WHITSUNDAY REGIONAL COUNCIL COASTAL HAZARD ADAPTATION STRATEGY (CHAS):

RESILIENT WHITSUNDAY COAST STRATEGY

MAXIMIZING THE RESILIENCE TO CLIMATE CHANGE IN OUR

Solar farm, Collinsville

WHITSUNDAY REGIONAL COUNCIL COASTAL HAZARD ADAPTATION STRATEGY (CHAS):

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Whitsunday Regional Council

MAYOR'S FOREWORD

I am pleased to present the Whitsunday Regional Council Coastal Hazard Adaptation Strategy. This strategy details the effects of climate change and coastal hazards on our coastal urban communities and sets out our commitment to managing those potential impacts into the future.

Council acknowledges the traditional owners and custodians of the lands in our region including the Ngaro, Gia, Juru, Jangga and Birriah groups. We pay respect to Elders past, present and emerging and acknowledge their ongoing relationship and connection to Country.

The Whitsunday coastal zone has significant ecological value and features a diverse range of natural landscapes which are highly valued by our residents and the thousands of visitors who visit the Whitsunday Region each year.

Home to the over 500 kilometers of coastline and the gateway to the 74 beautiful Whitsunday Islands and the Great Barrier Reef, we are fortunate to live in a naturally spectacular part of the world. As well as the thriving ecosystems, the coastline holds significant recreational, commercial, cultural and tourism value which underpins our economy.

Council acknowledges that our home is exposed to extreme weather events which are becoming increasingly common. Our coastal landscape is susceptible to storm tide, coastal erosion and inundation. In the future we will need to add sea level rise to the list of hazards.

I am proud that this Council is taking the important step of assessing our vulnerabilities so we can develop coastal adaptation options to mitigate the impacts of these hazards. Education and raising community awareness about climate change and coastal hazards can help build more resilient communities so I invite our residents to follow us on this journey.

The Queensland State Government and Local Government Association of Queensland (LGAQ) provided funding to Queensland coastal councils to develop a strategic approach to managing coastal hazards through the development of the Coastal Hazard Adaptation Strategy (CHAS).

With the funding awarded to Whitsunday Regional Council, we have been able to develop this Coastal Hazard Adaptation Strategy, and are now better prepared to plan and manage the future impacts associated with sea level rise in our urban coastal communities.

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Boardwalk, Cannonvale

1 INTRODUCTION

1.1 OUR COASTLINE

The Whitsunday region coastline extends 500 km across numerous coastal communities and adjacent to 74 islands which form a gateway to the Great Barrier Reef. The Whitsunday coastal zone is home to approximately 35,500 permanent residents. The region features a diverse range of natural landscapes such as beaches, reefs, rainforests and national parks which place the Whitsunday in prime position to become a world-class tourism destination.

The coastline is composed of a range of coastal landforms including sandy beaches, low beach-ridge plains, tidal mud flats, wetlands, rocky headlands, islands, near shore reefs and mangrove forests. The coastal zone provides valuable ecosystem services and a unique collection of terrestrial and aquatic species which support the region's economic and social wellbeing. The coastal environment is continuously changing as a result of dynamic natural processes such as tides, waves, erosion, inundation, storms and cyclones, and changes in sea level. However, coastal erosion and storm tide inundation have been identified as coastal hazards for the Whitsunday region because of their potential adverse impacts on people, the built environment and infrastructure.

1.2 THE RESILIENT WHITSUNDAY COAST STRATEGY

Context

Whitsunday Regional Council was successful in its funding application under the Coastal Hazards Adaptation Program (QCoast2100). The QCoast2100 program is a state-wide initiative of the Queensland Government and the Local Government Association of Queensland (LGAQ) to help coastal councils plan for and address climate change related coastal hazard risks over the long-term. Through their 'Resilient Whitsunday: Coastal Hazards and Responses' program, Whitsunday Regional Council have developed a Coastal Hazard Adaptation Strategy (CHAS), which is presented as the Resilient Whitsunday Coast Strategy.

The Resilient Whitsunday Coast Strategy:

- Has been developed to proactively manage the current and future impacts of coastal erosion and storm tide inundation
- Was developed in partnership with communities and other stakeholders
- Encompasses eight coastal communities including Airlie Beach, Bowen, Cannonvale, Conway Beach, Dingo Beach, Hydeaway Bay, Shute Harbour and Wilson Beach.

Purpose

The purpose of the Strategy is to:

- understand how climate change and coastal hazards affect coastal communities, local economy, natural environment and WRC operations (current and future impacts);
- identify areas likely to be exposed to current and future coastal hazards (e.g. storm tide, coastal erosion and inundation and sea level rise);
- assess the vulnerabilities and risks to key Council and community assets through a comprehensive data collection and spatial analysis process;
- develop potential coastal adaptation options to mitigate the impact of these hazards; and
- assess the viability of adaptation options through stakeholder engagement and economic analysis.

Approach

The Resilient Whitsunday Coast Strategy has been developed using an eight-phase process which align with the QCoast2100 Minimum Standards and Guidelines provided by LGAQ (see Figure 1). The process included a series of deliverables such as studies, spatial mapping, risk assessments and reports which aimed to:

- identify and assess areas at risk from coastal hazards
- engage the community to raise awareness of climate change impacts and offer a range of adaptation options
- propose priority adaptation options to address short-term impacts
- determine costs, priorities and time frames for implementation of adaptation actions

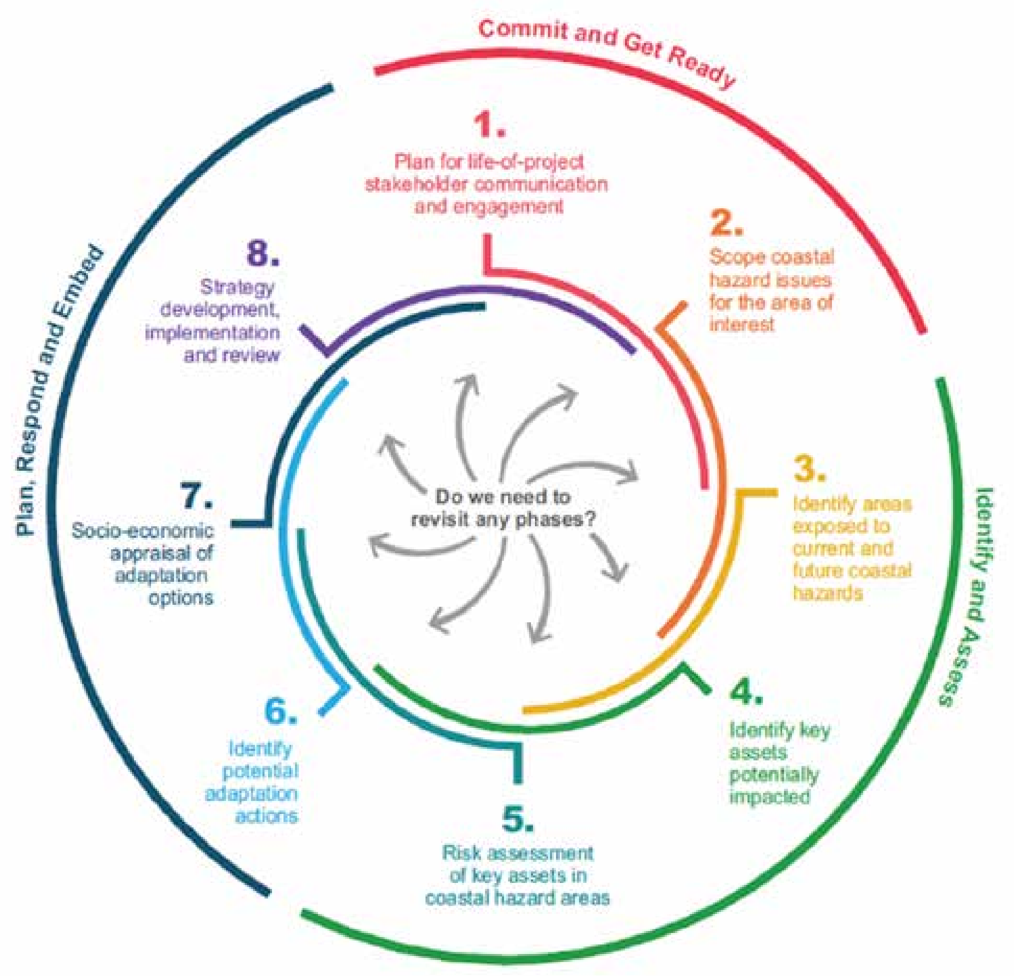

Figure 1: Diagram of project phases from Minimum Standards and Guidelines

1.3 ENGAGEMENT

Process

The Resilient Whitsunday Coast Strategy has been developed through a transparent engagement process with key stakeholders and the Whitsunday community. Initial community presentations were held in July 2017 at Bowen and Proserpine to encourage the community to participate and share their stories and memories of past weather events. During the early phases of the process, stakeholder engagement meetings were also held with representatives from:

