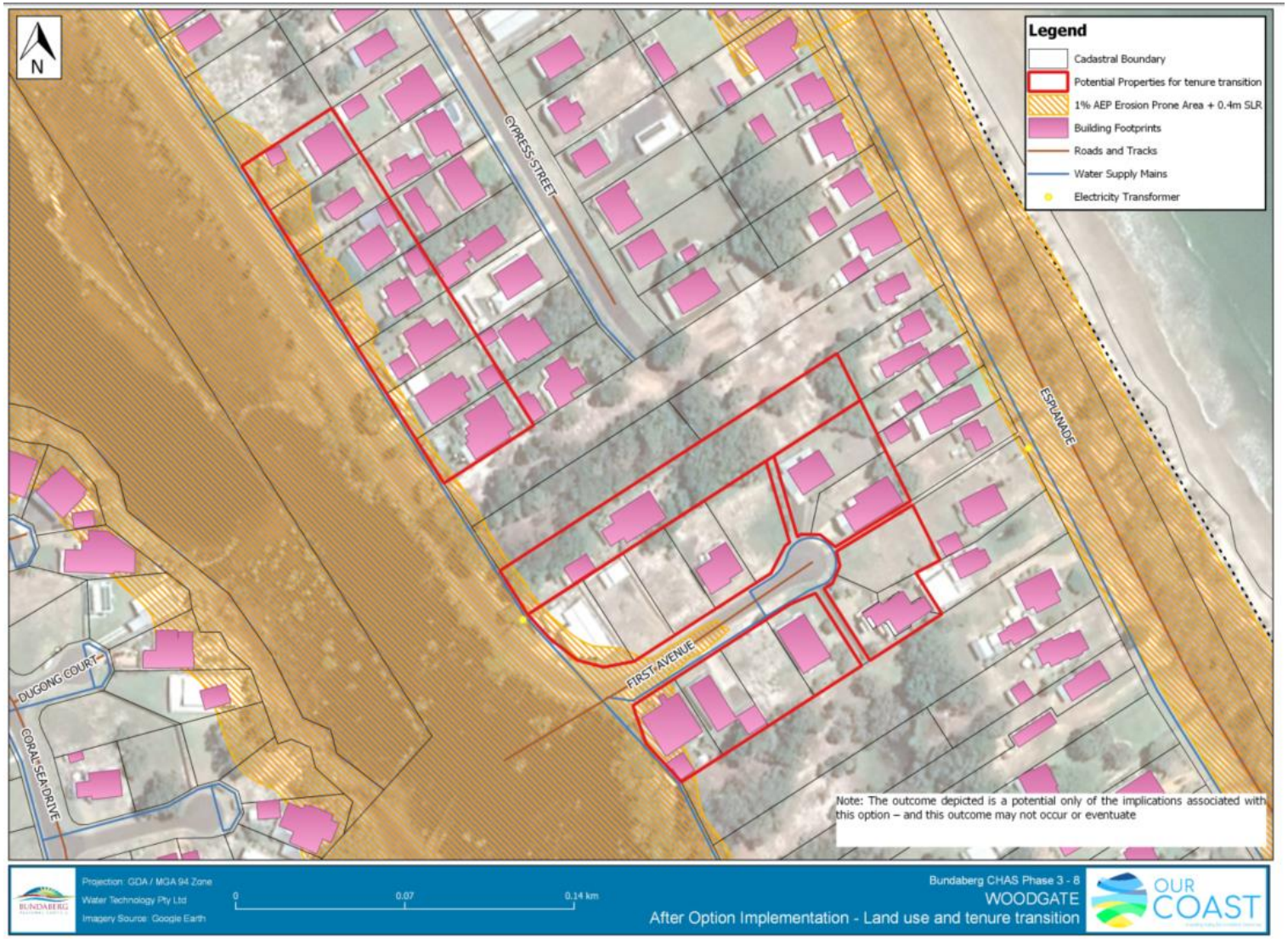


FIGURE 4-24 FIRST AVENUE, WOODGATE BEACH – LAND USE AND TENURE TRANSITION

4.14.2 Benefits

Land use and tenure transition of properties and land in First Avenue, Woodgate Beach is likely to be effective in removing the future isolation risks to people and property after a 0.4 m sea level rise scenario. However, this option is only effective for the specific properties investigated rather than the settlement as a whole. This option would:

- Remove 14 properties from the risks associated from permanent inundation and coastal erosion in time for the 0.8 m sea level rise scenario; and,
- Prevent approximately $217,442 (NPV) of damages in Woodgate Beach after the 0.4 m sea level rise scenario.

TABLE 4-50 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Settlement Option	Total Damages (NPV) without option in place	Total Damages (NPV) with option in place	Option Benefit Relative to Current Condition (NPV)
Woodgate Beach – Land use and tenure transition of properties in First Avenue	$19,507,343	$19,289,901	$217,442

4.14.3 Cost Estimate

Land use and tenure transition of properties in this precinct is based on current market values of approximately $13 million. This preliminary cost estimate is detailed in Table 4-51. Net present value has been applied to this option to enable direct comparison to cost of other options constructed at different sea level scenarios.

TABLE 4-51 PRELIMINARY COST ESTIMATE – WOODGATE BEACH LAND USE AND TENURE TRANSITION

Settlement Option	Lots	Property Value	Land Value[23]	Initial Cost	NPV
Woodgate Land use	10	$1,050,164 (DS)	$350/m^2	$13,693,985	$914,490
	4	$459,333 (SS)			

4.14.4 Benefit to Cost Ratio – BCR

When assessing the financial cost and benefit of land use and tenure transition in First Avenue, Woodgate Beach, the benefit to cost ratio was found to be 0.24 that is the cost of implementing this measure is approximately four times the benefits that could be achieved through reducing damages.

TABLE 4-52 BCR CALCULATION

Option Benefit Relative to Current Condition	NPV of Total Whole of Life Cost	Benefit / Cost Ratio (BCR)
$217,442	$914,490	0.24

[23] It was then assumed an average lot area of 1,000 m^2.

4.14.5 MCA – Summary

TABLE 4-53 MCA SUMMARY FOR LAND USE AND TENURE TRANSITION AT WOODGATE BEACH

Criteria	Objective	Performance – 0.4 m sea level rise	Score	Weighting	Weighted score
Effectiveness	Reduce erosion and storm risks to property and people	Land use and tenure transition is completely effective at removing the risk to people at risk from hazards. The economic benefits are not comparatively as high as other options.	6.4	32%	2.1
Adaptability	Ability to be adapted based on unexpected climate trends	Land use and tenure transition is adaptable to different climate trends. The decision is reversable, i.e. can be rented back if trends slow down.	50.0	22%	11.0
Beach Impact	Minimise impact on beach access and amenity	This option is not located on the beach and therefore has no impact on beach amenity or access.	100.0	15%	15.0
Env. Impact	Minimise impact to the environment	Estuarine and wetland ecosystems in vicinity will increasingly inundate. Likely that estuarine wetlands will migrate landward, putting at risk endangered ecosystems.	31.5	13%	4.1
Tech. Viability	Adaptation options that are technically viable	Will require acquisition of land which is considered to have a high impact on project viability.	72.7	9%	6.5
Approval	Minimise difficulty in obtaining required permits	Land use and tenure transition to less intensive uses will likely require no approvals, agreement from homeowners.	100.0	5%	5.0
Cost	Cost-effective adaptation options implemented	Relatively lower cost than other options but does not benefit the whole settlement compared to others in this location.	59.9	4%	2.0
Final Score					46.1
MCA ranking compared to other options:		**16th**	**(out of 19)**		

4.15 Final MCA Ranking

It is recognised that the 19 adaptation options (including the Do-nothing options) are wide ranging in terms of their cost and in reductions to damages they provide, therefore direct comparisons of the performance of each option are complex. To address these challenges, the comparison approach used draws upon the seven weighted evaluation criteria to measure each option's performance. The raw scores presented in the above analysis are presented in detail in Appendix C, the final scores of the MCA are presented in Table 4-54. The 'Do nothing' options for each settlement are presented in this table to visualise the performance option against the baseline for that settlement.