- Dingo Beach Progress Association
- Hydeaway Bay Progress Association
- Whitsunday Catchment Landcare
- Department of Agriculture and Fisheries
- Mackay Regional Council
- Reef Catchments
- Urban Development Institute of Australia
- Queens Beach Action Group

Whitsunday Regional Council facilitated an engagement workshop with Indigenous and Aboriginal stakeholders from the Whitsunday community in November 2018. The workshop enabled sharing of relevant coastal hazard information and allowed the Juru People to provide meaningful engagement about the potential impacts of adaptation options.

The results of an online survey completed by stakeholders and Council staff members was also used to determine preferences for weighting the criteria in the Multi-Criteria Analysis.

Throughout the process, residents from seven of Whitsunday's coastal communities joined community consultation events to explore the coastal processes shaping our coastlines, and to provide feedback on coastal management and adaptation options for the future.

Communication

Throughout the development of the Resilient Whitsunday Coast Strategy, regular updates were posted on Council's website to inform the wider community about the progress of the project. The 'Your Say Whitsunday' website also provided an online platform for the community to upload photos of past weather events, participate in online survey, engage in presentations and events and provide feedback about the project. A Communication Plan and Stakeholder Engagement Plan created in Phase 1 guided the engagement and communication process across all phases of the 'Resilient Whitsunday' project.

Community consultation of draft Resilient Whitsunday Coast Strategy

The Council conducted community consultation during May 2021 on the draft Resilient Whitsunday Coast Strategy. Community information stalls and meetings were held at the following locations:

- Queens Beach – Bowen (8th of May)
- Rose Bay – Bowen (8th of May)
- Front Beach – Bowen (8th of May)
- Wilsons Beach (9th of May)
- Cannonvale (15th of May
- Hydeaway Bay (16th of May)

There were 54 residents who attended the community information stalls over the 6 information stall events.

In addition, the Council conducted an online survey to gauge community support and interest in the draft Strategy. The Council received 10 submissions.

2 THE WHITSUNDAY REGION

2.1 COASTAL LANDSCAPE

Whitsunday's coastline is environmentally diverse. The land was the traditional home of the Gia People and Juru People. The coastline and islands are sprinkled with pristine sandy beaches which are one of the major natural draw cards for visitors. The natural landscapes offer diverse rainforests and large tracts of national parkland. The beautiful tropical coastline is protected and rejuvenated by extensive mangrove forests and river deltas. Whitsunday is right in the heart of the Great Barrier Reef, where fringing reefs adjoin the region's 74 islands. These features provide a range of ecosystem services critical to the region's economy, social well-being and ecosystems.

2.2 SOCIAL FEATURES

There were approximately 33,778 permanent residents recorded living in the Whitsunday region in 2016 (ABS 2016). A strong local economy and relative favourable climatic conditions (Bell and Moran 2016) are expected to drive an increase in population going forward with an annual rate of 2.3% projected for the next twenty years. Socio-economic indicators show that the Whitsunday region's is relatively advantaged compared to the State average, which is likely driven by the superior economic resources maintained by the Whitsunday population (in contrast to the State).

In June 2018, regional unemployment in the Whitsunday region was estimated to be 3.4%. This is a significant improvement from the 2015 'unemployment crisis' when a reduction in mining operations in the west of the region drove unemployment beyond 10% ((WRC 2016).

2.3 ECONOMIC DRIVERS

The Whitsunday region boast a strong and diverse economy which is supported by 15,805 jobs and a total of economic output of $5.6 billion per year (REMPLAN 2020). The Whitsunday regional economy is driven by three pillar industries - mining, tourism and agriculture.

Mining

The mining sector is the biggest contributor to the Whitsunday region's economy, worth $996.3 million or 17.9% of the region's total industry output (REMPLAN 2020). With mining generating approximately $926.6 million in regional exports, it is the Whitsunday's largest exporter and will continue to be a significant economic contributor going forward.

Tourism

Tourism industry supports around 3,284 jobs which makes it Whitsunday's biggest employer, representing 20.8% of total employment (REMPLAN 2020). Many of these jobs (79%) are from the Accommodation and Food Services which are supported by tourist expenditure. This presents opportunities to build on the region's rich indigenous and European history, food tourism and nature-based experiences. The value of Tourism in the region for 2019-2020 was estimated at $477 million (REMPLAN, 2020).

Agriculture

The Agriculture, Forestry & Fishing industry is the second largest contributor to the region's economic output, generating 1,646 jobs and $599.4 million per year (REMPLAN 2020). In 2017-18, the wider Mackay Isaac Whitsunday Region contributed over $1.1 billion in gross value to Queensland's agriculture production, which equates to 8.5% of the State (ABS 2019). Areas of the Whitsunday region also have a well-established horticulture industry that supports 13 major crop varieties. With around 22,000 hectares of cane-growing land currently under cultivation in Proserpine, there is also opportunity for region's sugar industry to grow.

2.4 VULNERABILITY AND RESILIENCE

Vulnerability is how susceptible exposed elements, such as people and assets, are to suffer adverse effects when impacted by a hazard. The concept of vulnerability is closely linked with resilience.

Building resilience involves maximising the capacity of systems to adapt to stressors (i.e. climate change) in a way which maintains their purpose and function. For Whitsunday to build a resilient coastal region, this project first explored characteristics of the region's ecosystems and the socio-economy which may influence their capacity to absorb and recover from coastal hazard impacts.

An economist conducted a vulnerability assessment to identify the social and economic susceptibilities of the eight coastal communities. Bowen and Conway Beach were identified as areas with high socio-economic vulnerability. The assessment also identified five key drivers of regional vulnerability:

1. Resource vulnerability
2. Financial sustainability
3. Access to affordable insurance
4. Council leadership
5. Climate change governance

3 COASTAL HAZARDS

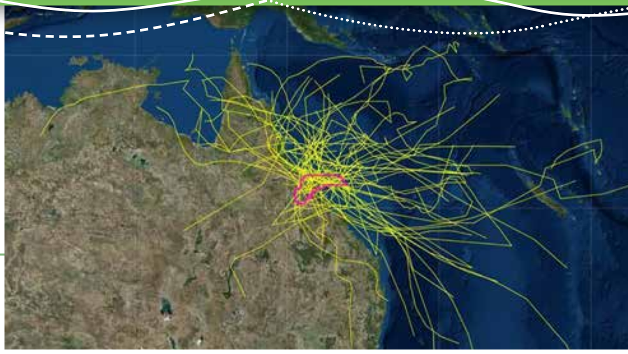

Figure 1a: Cyclones through the Whitsunday region since 1907 *(Source bom.gov.au website)*

3.1 HAZARDS

Coastal hazards include erosion of the coastal foreshore and storm tide inundation of low-lying coastal land. However, these naturally occurring processes are considered coastal hazards because they have the potential to negatively impact communities, development and natural assets along the coastline.

The Whitsunday region also experiences impacts from sea level rise and Tropical Cyclones which are drivers associated with coastal hazards and therefore have the potential to exacerbate coastal erosion and storm tide inundation.

3.2 COASTAL EROSION

Coastal erosion is the removal of beach and dune material which results in a loss of land along the coastline. This process occurs naturally and is typically driven by strong winds, changing wave conditions, high tides and severe storms (DILGP 2017).

Short-term erosion is a temporary cycle where beaches move naturally over periods of decades without causing a permanent change in the position of the shoreline. Through periods of short-term erosion, the coastline shifts backwards and forwards over many years. However, this erosion is not permanent, and the coastline, beaches and dunes can rebuild over time.

Furthermore, climate change is predicted to worsen coastal erosion. Sea level rise will speed up the process as waves reach higher up on the beach and cause permanent inundation of low-lying areas. This is likely to result in coastal recession which is the landward movement of the coastline over a longer period of time.

With a history coastal erosion events in the Whitsunday region, both short-term erosion and coastal recession may impact on Whitsunday's coastal assets, depending on their proximity to the shoreline.

3.3 STORM TIDE INUNDATION

Storm tide inundation is the temporary flooding of coastal land by unusually high sea levels. A storm tide occurs when a storm surge, a normal tide and wave action are combined to elevate the water levels well above normal tidal levels (DILGP 2017). The worst inundation impacts are likely to occur when the storm surge coincides with a high tide or king tide. This interaction creates a compounding effect which can lead to increased severity of a storm tide inundation. Storm tides are a prominent occurrence in the Whitsunday region during severe storm events and Tropical Cyclones.

3.4 COASTAL HAZARD MAPPING

Updated Mapping

Part of the 'Resilient Whitsunday' project included an update to Whitsunday Regional Council's coastal hazard mapping. Engineering consultants were tasked with producing coastal erosion mapping and storm tide inundation modelling of the entire Whitsunday coastline. These mapping updates included:

- New mapping of coastal erosion prone area for the entire coastline[1]
- New mapping of permanent inundation due to sea level rise for the entire coastline[2]
- Updated mapping of storm tide inundation for Bowen[3]
- Updated mapping of storm tide inundation for the Town of Whitsunday[4]

In accordance with Queensland Government requirements, a sea level rise of 0.4m by 2050 and 0.8m by 2100 has been adopted for the Whitsunday Resilient Strategy.

[1] ***Whitsunday Regional Council Hazard Mapping Refinement (BMT WBM 2018)***
[2] ***Ibid.***
[3] ***Bowen Water Hazards Assessment Stage 1: Storm Tide Modelling Basis Report (BMT WBM 2018)***
[4] ***Town of Whitsunday Drainage Study (BMT WBM 2017)***

Planning Horizons

Planning horizons were considered in the creation of coastal hazard maps to ensure that the adaptation options undertaken by council encompass short, medium, and long-term actions. The mapping for coastal erosion and storm tide inundation includes three planning horizons: current day, 2050 and 2100 (see Table 1). Two sea level rise allowance were adopted for future planning horizons, including 0.4m of sea level rise for 2050 and 0.8m for 2100, relative to present-day mean sea level (BMT WBM 2018). Storm tide inundation was also mapped using three levels of probability called Annual Exceedance Probability (AEP), which represent different chances of inundation occurring. For each planning horizon, maps were generated for 1% AEP, 0.5% AEP and 0.2% AEP storm tide inundation events.

Refer the reader to the council website where the coastal hazard mapping is located.

https://mapping.whitsundayrc.qld.gov.au/connect/analyst/mobile/#/main?mapcfg=CHAS

Figure 2: Damage cause by coastal storms, Airlie Beach

Table 1: Coastal hazard maps

Coastal Hazard	Planning Horizon	Sea Level Rise Allowance	AEP Scenarios
Coastal Erosion	Current Day	-	-
	2050	0.4 m	-
	2100	0.8 m	-
Sea Level Rise Inundation	2050	0.4 m	-
	2100	0.8 m	-
Storm Tide Inundation	Current Day	-	1%, 0.5%, 0.2%
	2050	0.4 m	1%, 0.5%, 0.2%
	2100	0.8 m	1%, 0.5%, 0.2%

These coastal maps illustrate the areas that may be exposed to coastal erosion and storm tide inundation under current and future planning horizons. This does not mean that the land inside the exposure are will be lost, rather that the assets and people within these areas are likely to be impacted by coastal hazards. For more information on the mapping approached used, see the technical reports developed in Phase 3.

4 ASSETS EXPOSED TO COASTAL HAZARDS

4.1 TOTAL EXPOSURE

The spatial mapping indicates that Whitsunday's coastal communities are expected to experience increased exposure to coastal erosion and storm tide inundation by 2050. These communities will likely see double the area exposed to coastal erosion by 2050, which will reach 1.9 km2 by 2100 (see Table 2). At present, around 10km2 of land is at risk of exposure to a 1 in 100 year storm inundation (1% AEP) event. Under this scenario, there is a 58% increase in the total area exposed to storm tide inundation by 2100. For more severe storm tide inundation events, up to 21 km2 of land is predicted to be exposed for the 2100 planning horizon. Additional information on exposure is provided in the summary report produced in Phase 4.

Table 2: Total area exposed to coastal hazards for all coastal communities (each planning horizon)

Coastal Hazard	Current Day	2050 Planning Horizon	2100 Planning Horizon
Coastal Erosion	0.7 km2	1.4 km2	1.9 km2
1% AEP Storm Tide Inundation	10 km2	13 km2	16 km2
0.5% AEP Storm Tide Inundation	11 km2	14 km2	17 km2
0.2% AEP Storm Tide Inundation	13 km2	17 km2	21 km2

**(Note 1km2 = 10ha)*

4.2 ASSETS EXPOSED TO COASTAL EROSION

Coastal erosion is likely to have the greatest impact on sandy beaches and buildings situated along the shoreline. All coastal communities will experience increases in the number of building exposed to future coastal erosion, with Bowen showing the highest risk (see Figure 2). In Bowen it is estimated that 38 buildings will be exposed in 2050, which more than doubles by 2100 to 93 buildings.

By 2100, there will be approximately 0.448 km2 of council parks exposed to coastal erosion, which is equivalent to the area of 25 sporting ovals or 44ha. There are also over 190 km of roads and around 222 km of both sewer and water mains at risk of coastal erosion by 2100. Sandy beaches are the most at risk from future coastal erosion, with over 66% of beaches exposed in 2050 and 2100.

4.3 ASSETS EXPOSED TO STORM TIDE INUNDATION

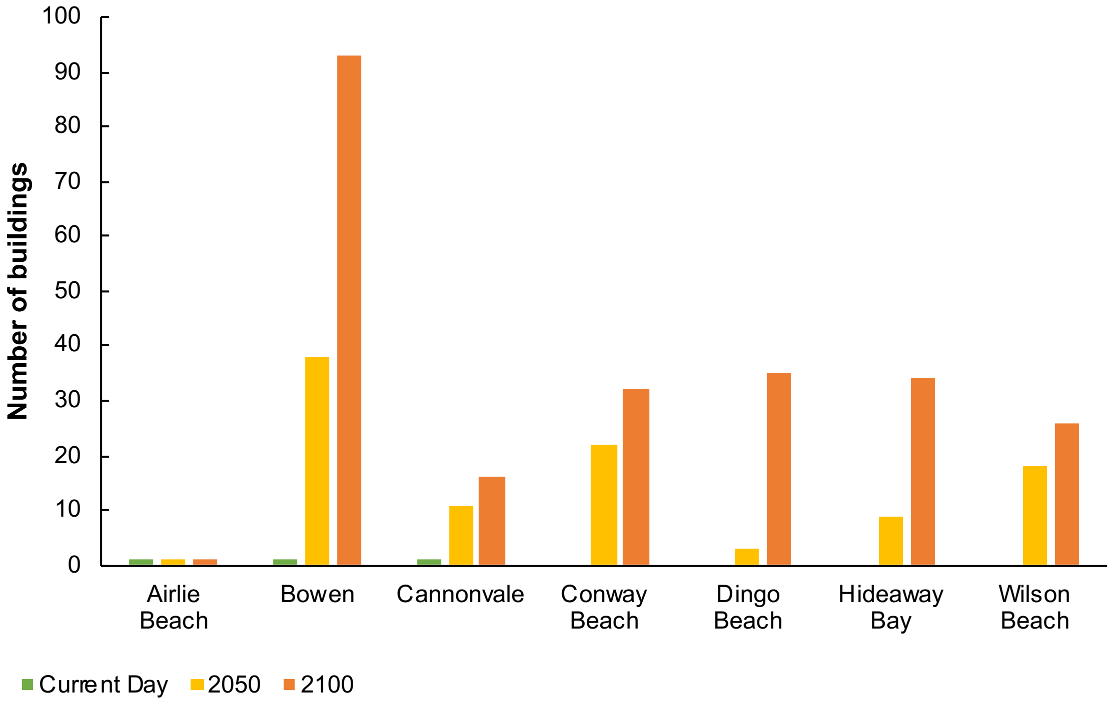

Figure 2: Number of buildings exposed to coastal erosion in each coastal community