TABLE 4-54 FINAL RANKING OF ADAPTATION OPTIONS BASED ON MCA SCORE

MCA ranking	Adaptation option	Sea Level Rise trigger	MCA score
1	**Moore Park Beach** Beach Nourishment with Dune (re)construction	0.4 m SLR	**77.3**
2	**Woodgate Beach** Beach Nourishment with Dune (re)construction	0.4 m SLR	**73.8**
3	**Moore Park Beach** Seawall/Rockwall/Buried Seawall	0.4 m SLR	**67.4**
4	**Coonarr** Beach Nourishment with Dune (re)construction	0.2 m SLR	**63.8**
5	**Burnett Heads** Storm Surge Barrier and Dyke	0.8 m SLR	**60.6**
6	**Coonarr** Land use and tenure transition	0.2 m SLR	**59.6**
7	**Burnett Heads** Do nothing	0.8 m SLR	**58.8**
8	**Innes Park and Coral Cove** Beach Nourishment with Dune (re)construction	0.8 m SLR	**58.8**
9	**Bargara** Beach Nourishment with Dune (re)construction	0.8 m SLR	**58.4**
10	**Moore Park Beach** Do nothing	0.4 m SLR	**56.9**
11	**Coonarr** Seawalls /Rockwall / Buried Seawall	0.2 mSLR	**56.3**
12	**Woodgate Beach** Do nothing	0.8 m SLR	**54.9**
13	**Coonarr** Do nothing	0.2 m SLR	**52.8**
14	**Innes Park and Coral Cove** Do nothing	0.8 m SLR	**50.8**
15	**Bargara** Do nothing	0.8 m SLR	**49.8**

16	**Woodgate Beach** Land use and tenure transition	0.4 m SLR	**46.1**
17	**Woodgate Beach** Seawalls/Rockwall/Buried Seawall	0.4 m SLR	**43.1**
18	**Innes Park and Coral Cove** Seawalls/Rockwall/Buried Seawall	0.8 m SLR	**40.3**
19	**Bargara, Kellys beach** Seawall/Rockwall/Buried Seawall	0.8 m SLR	**37.7**

4.16 Cost and Benefit-Cost Ratios

Preliminary costs for each adaptation option presented in the socio-economic appraisal were estimated based on the methodology and rates presented in Appendix B. These costs include construction and on-going maintenance costs. Total whole of life costs at the assumed year of implementation have been expressed as a net present value to allow direct comparison of all options.

The benefits for each option have been estimated based on the reduction in damages that would accrue from each option. Again, benefits have been expressed as a net present value to allow for direct comparison. While it is recognised that there is some overlap between the benefits and costs in the CBA and effectiveness and cost within the MCA, there are benefits such as the cost of a human life, which have not been included in the cost benefit analysis.

Table 4-55 below presents the costs and benefits for each option as well as the benefit-cost ratios.

TABLE 4-55 SUMMARY OF BENEFIT TO COST RATIO FOR EACH OPTION

Adaptation Option	Option Benefit Relative to Current Condition	NPV of Total Whole of Life Cost	BCR
Bargara Beach Nourishment with Dune (re)construction	$225,164.83	$5,846.38	**38.5**
Innes Park and Coral Cove Beach Nourishment with Dune (re)construction	$89,649.34	$11,595.01	**7.7**
Moore Park Beach Beach Nourishment with Dune (re)construction	$3,830,002.07	$525,219.62	**7.3**
Bargara, Kellys Beach Seawall/Rockwall/Buried Seawall	$225,164.83	$33,270.54	**6.8**
Woodgate Beach Beach Nourishment with Dune (re)construction	$6,034,801.27	$1,072,437.43	**5.6**
Moore Park Beach Seawall/Rockwall/Buried Seawall	$3,830,002.07	$802,348.00	**4.8**
Coonarr Beach Nourishment with Dune (re)construction	$675,539.45	$177,477.21	**3.8**
Woodgate Beach Seawalls/Rockwall/Buried Seawall	$6,034,801.27	$1,804,230.55	**3.3**
Innes Park and Coral Cove Seawalls/Rockwall/Buried Seawall	$89,649.34	$28,987.53	**3.1**
Coonarr Seawalls/Rockwall/Buried Seawall	$675,539.45	$511,532.24	**1.3**
Burnett Heads Storm Surge Barrier and Dyke	$34,173.96	$80,273.15	**0.4**
Coonarr Land use and tenure transition	$693,254.34	$1,553,137.49	**0.4**
Woodgate Beach Land use and tenure transition	$217,441.66	$914,489.55	**0.2**

4.17 Comparison of Options

In order to provide an overall assessment and comparison of the 13 options, the BCR, MCA and costs need to be considered together. This comparison seeks to provide recommendations for ‘preferred pathways’ for each settlement, that is the option that provides the optimum adaptation approach that aligns with the adaptation principles, reduces coastal hazard risk and upholds community values of the coast.

Three approaches of comparing the options (Jacobs, 2016) are to display costs versus the MCA score; BCR versus MCA Score; and cost versus BCR. The following figures provide a visual comparison.

4.17.1 Cost (NPV) vs MCA Score

A useful comparison of options is to display cost versus MCA score, this is shown in Figure 4-25.

It is apparent from this graphic that the adaption options that have high performance are presented in the 'good outcome' quadrant. These options have a low net present value of cost and a high MCA score. These options are:

- Moore Park Beach – Beach Nourishment/Dune (re)construction;
- Woodgate Beach – Beach Nourishment/Dune (re)construction;
- Moore Park Beach – Seawall/Rockwall/Buried Seawall;
- Coonarr – Beach Nourishment/Dune (re)construction;
- Burnett Heads – Storm Surge Barrier and Dyke; and
- Coonarr – Land use and tenure transition.

4.17.2 Benefit-Cost Ratio vs MCA Score

A second useful comparison of options is to display BCR versus MCA score, this is shown in Figure 4-26.

Again, options which perform well are shown in the 'good outcome' quadrant. These options have a high BCR and high MCA score. These options are:

- Moore Park Beach – Beach Nourishment/Dune (re)construction;
- Woodgate Beach – Beach Nourishment/Dune (re)construction;
- Kellys Beach, Bargara – Beach Nourishment/dune (re)construction; and
- Innes Park – Beach Nourishment/Dune (re)construction.

Note the scale of the y-axis in this figure is up to 8.0. The beach nourishment option at Kellys Beach, Bargara scores a very high BCR of 38 due to the highly capitalised residential dwellings that front Kellys Beach shoreline.

4.17.3 Benefit-Cost Ratio vs Cost

Thirdly, costs versus BCR shows options which are comparatively affordable and present better economic viability, this is shown in Figure 4-27.

The options which are affordable and are shown to economically viable are:

- Moore Park Beach – Beach Nourishment/Dune (re)construction;
- Woodgate Beach – Beach Nourishment/Dune (re)construction;
- Kellys Beach, Bargara – Beach Nourishment/Dune (re)construction;
- Innes Park – Beach Nourishment/Dune (re)construction; and
- Kellys Beach, Bargara – Seawall/Rockwall/Buried Seawall.

4.17.4 Comparison of Options Summary

Consistently, beach nourishment / dune reconstruction at Moore Park Beach, Woodgate Beach, Innes Park and Kellys Beach at Bargara are presented as 'good outcomes' for each settlement. It is noted that the very high BCR score of beach nourishment at Kellys Beach is due to the private properties that are potentially afforded protection by this adaptation option.

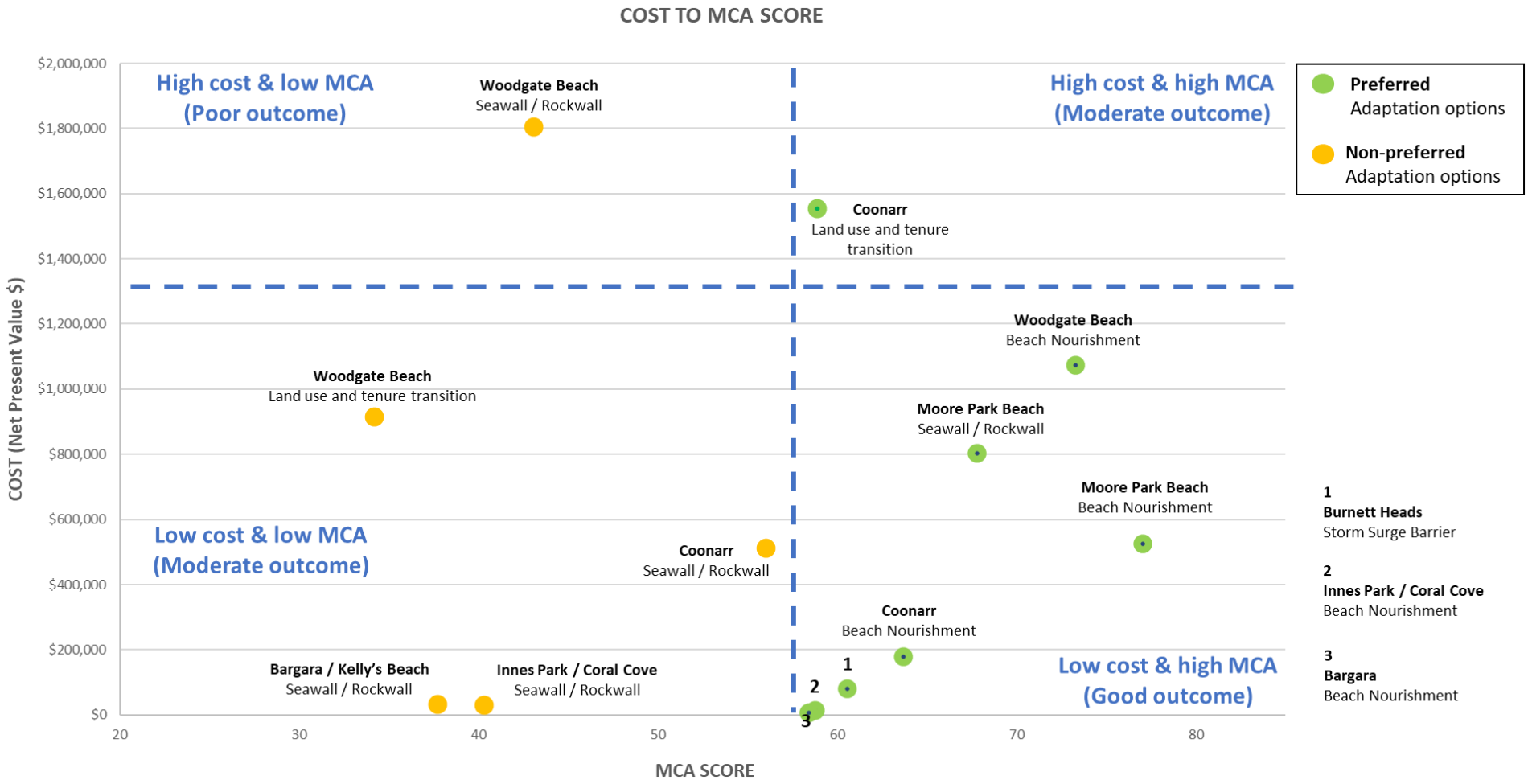


FIGURE 4-25 COST VS MCA OPTION COMPARISON

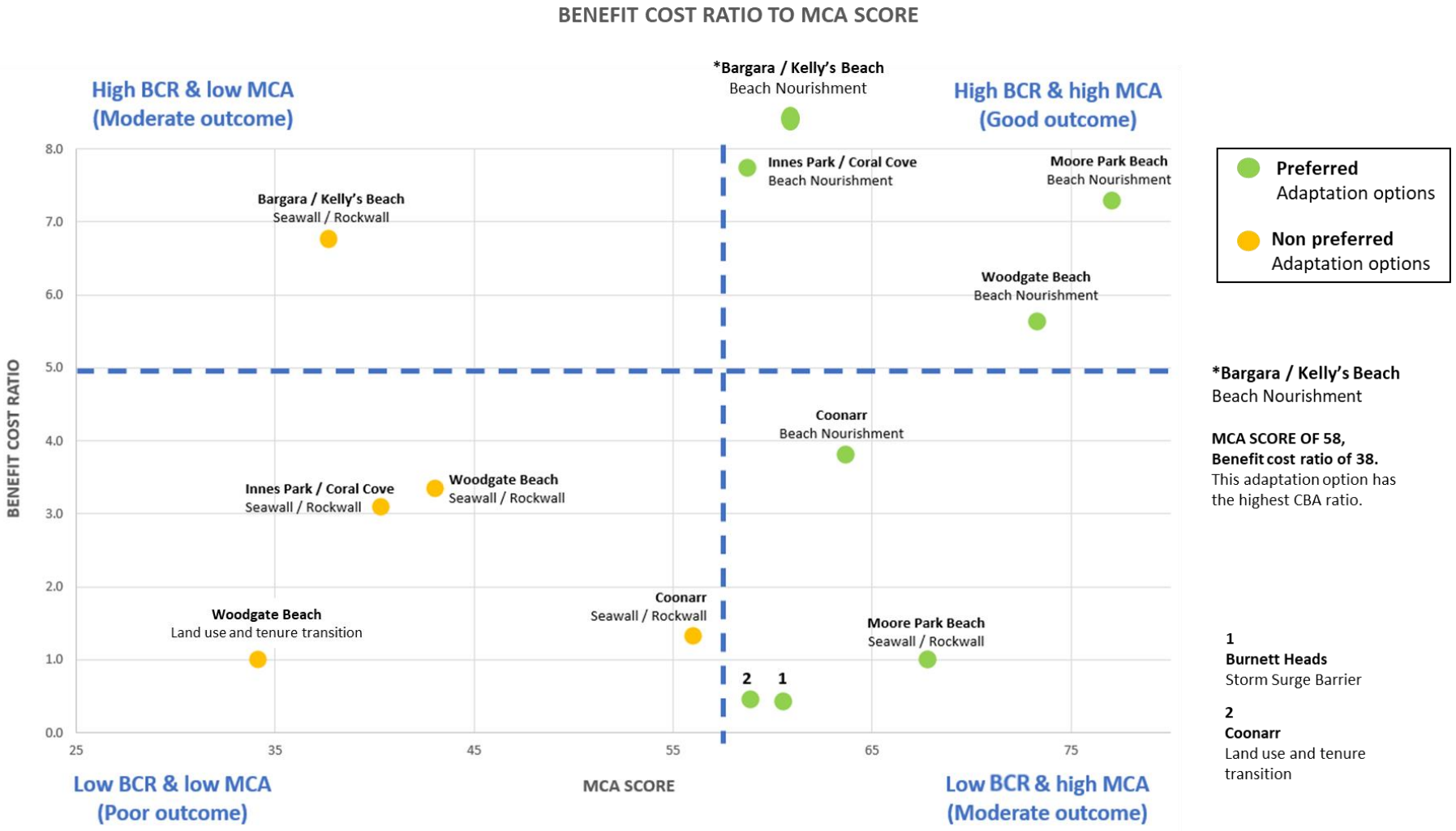


FIGURE 4-26 BCR VS MCA OPTION COMPARISON

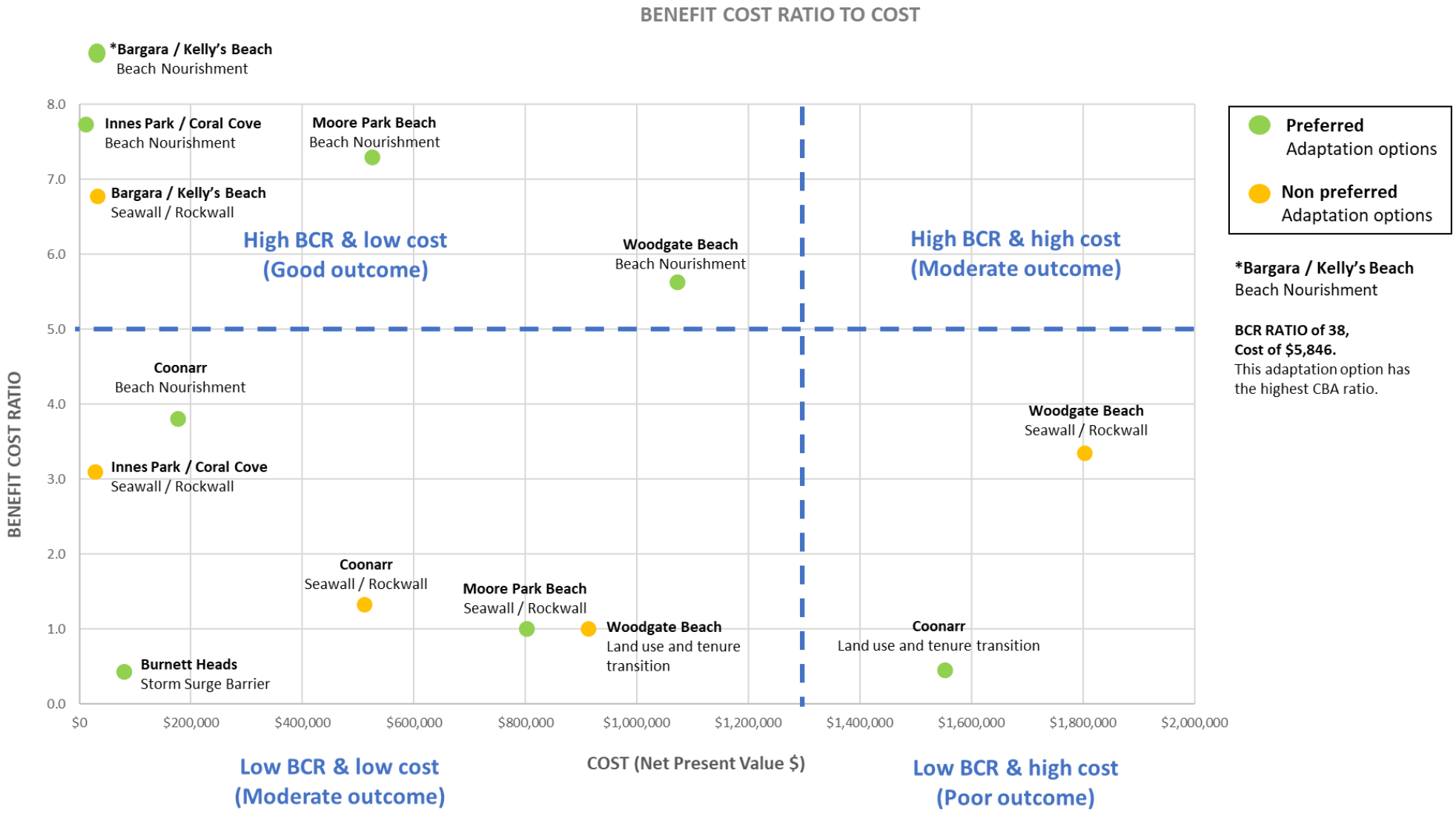


FIGURE 4-27 BCR VS COST OPTION COMPARISON

4.18 Overall Ranking of Options

Table 4-56 provides an overall assessment and comparison of the 13 physical adaptation options. MCA, Cost and BCR are considered together. Options have been recommended for further assessment or 'preferred' pathways for each settlement. In some cases, multiple options are preferred. In each settlement, there is a clear priority for immediate implementation of disaster management planning, an education and awareness campaign, land use planning and continued monitoring of erosion. However, the timing of projected impacts means that planning for a range of additional options needs to commence immediately, focusing on modifying and transforming settlements.