A storm tide inundation event is likely to have considerable impacts on property, infrastructure, social and environmental assets both now and in the future. Under a current day 1% AEP storm tide inundation event there are 44 buildings exposed with most of these properties located in Bowen (see Table 3). By 2050, coastal communities can expect around 224 buildings to be at risk of a 1 in 100 year storm tide inundation event. If this scenario where to occur in 2100, it is estimated that 583 building would be exposed, with around 80% originating in Bowen.

Table 3: Number of buildings exposed to a 1%AEP storm tide inundation event in each coastal community

Interest Area	Number of buildings		
	Current Day	2050	2100
Airlie Beach	5	13	19
Bowen	34	172	466
Cannonvale	2	7	32
Dingo Beach	-	-	17
Hydeaway Bay	1	2	3
Shute Harbour	-	1	1
Wilson Beach	2	29	45
Total	**44**	**224**	**583**

Over half of the council parks are at risk of storm tide inundation by 2100, which is a 63% increase from current day exposure and equates to the area of 71 sporting ovals. At least 2.9 km of sandy beach is exposed to both current and future storm tide inundation in urban areas. In 2018, there are 13 km of infrastructure potentially impacted by a 1% AEP storm tide inundation event. This increases 7-fold by 2100 with over 90 km of infrastructure exposed (see Figure 3). By 2100, there could potentially be 25 km of roads, 33 km of sewer mains, 23 km of water mains, and 9 km of storm water exposed to storm tide inundation across all coastal communities.

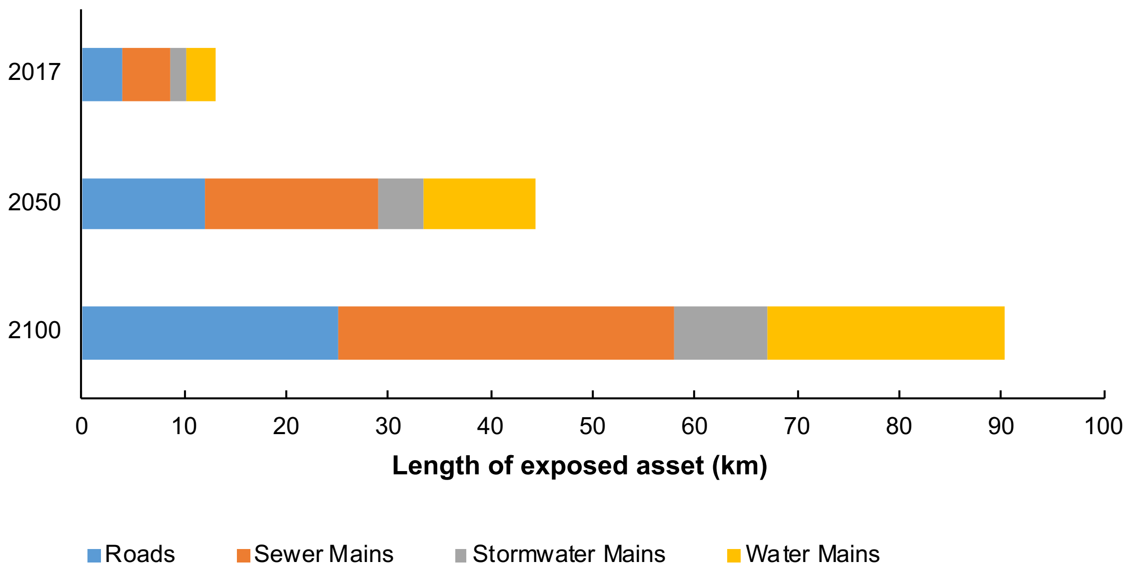

Figure 3: Length of assets exposed to storm tide inundation for each scenario (by asset subclass)

4.4 ECONOMIC COST OF EXPOSURE

During this project, economic values sourced from Council's financial databases were assigned to a range of assets, including property, transport, water, sewer and social assets. The results show the present value of assets exposed, which represents the current cost required to replace the assets.

For each coastal hazard, the economic cost of assets exposed is estimated to increase substantially in the future, under both the 2050 and 2100 planning horizons (see Figure 2). The replacement cost of assets exposed to coastal erosion is likely to rise by $123 million dollars from current day to reach over $126 million dollars in 2100.

For Whitsunday coastal communities, the present value of assets exposed to a current day 1% AEP storm tide inundation event is estimated to be $14 million. In the absence of adaptation, this is predicted to increase to $89 million dollars by 2060, and over $188 million dollars by 2100. These economic costs are likely to be higher for more intense storm tide inundation events (i.e. 0.5% and 0.2% AEP).

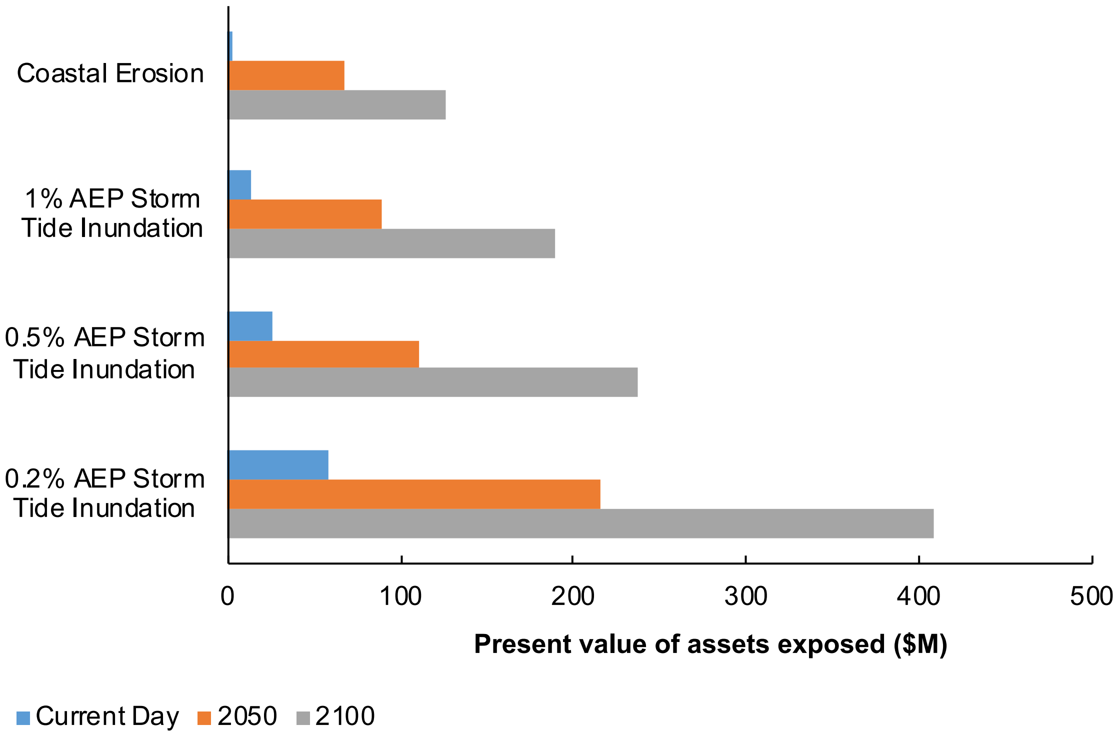

Figure 4: Present value of assets exposed to coastal erosion and storm tide inundation (across planning horizons)

Bowen is the coastal community with the highest economic risk to future coastal hazards (see Table 4). If a 1% AEP storm tide inundation event were to occur in 2100, 66% of the economic costs would originate from Bowen, making it the largest contributor to economic exposure compared with the other coastal communities (see Figure 5). In 2100, it is estimated to cost $51 million dollars to replace the assets exposed to coastal erosion and a further $117 million dollars from a 1 in 100 year storm tide inundation event (1% AEP).

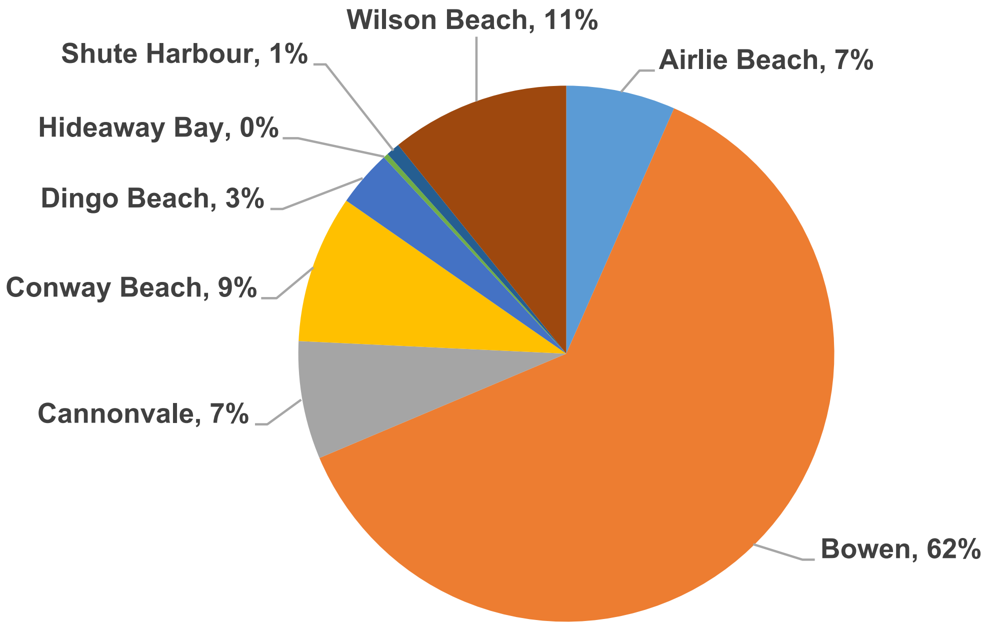

Figure 5: Percentage of economic costs to each coastal community from a 1% AEP storm tide inundation event in 2100

In Wilson Beach, it is likely to cost over $20 million dollars for assets exposed to a 1% AEP storm tide inundation event. Although, with few permanent residents this may present as an economic challenge for a small coastal town.

Table 4: Present value of assets exposed to coastal erosion and storm tide inundation in 2100 (each coastal community)

Coastal Community	Present value of assets exposed ($M)			
	Coastal Erosion	1% AEP storm tide inundation	0.5% AEP storm tide inundation	0.2% AEP storm tide inundation
Airlie Beach	0.9	12.4	13.7	15.1
Bowen	50.9	117.1	158.3	318.0
Cannonvale	6.5	13.4	18.2	23.4
Conway Beach	24.4	16.8	16.9	17.0
Dingo Beach	19.3	6.4	8.4	12.5
Hydeaway Bay	11.1	0.6	0.7	1.0
Shute Harbour	-	1.6	0.0	0.0
Wilson Beach	13.4	20.4	21.0	21.8
Total	**126.5**	**188.8**	**237.2**	**408.8**

Environmental assets

The 'Resilient Whitsunday' project also estimated the economic loss that ecosystem services in Whitsunday's coastal communities would experience from coastal hazards. It focused on four key environmental assets, these included: coastal forests, mangroves/saltmarshes, reefs/shoals and seagrass, and sandy beaches.

The environmental assets at greatest risk of coastal hazards are sandy beaches. For Whitsunday's coastal communities, the loss of sandy beaches to coastal erosion is estimated to cost around $65 million dollars in 2100. The expected losses of sandy beaches to a 1 % AEP storm tide inundation event is estimated to exceed $30 million dollars in 2100.

Sandy beaches affect three key stakeholder groups in the Whitsunday region, including:

- **Tourism businesses:** Tourism businesses rely on the regions unique and pristine environment as the primary tourist attraction to the region. Degradation of sandy beaches assets is likely to reduce tourist satisfaction which may result in less repeat visitation, reduced numbers of tourists visiting the region, and/or tourists staying for shorter periods of time (Stoeckl 2014). These risks are very important for the broader Whitsunday economy.
- **Local residents:** Local residents receive significant enjoyment from ecosystem-based recreation activities (such as fishing, diving and walking) as well as the visual aesthetic provided by these assets.
- **Whitsunday Regional Council:** Council currently maintain and remediate sandy beach areas in some key locations (e.g. Airlie Beach). If these responsibilities are to continue, then damage to these assets represents a substantial cost impost.

5 ASSESSING RISKS TO ASSETS

5.1 APPROACH

An important part of the 'Resilient Whitsunday' project was to identify key assets exposed to coastal erosion and storm tide inundation and estimate the level of risk posed by these coastal hazards. A risk assessment was conducted using information about an assets' exposure (consequence) combined with the probability of a hazard event occurring (likelihood) to determine the risk level to each asset. The risk assessment included an analysis of:

- Council-owned infrastructure assets (buildings, roads, water, sewer)
- Council-owned buildings and open space assets (buildings, coastal structures, open spaces)
- Building footprints (residential, community and industry buildings) created through spatial mapping
- Cultural sites and heritage places
- Environmental and ecosystem assets

The process aligned with the Australian standard for risk management AS/NZS ISO 31000:2009. The risk assessment followed three steps:

1. **Assess likelihood of occurrence:** The probability of each coastal erosion and storm tide inundation scenario occurring was determined (see Table 5). Five likelihood levels (consistent with the Australian standard) were considered. These include almost certain, likely, possible, unlikely, and rare.

Table 5: Risk likelihood rating for each coastal hazard scenario

Hazard Category	Planning Horizon	AEP (%)	Likelihood
Coastal Erosion	Current day	-	Almost certain
	2050	-	Possible
	2100	-	Unlikely
Storm Tide Inundation	Current day	1%	Unlikely
	2050	1%	Unlikely
	2100	1%	Unlikely
	Current day	0.5%	Unlikely
	2050	0.5%	Unlikely
	2100	0.5%	Unlikely
	Current day	0.2%	Rare
	2050	0.2%	Rare
	2100	0.2%	Rare

2. **Assess level of consequence for assets:** The anticipated impact on each asset was identified based on the severity of exposure. To achieve this, two consequence matrices (for erosion and inundation) were developed based on workshops with department stakeholders to identify key asset groups (i.e. property, transport, sewer, water, social, cultural and environment). Five levels of consequence were adopted including insignificant, minor, moderate, major and catastrophic.

3. **Assign the level of risk:** the risk to each asset (for erosion and inundation) was calculated using a risk matrix which combined the likelihood and consequence levels (see Table 6). The matrix includes four risk levels: low, medium, high and extreme.

Table 6: Risk matrix

		CONSEQUENCE				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
LIKELIHOOD	Almost Certain	Low	Medium	High	Extreme	Extreme
	Likely	Low	Medium	High	Extreme	Extreme
	Possible	Low	Medium	High	High	Extreme
	Unlikely	Low	Medium	Medium	High	Extreme
	Remote	Low	Low	Medium	Medium	High

5.2 SUMMARY OF RISKS TO ASSETS

The Project Team assessed a total of 3,472 risks to assets exposed to coastal hazards in the identified areas of interests. Since a plethora of information was obtained from the analysis, not all the results can be presented in this report. This section provides a collective summary of the number of asset subclasses assigned to each risk level for a current day event and 2100 planning horizon.