In the case of Burnett Heads, the storm surge barrier option at 0.8m sea level rise scenario has a BCR of 0.4 which means that this option is probably not economically viable. As discussed in Section 4.4, the damages to properties expected from sea level rise and permanent inundation could be reduced if the option is implemented before a 0.8m sea level rise scenario, thus providing a more favourable BCR to this adaptation option. It is recommended that Council investigate the timing of implementation as this may provide a greater BCR, this should be considered in any future planning process.

The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

TABLE 4-56 MCA AND COST TO BENEFIT TO RATIO FOR EACH OPTION

Adaptation option	MCA score	Cost estimate	Benefit estimate	Ratio
OPTIONS RECOMMENDED AS PREFERRED ADAPTATION PATHWAYS				
Moore Park Beach Beach Nourishment with Dune (re)construction	77.3	$525,219	$3,830,002	7.3
Woodgate Beach Beach Nourishment with Dune (re)construction	73.8	$1,072,437	$6,034,801	5.6
Moore Park Beach Seawall/Rockwall/Buried Seawall	67.4	$802,348	$3,830,002	4.8
Coonarr Beach Nourishment with Dune (re)construction	63.8	$177,477	$675,539	3.8
Burnett Heads Storm Surge Barrier and Dyke	60.6	$80,273	$34,173	0.4
Coonarr Land use and tenure transition	59.6	$1,553,137	$693,254	0.4
Innes Park and Coral Cove Beach Nourishment with Dune (re)construction	58.8	$11,595	$89,649	7.7
Bargara Beach Nourishment with Dune (re)construction	58.4	$5,846	$225,164	38.5
OPTIONS NOT RECOMMENDED AS PREFERRED ADAPTATION PATHWAYS				
Coonarr Seawalls/Rockwall / Buried Seawall	56.3	$511,532	$675,539	1.3
Woodgate Beach Seawalls / Rockwall/Buried Seawall	46.1	$1,804,230	$6,034,801	3.3
Innes Park and Coral Cove Seawalls/Rockwall/Buried Seawall	43.1	$28,987	$89,649	3.1
Bargara, Kellys beach Seawall/Rockwall/Buried Seawall	40.3	$33,270	$225,164	6.8
Woodgate Beach Land use and tenure transition	37.7	$914,489	$217,441	0.2

5 PREFERRED ADAPTATION PATHWAYS

5.1 Overall

This chapter contains the preferred adaptation pathway diagrams per settlement. The options for each settlement are presented based on the high-level screening process in Phase 6 and results of the socio-economic appraisal discussed earlier. Table 5-1 shows the symbology of the pathway diagrams.

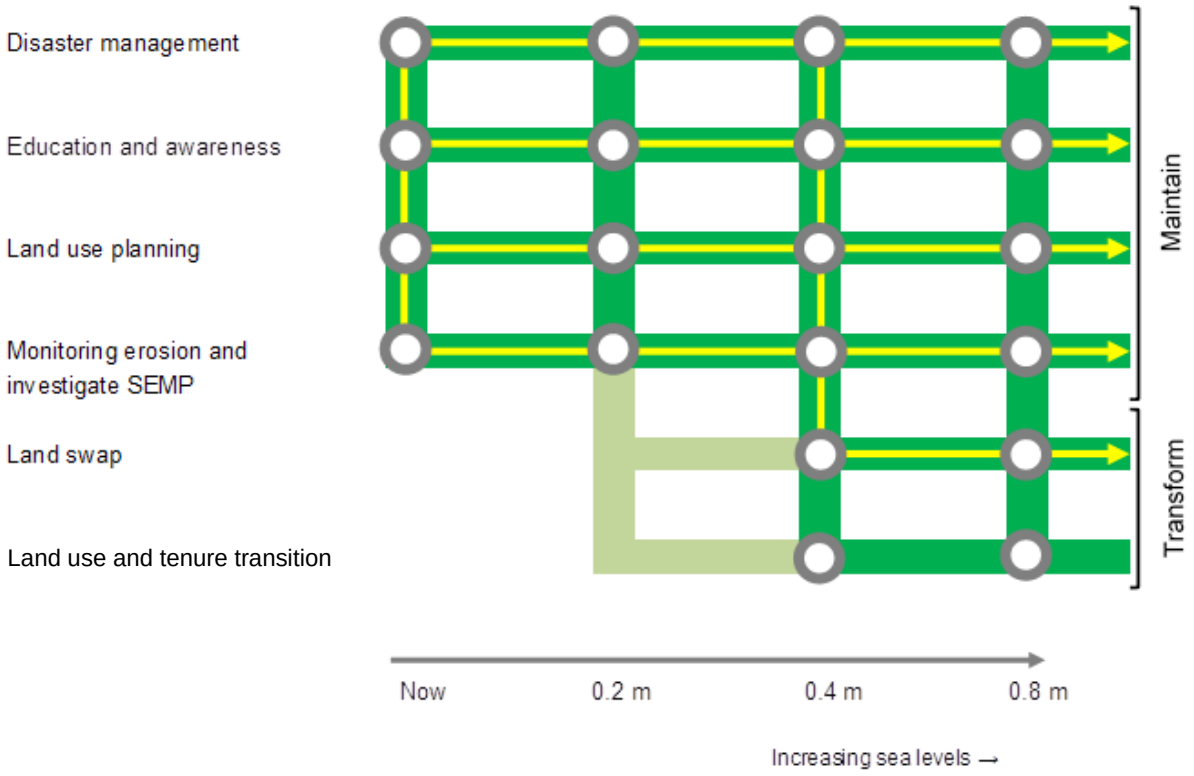
Preferred adaptation options are recommended for further assessment and implementation.

Adaptation pathway summaries are provided in yellow boxes for each settlement. It is important to note that for all settlements, adaptation will require an immediate focus upon on disaster management, education and awareness campaigns and land use planning to ensure the settlement vision and growth pattern are commensurate with the risk.

TABLE 5-1 EXPLANATION OF PATHWAYS DIAGRAMS

Symbol	Interpretation
	Circles indicate decision points, that is, points in time when a decision needs to be made between alternate adaptation options. The timing of decision points has been set to coincide with present day conditions (now) and sea level rise scenarios of 0.2 m, 0.4 m and 0.8 m.
	Planning or investigation commences for adaptation option
	Indicates when a non-preferred adaptation option would likely be implemented
	Preferred adaptation option indicating the preferred pathway for adaptation
	Ruled out option, however this pathway indicates when planning or investigation would likely commence IF the option is reconsidered
	Ruled out option, however this pathway indicates when implementation would likely commence IF the option is reconsidered

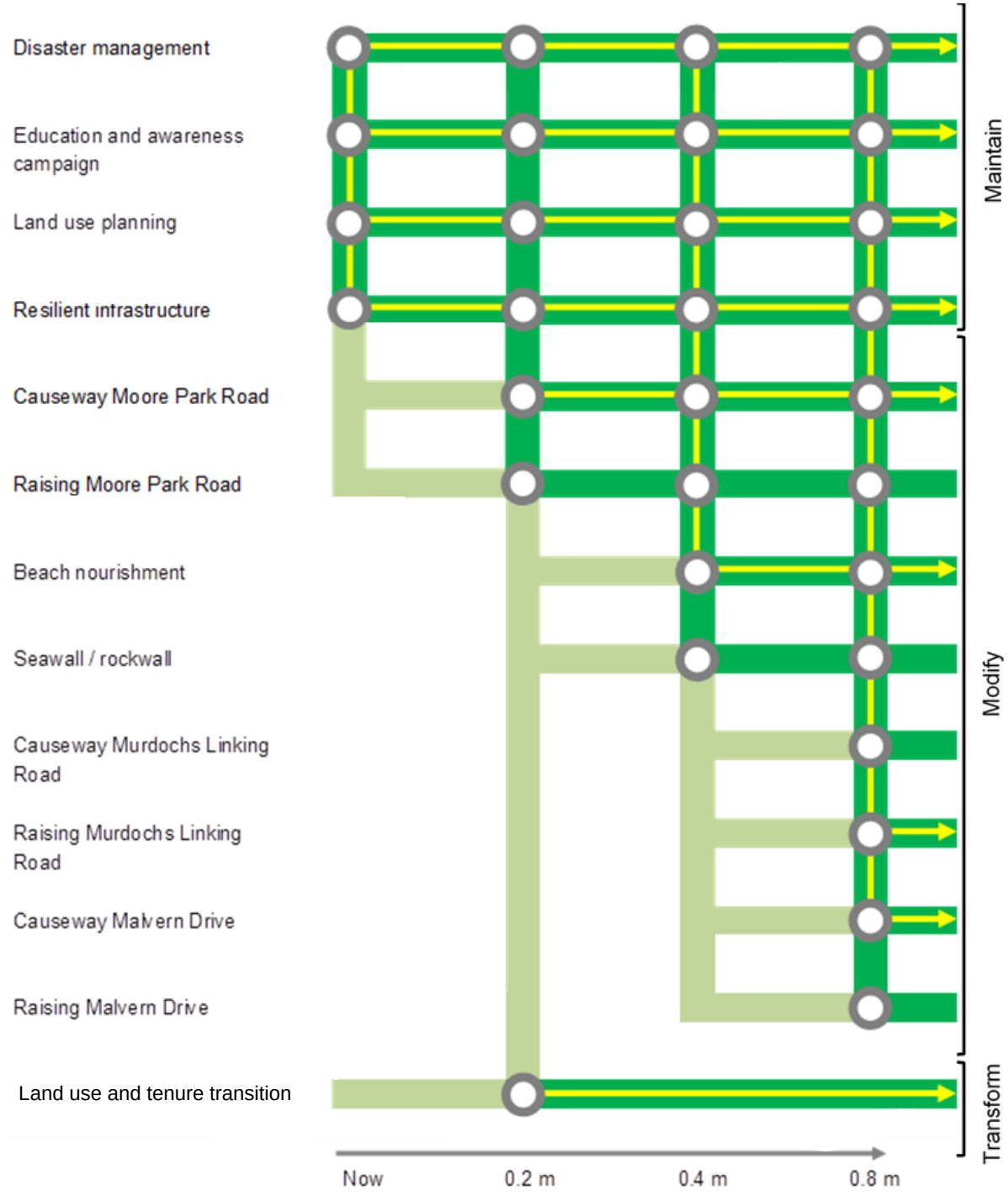
5.2 Miara, Winfield And Norval Park



ADAPTATION PATHWAY SUMMARY

- Adaptation in Miara, Winfield and Norval Park will require a focus on disaster management, education and awareness campaigns, and land use planning to ensure limited growth in the settlement.
- Council will continue to monitor the rate of erosion in Colonial Cove over time, which may lead to the implementation of a SEMP in this location.
- Modification of operations at the Miara Caravan Holiday Park may be required to facilitate a relocation via a land swap in the longer term.

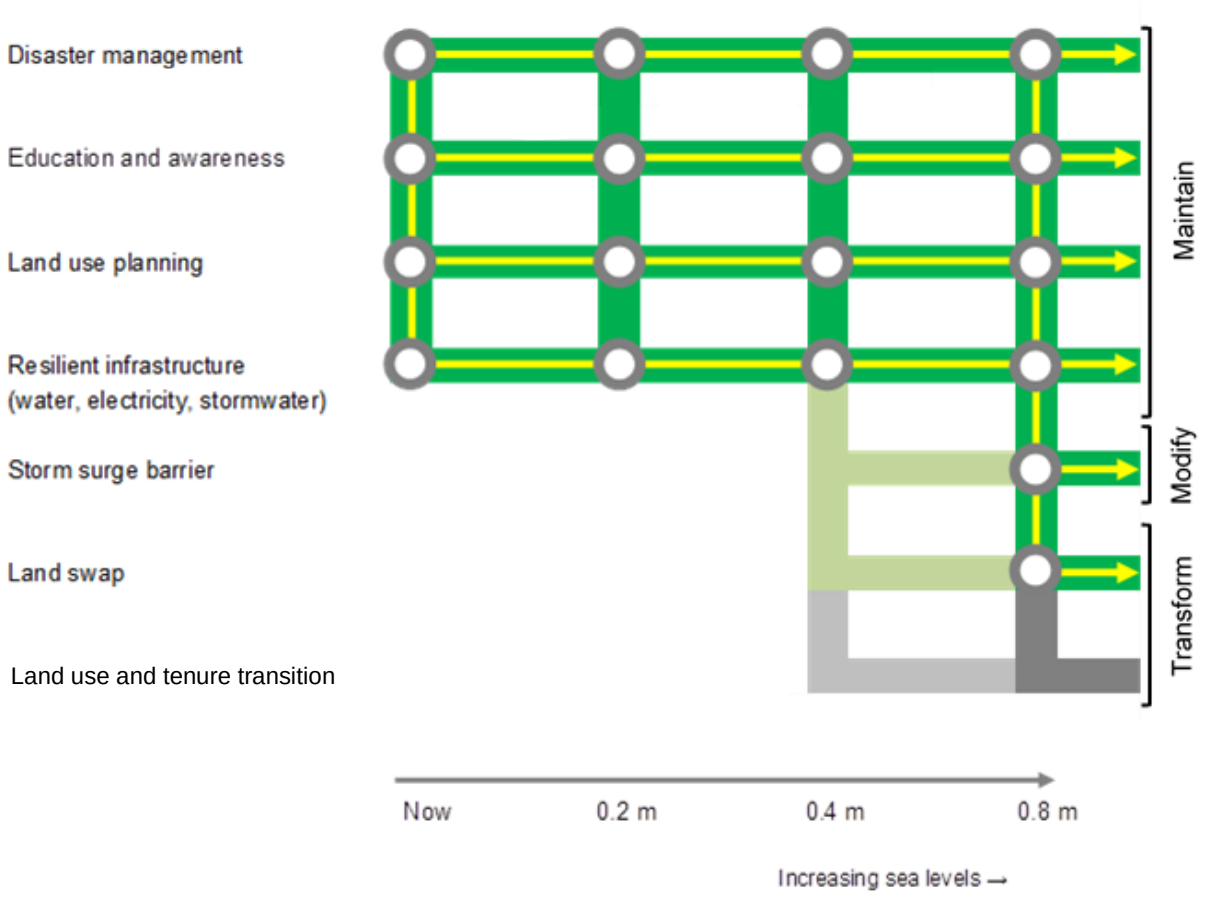
5.3 Moore Park Beach



ADAPTATION PATHWAY SUMMARY

- In the short-term the preferred 'Modify' options consist of planning the construction of a causeway in Moore Park Road to prevent regular inundation of these key access routes.
- The next steps will be to commence planning for raising Murdochs Linking Road and beach nourishment along the beach front, these measures should commence after the 0.2 m sea level rise scenario in time for a 0.4 m sea level rise scenario when intolerable risks may occur.
- Modification of operations at the surf club may be required to facilitate a relocation out of the erosion prone area via a land swap.

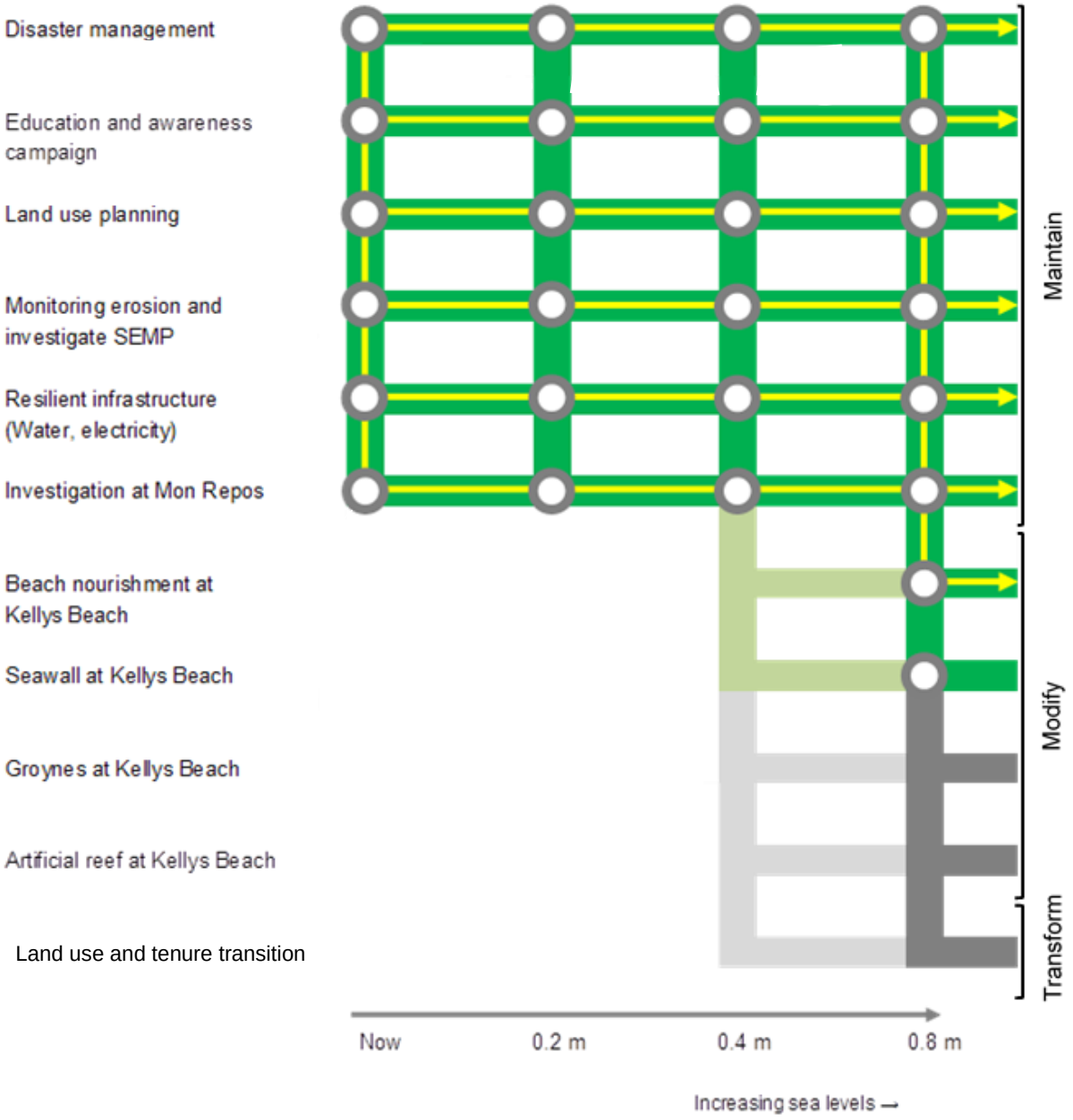
5.4 Burnett Heads



ADAPTATION PATHWAY SUMMARY

- Adaptation in Burnett Heads will require a focus on disaster management, education and awareness campaigns.
- Communication with the Port of Bundaberg throughout its development to ensure proposals for the State Development Area (SDA) are cognisant of risk exposure via appropriate land use planning responses.
- The preferred 'Modify' options consists of a feasibility investigation into the timing of a possible storm surge barrier and dyke.
- Modification of operations at the Lighthouse Holiday Park may be required to facilitate a relocation via a land swap in the longer term.