The hazard identified with the greatest risk was sea level rise inundation in 2100, with 20 assets receiving an 'extreme' level of risk (see Figure 4). There were also three asset subclasses which recorded an 'extreme' risk for a current day coastal erosion event. For a current day event, there are 12 assets with a 'high' risk for coastal erosion and 16 assets which received a 'high' level of risk under the 0.2% AEP storm tide inundation event (see Table 25). However, there are numerous assets which received a 'high' risk level for all coastal hazards under a 2100 planning horizon. In particular, there were 51 asset subclasses with a 'high' risk for the 1% AEP storm tide inundation scenario. This is of importance because these 'high' risk assets are considered to have a 'tolerable' risk which means they still require immediate to short-term action to reduce the risk to acceptable levels. Site specific risk summaries are presented in Section 7.

Table 7: Number of asset subclasses assigned to each risk level for coastal hazards under a current day event

Hazard Type	Number of asset subclasses assigned to each risk level				
	None	Low	Medium	High	Extreme
Coastal erosion in 2018	195		38	12	3
1% AEP storm tide inundation in 2017	149	82		17	
0.5% AEP storm tide inundation in 2017	145	81		22	
0.2% AEP storm tide inundation in 2017	142	77	16	13	

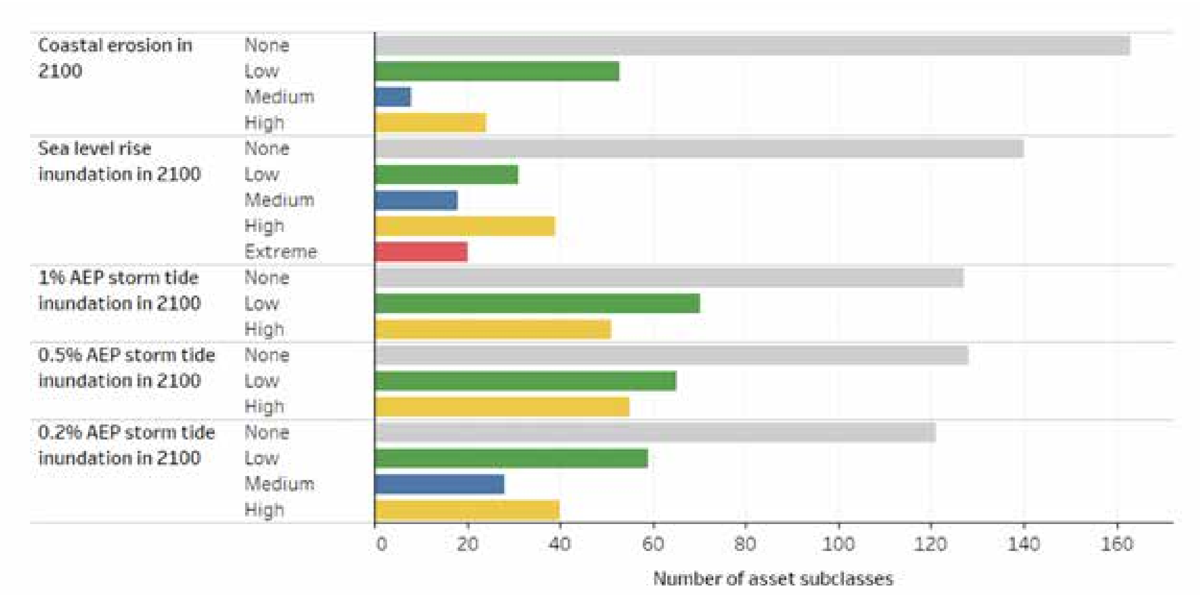

Figure 6: Number of asset subclasses assigned to each risk level for coastal hazards under a 2100 planning horizon

6 APPROACH TO ADAPTATION

Adaptation Response

MONITOR

At localities where the coastal hazard risk profile is low (according to the Strategic Plan), the adaptation response is to monitor risk and undertake existing maintenance/asset management activities. If, over time, the risk profile is observed to increase (as indicated by local trigger levels), then the adaptation response may shift to mitigate.

MITIGATE

At localities where coastal hazard risks have been identified the adaptation response is to actively mitigate the risk through implementing a range of adaptation options. Mitigation will be tailored to each locality, incorporating site-specific processes, community input, and statutory planning considerations. If, over time, the risk profile is observed to increase (as indicated by local trigger levels), and mitigation becomes infeasible (due to economic or other factors), then the adaptation response may shift to transition.

TRANSITION

In some specific areas within a locality, if the coastal hazard risk profile is very high (according to the Strategic Plan), and mitigation becomes infeasible (due to economic or other factors), a strategic decision may be made to transition to an alternative land use. Transition is likely to be a gradual process over time, where mitigating hazards for a period is part of the transition process.

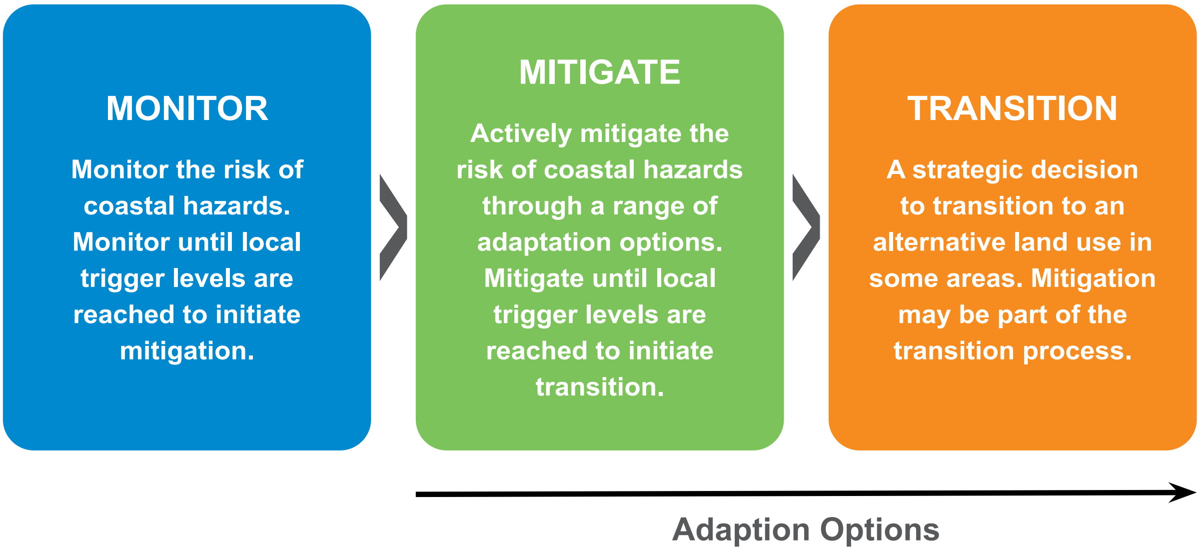

Figure 7: Adaptation response for Council owned land and assets

6.1 REGENERATIVE OPTIONS

Regenerative adaptation options are solutions which aim to mimic natural processes and are typically designed to "either improve or create existing coastal ecosystems and landforms [which] reduce the risk of coastal hazards" (Griffith University Centre for Coastal Management and GHD 2012). The regenerative options reviewed include beach nourishment, dune construction and regeneration, riparian corridors restoration and generation, and mangrove forests.

6.1.1 BEACH NOURISHMENT

Beach nourishment is primarily used as a soft engineering approach in response to coastal erosion, which involves the artificial addition of sand to a beach system that has a sediment deficit (Zhu, Linham and Nicholls 2010). This nourishment of a beach helps to dissipate wave energy, and when combined with dune regeneration, can provide protection from coastal recession and inundation from storm surges.

Beach nourishment not only maintains the natural values and aesthetics of the beach and coastline (Griffith University Centre for Coastal Management and GHD 2012) but also provides ecological benefits such as restoring dune habitat, and creating nesting sites and spawning areas. For example, the Ocean City Beach replenishment project (see Figure 3 and Figure 4) was initiated in 1988 to prevent further erosion to the beaches, and required periodic replenishment of beach sand every three years to maintain a stable beach profile (Van Ryswick 2016).