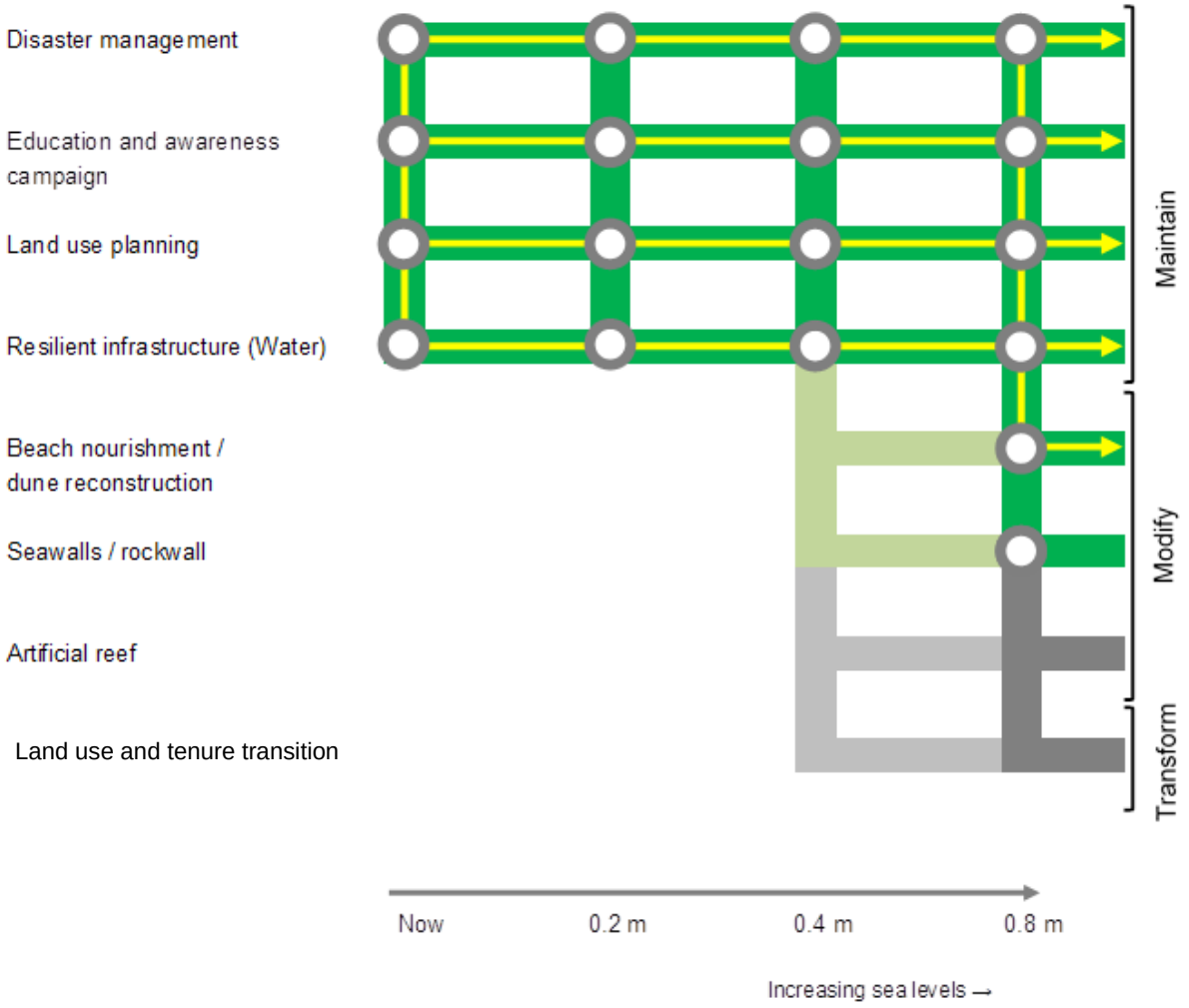
5.5 Bargara



ADAPTATION PATHWAY SUMMARY

- Council to continue to monitor the erosion at the Bargara Foreshore and Nielson Beach which may lead to a SEMP in these locations
- As an economically and environmentally important site to the region, a resilience and adaptation investigation should be undertaken at the Mon Repos Turtle Centre
- The preferred 'Modify' option is beach nourishment at Kellys Beach. Collectively, private property owners are to investigate the feasibility of protecting their assets.

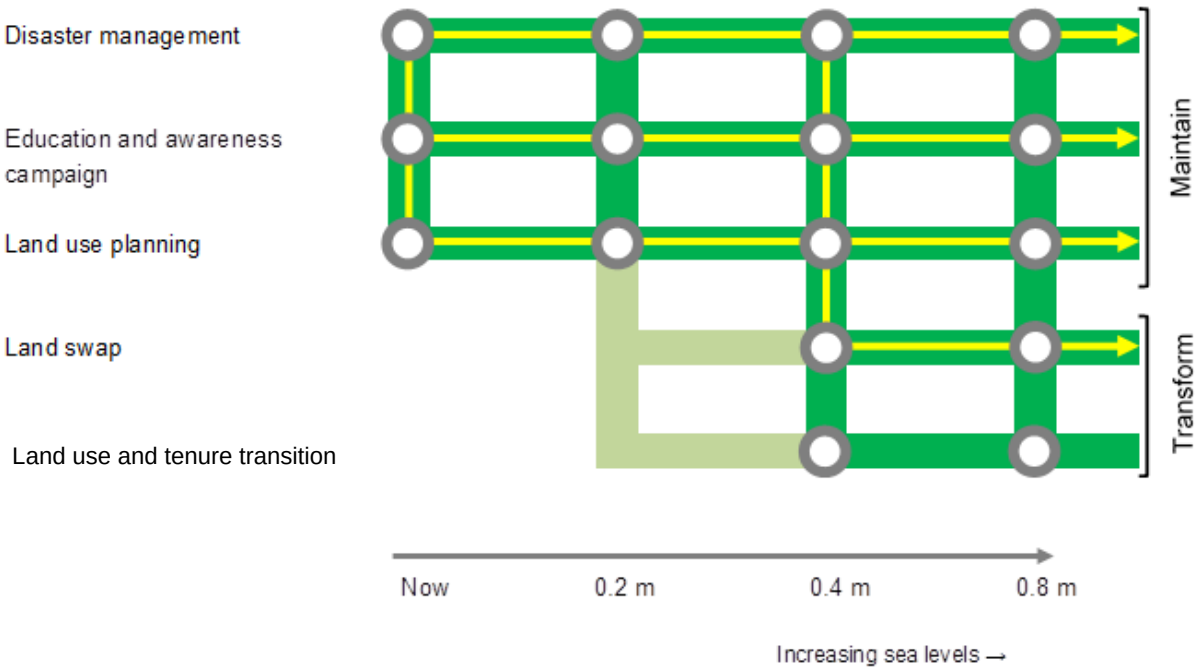
5.6 Innes Park and Coral Cove



ADAPTATION PATHWAY SUMMARY

- Adaptation in Innes Park and Coral Cove will require a focus on disaster management, education and awareness campaigns and land use planning to ensure a low-density settlement pattern with open space around the foreshore continues
- The preferred 'Modify' option in this settlement consists of beach nourishment in the longer term in the area of Innes Park and Palmers Creek.

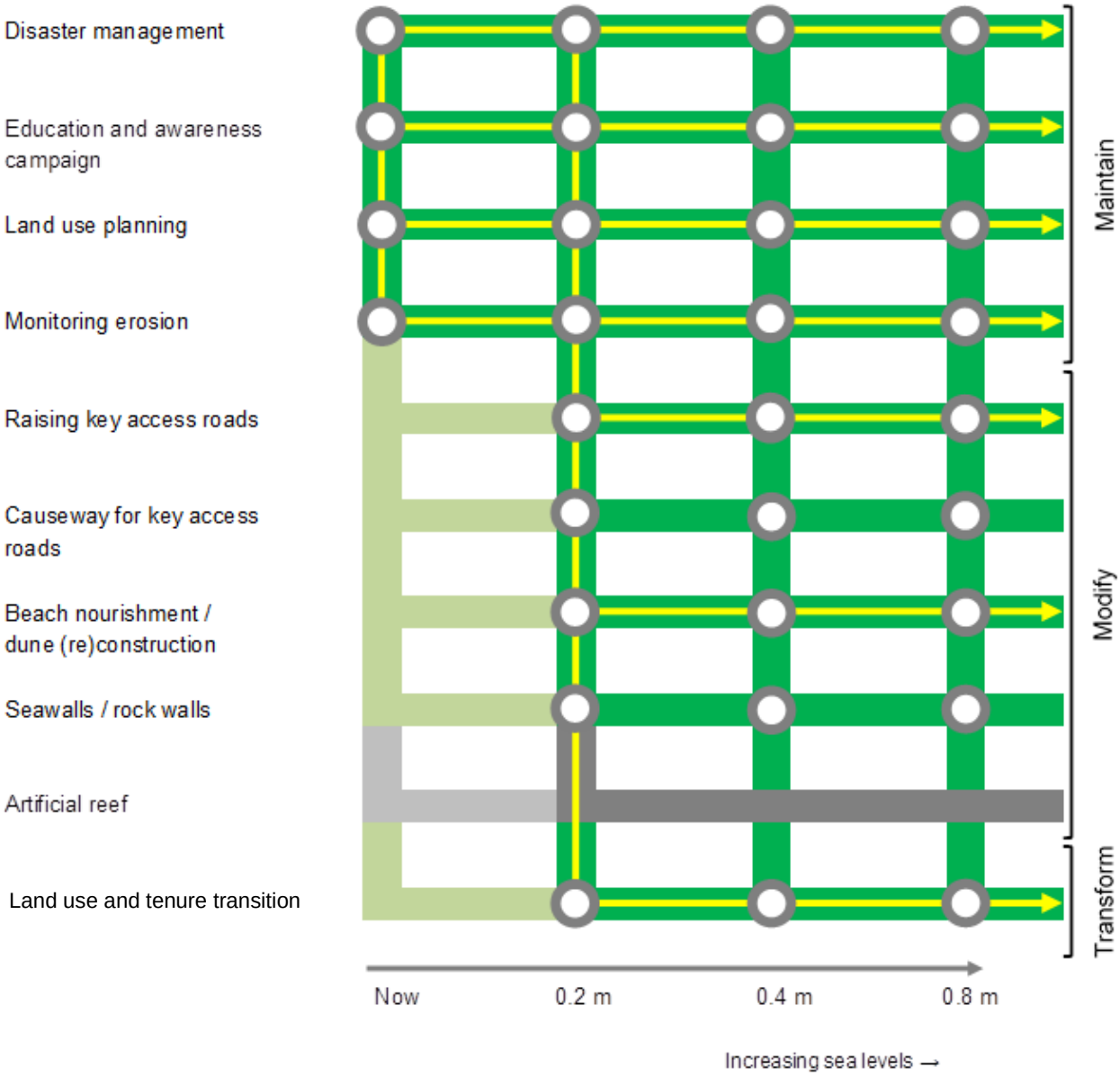
5.7 Elliott Heads



ADAPTATION PATHWAY SUMMARY

- Adaptation in Elliott Heads will require a focus on disaster management, education and awareness campaigns, and land use planning to ensure the existing zoning pattern is maintained and to ensure no intensification or increase in risk.
- There are no 'Modify' options appropriate for this settlement study area.
- In the medium term, the Elliott Heads Tourist Park may consider modifying some operational practices with a long-term view of transforming or relocation via a land swap.

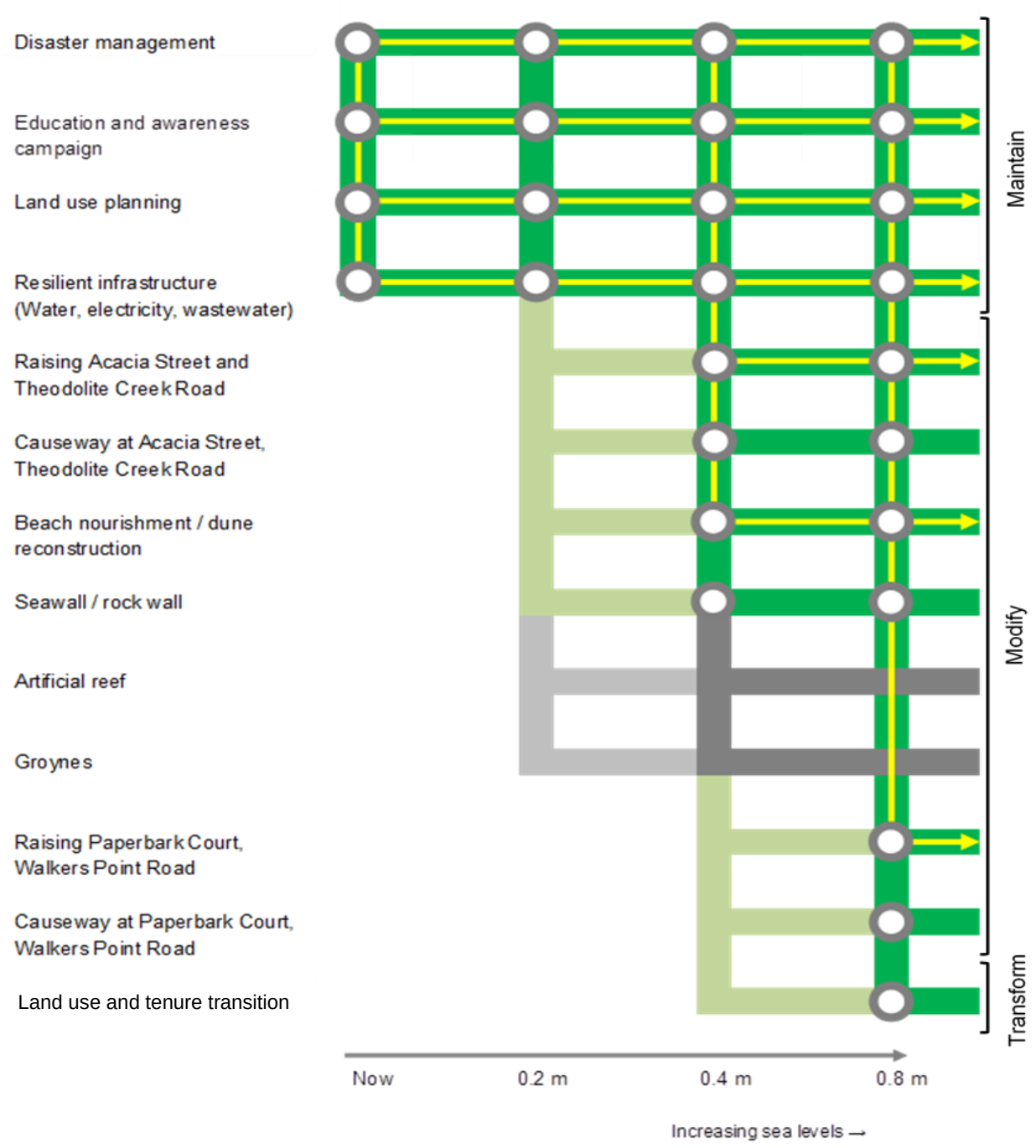
5.8 Coonarr



ADAPTATION PATHWAY SUMMARY

- The timing of projected impacts means that planning for a range of additional 'Modify' options needs to commence immediately
- The preferred adaptation options consist of beach nourishment, raising Coonarr Beach Road to prevent potential isolation to the beach front properties, and potential land use and tenure transition of the same properties
- The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