Beach nourishment is expensive and must be repeated periodically to maintain an adequate sand profile. The current cost of beach nourishment is estimated to be between $55 - $80 per cubic metre. These values were supplied by WRC who estimate it to cost $55 per cubic metre for Bowen and $80 per cubic metre for Airlie Beach for sourcing of sand from Don River, as well as delivery, spreading, and sand pushing and scraping.

Depositing sand onto beaches can also cause a range of adverse environmental impacts including burial of animals and organisms, increase in water turbidity, altered sediment compositions, and disruption of beach and ocean habitats (Dean 2002).

Figure 8: Airlie Beach sand nourishment

6.1.2 DUNE CONSTRUCTION AND REGENERATION

Sand dunes are a naturally formed vegetation barrier which store sand deposits and provide stability to the shoreline (CRD n.d.). Dune construction is when engineering solutions are used to create artificial dunes which mimic the functioning of a natural dune system (Griffith University Centre for Coastal Management and GHD 2012). Dune regeneration is the restoration of natural dunes to improve their overall ecosystem function (Zhu, Linham and Nicholls 2010), whilst also reducing the risk to coastal erosion and storm tide inundation.

The regeneration of sand dunes provides a range of coastal protection benefits including increased stability of dunes, habitat for specialised plants and animals, shade for beach users, and wildlife corridors (NCCARF 2016). For example, in Cronulla New South Wales, high foot traffic and damaged dune vegetation had resulted in areas of exposed, unconsolidated sands which were highly vulnerable to coastal erosion (see Figures 5 and 6). In 2015, regeneration works were commenced to restore the affected sand dunes which included installing new barricade fencing and wind barriers as well as revegetating the bare dunes with salt tolerant plants (Southern Habitat 2015).

Figure 10: Rose Bay dune restoration

The current costs for dune stabilisation can range from $5,800-$23,200 per hectare (Zhu, Linham and Nicholls 2010).This includes the depositing sediment onshore, shaping of sand using bulldozer, dune grass planting and fencing. In 2012, the dune restoration of Merimbula Beach cost a total of $40,833 including a project officer (Office of Environment and Heritage 2012).

Since sand dunes also pose a barrier to beach access, reconstruction of dunes may receive opposition from developers or the local community (Zhu, Linham and Nicholls 2010). In some cases, it may be unfeasible to restrict public access to areas of a beach which are frequently used for tourism and recreation.

Figure 11: Conway Bea sea wall built in 2020

6.1.3 RIPARIAN CORRIDORS RESTORATION AND GENERATION

Riparian corridors are vegetated zones which run alongside wetlands, rivers, estuaries and waterways (Land for Wildlife 2011). These systems are typically "comprised of vegetation (trees, shrubs, grasses and herbs), soils and topography" which regulates ecological processes and supports diverse biological communities (Beesley, et al. 2017). Restoration and generation projects reinforce the healthy functioning of riparian zones, allowing them to provide protection against rising sea levels and storm tide inundation (Zhu, Linham and Nicholls 2010).

Riparian corridors deliver a wide range of ecological and societal services including absorbing incoming storm energy and high river flows, providing recreational opportunities, and encouraging relaxation and connection with nature (Zhu, Linham and Nicholls 2010). For example, a large-scale restoration project was commenced in 2015 to protect, enhance and expand riparian vegetation along a section of the Maroochy River catchment (Sunshine Coast Council 2019). Over a four-year period, approximately 4.2 ha of land was restored with 11,000 native plants, and 9 ha rehabilitated through weed control and assisted regeneration techniques (see Figures 7 and 8).

Riparian corridor regeneration is generally expensive, and the costs can vary depending on the extent and characteristics of vegetation to be restored (Griffith University Centre for Coastal Management and GHD 2012). For this reason, community involvement is usually employed to reduce costs. The success of revegetation is also dependent on careful planning to avoid inappropriate selection of plant species and problems with stream stability (Land for Wildlife 2011).

There have been many riparian revegetation projects in the Whitsunday region over the last 25 years. It is estimated that between 200 and 250 small (<1ha) vegetation plots have been established in coast flowing waterways. In the period 2018 to 2021, approximately 1.5ha of Waite Creek and Twin Creek have been revegetated in Cannonvale with 4500 seedlings.

Figure 12: Twin Creek revegetation

Figure 13: Bowen see bee sea wall

6.1.4 MANGROVE FORESTS

Mangrove forests are increasingly being used as a natural coastal defence system to protect shorelines from coastal hazards (Spalding, et al. 2014). These natural systems bind and build up soils to help prevent coastal erosion, reduce wave damage from storm surges, and can contribute to sustaining land as sea levels rise.

A key benefit of mangroves forests over hard engineering structures is that they can adapt to changes in climate and self-repair after a coastal erosion or storm tide inundation event (Morris, et al. 2018). Mangroves also provide valuable resources (e.g. fish, timber) which can improve social resilience by helping communities recover after a natural disaster.

For example, University of Melbourne scientists are trailing mangrove forests as natural coastal defence structures to protect the shoreline of Port Phillip Bay. The project will use a 'hybrid' approach which "involves planting the mangroves within concrete cultivars that attenuate waves, accrete sediment and provide the right conditions for the forests to grow" (Morris, et al. 2018) (see Figure 9). Scientists believe these mangroves forests will reduce wave height and energy by trapping sediment and increasing the elevation of the land relative to sea level (Morris, et al. 2018).

Figure 14: Mangroves planted within concrete cultivars (Morris, et al. 2018)

Restoration of large areas of mangrove forest can be an expensive solution, with current costs calculated to be approximately US$6,200 (AU$9,000) per hectare (Tran and Tinh 2013). This was source from the Thi Nai Lagoon project which cost US$850,000[5] to restore 150 ha of mangrove forest. Natural coastal defence systems also require ongoing protection and management, and without appropriate planning, mangrove forests may not achieve the desired level of protection for the coastline (Morris, et al. 2018).

The Whitsunday Regional Council has not implemented any mangrove forest restoration works.

[5] ***Labour costs are likely to be higher in Australia***

Figure 15: Grays Bay sand bag wall

6.2 COASTAL ENGINEERING OPTIONS

Coastal engineering adaptation options are hard engineering solutions which are constructed with the primary purpose of protecting the shoreline from coastal erosion and storm tide inundation (Griffith University Centre for Coastal Management and GHD 2012). Coastal engineering options reviewed include artificial reefs, detached breakwaters, groynes and artificial headlands, sea dykes or levees and seawalls.

6.2.1 ARTIFICIAL REEFS

Artificial reefs are submerged structures designed to reduce the force of breaking waves and dissipate the energy which hits the beach (Cummings et al. 2012). They are typically constructed with either sand filled geotextile bags or rock/concrete blocks which are transported offshore and dropped at pre-determined locations based on design requirements (Griffith University Centre for Coastal Management and GHD 2012). A well-engineered artificial reef can protect the shoreline from coastal erosion, wave action and storm surges, whilst also promoting the growth of marine organism on reef structures.

Artificial reefs also provide recreational benefits through the improvement in surfing conditions, and creation of diving and snorkeling opportunities (Griffith University Centre for Coastal Management and GHD 2012). For example, in the 1999 an artificial reef was constructed off the coast of Narrowneck to protect the Gold Coast shoreline from coastal erosion (see Figure 10). The positioning of 400 prefabricated geotextile bags into a split-V pattern has successfully reduced the velocity of incoming waves and now accommodates a great abundance and diversity of marine species (Gold Coast City Council 1999).

The design and construction costs of building an artificial reef can vary considerably depending on the size and shape of the structure (Griffith University Centre for Coastal Management and GHD 2012). The Narrowneck artificial reef cost approximately $2.5 million in 2000 (Gold Coast City Council 1999), however City of the Gold Coast is currently constructing an artificial reef in Palm Beach, Gold Coast, which is estimated to cost $18.2 million (City of Gold Coast 2019).

Furthermore, a poorly managed artificial reef can cause damage to natural habitats through increase visitation presence, overexploitation of the reef resources or introduction of invasive species (Fabi, et al. 2015). Artificial reefs will require management costs to regulate such potential adverse impacts.