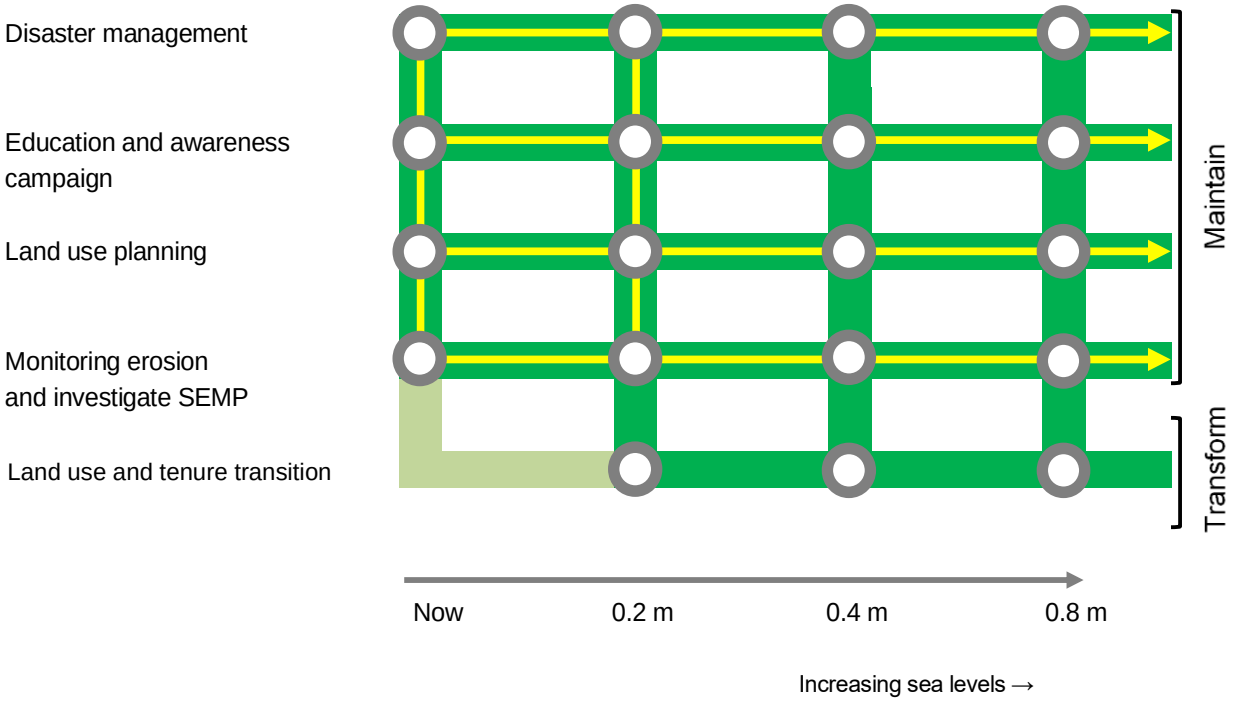
5.9 Woodgate Beach and Walkers Point



ADAPTATION PATHWAY SUMMARY

- There is an immediate requirement to focus on disaster management, education and awareness campaigns, and land use planning to maintain the vision for low or no growth and the characteristics of a coastal township. Development capacity should not increase in future planning schemes
- In the short-term the preferred 'Modify' options consist of beach nourishment and raising Acacia Street and Theodolite Creek Road to prevent regular inundation of these key access routes
- In the longer term, the preferred adaptation option will be to commence planning for raising Paperbark Court Rd and Walkers Point Road

5.10 Buxton



ADAPTATION PATHWAY SUMMARY

- Adaptation in Buxton will require a focus on disaster management, education and awareness campaigns, and land use planning to maintain a vision as a coastal character village with limited growth
- There are no 'Modify' options appropriate for this settlement study area.
- Council will continue to monitor the erosion in the area of Wharf Street, which may lead to a SEMP in this location.

5.11 Closing Remarks

The diagrams show preferred adaption pathways based on the screening methodology in Phase 6 and socio-economic appraisal in Phase 7. There is an identified need to implement the measures within the 'Maintain' category with immediate effect and it is recognised that Council are already implementing some of these measures as part of core business.

The next phase of the CHAS will investigate the role of Council and the community to create a suitable action plan based on the preferred adaptation pathways to ensure the coastal values are upheld and coastal hazard risk remain tolerable.

6 SUMMARY AND NEXT STEPS

6.1 Commentary

The socio-economic appraisal undertaken in Phase 7 has resulted favourably for the traditionally 'soft-engineering' approach of beach nourishment in comparison to seawalls, this is true for all the priority settlements considered in this analysis.

Beach nourishment / dune reconstruction at Moore Park Beach, Woodgate Beach, Innes Park and Kellys Beach at Bargara consistently show as the preferred 'Modify and Transform' adaptation options, along with raising of key access roads to the settlements of Moore Park Beach, Coonarr, Woodgate Beach and Walkers Point.

Furthermore, land use and tenure transition of beach front properties in Coonarr is ranked higher than the option to construct a seawall in front of the same settlement.

During the analysis, the effectiveness of beach nourishment in the analysis is assumed to be same as a seawall in each of the priority settlements by use of the spatial analysis, however, the superior adaptability of this option given the uncertain nature of future sea level scenarios contributes to an overall higher ranking.

In Burnett Heads, the storm surge barrier represents the only option that effectively mitigates storm tide inundation. This adaptation option is highly effective in reducing risk to life. The cost of this option is expected to be very high, but if investigated further in combination with future planned road upgrades, a 'barrier' could become an economically viable option.

Implementation of disaster management, education and awareness, land use planning responses, building resilient infrastructure and monitoring rates of erosion have been identified as preferred options to maintain the current risk trends.

The preferred adaptation pathways identify the optimal timing for investment, i.e. planning and implementation of an option should commence prior to the sea level rise scenario that triggers intolerable risk.

6.2 Next Steps

If these preferred adaptation options are adopted for further assessment the following next steps are required for progression:

- Recognising the limitations of this high-level assessment, further quantification of the costs and benefits (including intangible benefits).
- Explore combinations of preferred 'Modify' and 'Transform' options to priority settlements, such as beach nourishment, seawalls, raising key access roads and land use and tenure transition, in consultation with the community.
- Ensure the strategy actions are embedded across all council programs for risk-aware decisions as business as usual. The CHAS works in tandem with many other aspects of council business and community values and will be embedded into:
  - Land use planning and community visioning;
  - Building regulations;
  - Community facilities and support programs;
  - Asset management processes;
  - Infrastructure planning and cost-benefit analysis tasks;
  - Parks and environmental protection;

  - Emergency management and disaster recovery; and
  - Monitoring and reporting system.
- Decisions one organisation or landowner will make will not be appropriate for other organisations, properties or locations. Being risk aware and adaptable is an intensely individual experience. Everyone's risk exposure is different. Individual understanding of risk and personal strategy development is the first step to a more resilient coastal community.
- Council will be the facilitator and leader of recommendations but not necessarily responsible for taking direct action. There are practical roles for residents, business, community organisations, state agencies, and disaster management. An ambitious aim of the CHAS is that every part of the community in the coastal area: private land or business owner, surf club, school, retirement village, local motel or sports club should know and understand their own risks and create a suitable action plan for assets, premises, and members.
- As the facilitator and leader, Council will provide tools, templates, guidance, in kind assistance and alert the community to any appropriate funding streams among council-specific actions and a plethora of possible small-scale actions across all council programs.

7 REFERENCES

Australian Bureau of Statistics (ABD): https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/LGA31820/opendocument, data from census 2016.

AIDR (Australian Institute for Disaster Resilience): Managing the floodplain: a guide to best practice in flood risk management in Australia, 2017.

Bewsher Consulting: Draft Floodplain Risk Management Plan, In: Towradgi Creek, Wollongong Floodplain Risk Management Study. Bewsher Consulting Pty Ltd, 2003.

Bewsher Consulting: Flood Damage Assessment, In: Macquarie Park FRMS&P. Final Report. Bewsher Consulting Pty Ltd, 2011a

Bewsher Consulting: Defining the Flood Problem, In: Double Bay Catchment FRMS&P. Draft Report for Public Exhibition. Bewsher Consulting Pty Ltd, 2011b.

BTE: Report 103: Economic Costs of Natural Disasters in Australia. Bureau of Transport Economics, Canberra, 2001.

Coastal Hazards Technical Guide (1993) https://www.ehp.qld.gov.au/coastalplan/pdf/hazards-guideline.pdf

Flood Hazard Research Centre (FHRC): The Multi-Coloured Manual. Middlesex University London. Available online: https://www.mdx.ac.uk/our-research/centres/flood-hazard/projects/multi-coloured-manual, 2013.

Geoscience Australia: Storm Surge Vulnerability Functions for Australian Buildings, Summary of Current Geoscience Australia Model Suite, compiled by M. Wehner, November 2012a.

Geoscience Australia: Vulnerability Models for Inundation – Contents, compiled by M. Wehner, 2012b.

HNFMSC (Hawkesbury-Nepean Floodplain Management Steering Committee): Managing Flood Risk Through Planning Opportunities: guidance on land use planning in flood prone areas. Hawkesbury-Nepean Floodplain Management Steering Committee, 2006.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

Jacobs., 2016 Bundaberg Flood Protection Study prepared for the Queensland State Department of Infrastructure Local Government and Planning, Flood Mitigation Options Assessment Report. December 2016

QNRM, 2002. Guidance on the Assessment of Tangible Flood Damages. The State of Queensland, Department of Natural Resources and Mines

Queensland Emergency Risk Management Framework (QERMF) Risk Assessment Process Handbook, Prepared by Community Resilience and Risk Mitigation Unit, Emergency Management and Community Capability, Queensland Fire and Emergency Services.

Scawthorn, C., Flores, P., Blais, N., Seligson, H., Tate, E., Chang, S., Mifflin, E., Thomas, W., Murphy, J., Jones, C. and Lawrence, M. 2006. HAZUS-MH Flood Loss Estimation Methodology II. Damage and Loss Assessment. Natural Hazards Review, May 2006, 72-81.

Standards Australia (2013). *Australian Standard: Climate change adaptation for settlements and infrastructure - A risk-based approach*, AS 5334-2013, published by Standards Australia, Australia

State of Queensland: Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments, Prepared by: The Local Government Association of Queensland and The Department of Environment and Heritage Protection, October 2016.

State of Queensland, 2015. Coastal Hazard Areas Map – Storm Tide Inundation Areas, Version 4 – October 2015

State of Queensland, 2016. Coastal Hazard Areas Map – Erosion Prone Areas, Version 6 – October 2016

State of Queensland, 2017. State Planning Policy—state interest guideline Natural hazards, risk and resilience, Dept of Infrastructure, Local Government and Planning

Tooth, R.: Analysis of Demand for Home and Contents Insurance, Insurance Council of Australia, August 2015.

User Guide on Applied Adaptation Pathways - Adaptation Pathways Network

Victorian Government Local Government Asset Investment Guidelines

Water Technology. (2018) Woodgate Beach Shoreline Erosion Management Plan. Prepared for Bundaberg Regional Council