The Whitsunday Regional Council has not implemented any off-shore artificial reef projects.

6.2.2 DETACHED BREAKWATERS

Breakwaters are hard coastal structures which protect the shoreline from extreme wave energy and minimise coastal erosion by modifying wave transmission to the beach (Cummings, et al. 2012). Detached breakwaters are sloping walls which are constructed from rocks or concrete units and detached from the coast, forming an offshore structure (Webb 2016).

Detached breakwater can benefit a coastline by maximising sediment transport patterns and maintaining coastal stability. Innovative ecological designs can also be incorporated into these hard engineering structures to improve the functioning of coastal ecosystems and increase the diversity of aquatic habitats (New York State 2016). For example, living breakwaters were constructed off the coast of Staten Island in New York City using bio-enhancing concrete, a geotextile seabed, reef streets, reef ridges and oyster shell gabions (see Figure 11).

Figure 16: Inundation map, Wilson's Beach

Although breakwater require low maintenance, their construction costs are high with the current price estimated between EUR$11,000 and EUR$58,000 per linear metre or around AU$19,000 - $94,000 per linear metre (Climate-ADAPT 2015b). This is consistent with the Living Breakwaters project which cost around US$60 million (AU$86 million) to construct (New York State 2016).

The primary adverse impact of detached breakwaters that they reduce the longshore transport of sand which has the potential to cause or significantly increase erosion on neighbouring stretches of beach (Griffith University Centre for Coastal Management and GHD 2012). Additionally, breakwaters may have a negative impact on the coastal landscape when they are designed to protrude above the sea level (NCCARF 2016).

There are a number of rock breakwaters in the Whitsunday region associated with coastal marinas.

6.2.3 GROYNES AND ARTIFICIAL HEADLANDS

A groyne or artificial headland is a coastal protection structure that is built perpendicular to the shoreline and extends from the shore, over the beach and into the ocean (Climate-ADAPT 2015a). Groynes are designed to trap sand moving along the coast which makes them effective in controlling coastal erosion and longshore drift (Zhu, Linham and Nicholls 2010).

Figure 17: Geotextile groyne on Drummond Cove foreshore (City of Greater Geraldton 2019)

Their function increases the amount of sand on to the updrift side of the groyne which helps stabilise beaches, provides public space for recreation and fishing, and improves resilience of a beach against a coastal erosion event (Griffith University Centre for Coastal Management and GHD 2012). For example, in 2018 the City of Greater Geraldton constructed two low-crest 40m long groynes on the Drummond Cove Foreshore to reduce the impacts of coastal erosion (City of Greater Geraldton 2019) (see Figure 12). These geotextile groynes have been successful in retaining sand and reducing reliance on temporary sand nourishment operations (Everything Geraldton 2019).

A small geotextile groyne such as the ones built for the Drummond Cove Foreshore project are expected to cost around $3,100 per linear metre (City of Greater Geraldton 2019). However, costs are highly influenced by the size of the groyne, the type and availability of material used and transport rates. Groynes constructed from rock are more expensive and can start from around EUR$3,400 which is equivalent to AU$5,600 per metre (Climate-ADAPT 2015b).

There are numerous side effects to constructing groynes including reduced aesthetics of the coastal landscape, altered surfing conditions, restricted access to walking along the beach, and changes to coastal ecosystems (NCCARF 2016).

6.2.4 SEA DYKES OR LEVEE

A sea dyke is a coastal structure designed to "protect low-lying, coastal areas from inundation by the sea under extreme conditions" (Zhu, Linham and Nicholls 2010). A sea dyke consists of a sand core, a protective waterproof outer layer and a drainage channel (Page and Thorp 2010). Since sea dykes are primarily used to control extreme water levels associated with storm tides and sea level risk, they do not preserve beaches from the effects of coastal erosion (Zhu, Linham and Nicholls 2010). Sea dykes may also be referred to as embankments, levees, floodbanks and stopbanks.

The main benefit of sea dykes is they are often the cheapest hard defence solution which means they can provide a high degree of protection in low-lying coastal areas when the value of coastal land is low (Griffith University Centre for Coastal Management and GHD 2012). For example, the Scheveningen Boulevard is a curved dike which has been integrated with the esplanade to form a wave design (see Figure 13), separating the various uses of public space and maximising public recreational opportunities in the coastal zone (de Solà-Morales 2012).

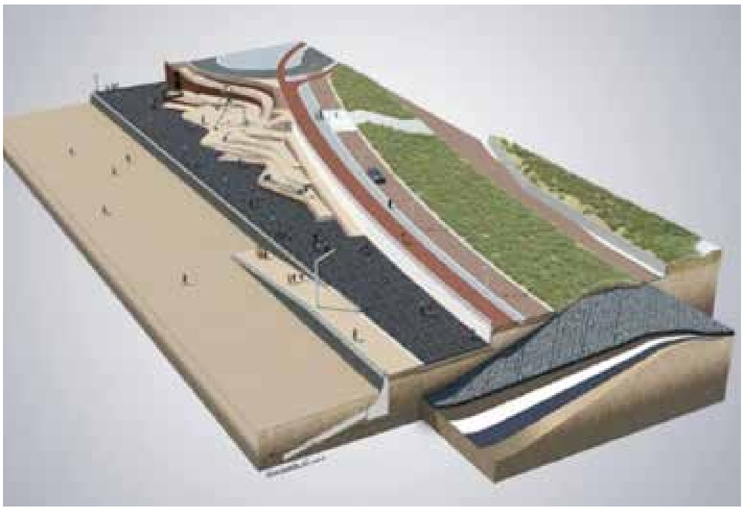

Figure 18: 3D model of dike redevelopment in The Hague (de Solà-Morales 2012)

Sea dykes can be expensive structures to construct with costs ranging between US$1 and 7.6 million per kilometre (AU$1.4 -$10.9 million per kilometre) depending on type and size of infrastructure and global location (Linham and Nicholls n.d.). Since sea dykes are elevated structures, there presence may act as a visual barrier between the community and the shore, causing negative impacts on the social connectivity and access to the beach (SGS Economics and Planning 2011).

6.2.5 SEAWALLS

Seawalls are hard engineered structures constructed as a last line of defence against coastal erosion and to protect the foreshore against storm tide inundation (Cummings, et al. 2012). Although seawalls can take many different physical forms (i.e. vertical, sloping) and be constructed from a range of materials (i.e. rock, concrete) (Zhu, Linham and Nicholls 2010), they are all designed to be a strong and durable barrier that can withstand the erosive forces of the ocean (Cummings, et al. 2012). Seawalls may also be referred to as revetments, which can be constructed from either rock or geotextile materials.

The primary advantage of seawalls is that they prevent any further erosion of beaches and protect against damage to coastal infrastructure during extreme storm surge events (NCCARF 2016). A well-designed seawall can also have ecological benefits such as providing potential marine habitats and promoting colonisation of species on hard substrates. For example, in 2016 the Elliott Bay Seawall was restored using various ecological features such as cobbled surfaces, shelves and native riparian vegetation on the wall's surface (see Figure 14). It also integrated light penetrating surfaces and shallower water habitats to promote marine growth (Seattle Department of Transportation 2016).

Construction of a sea wall is predicted to cost between $2,500 - $5,600 per linear metre. These values were supplied by WRC who calculated the cost of a 105m sea wall at Wilson Beach to cost $600,000 and also priced the 85m seabee seawall on the Bowen Golf Course at $330,000. They also noted that the Rose Bay sand bag sea wall cost about $2,500 per linear metre.

A key negative impact of seawall construction is the displacement of sediment from beaches, which can potentially affect the local economy through reduced scenic amenity and a loss of tourism and recreational opportunities (NCCARF 2016).

Figure 19: Illustration of the sea wall's ecological design (Seattle Department of Transportation 2016)

6.3 COASTAL SETTLEMENT DESIGN OPTIONS

Coastal settlement design options are innovative and sustainable solutions which respond to coastal hazards and facilitate the integration of appropriate development ideas within the coastal environment (Norman 2014). Coastal settlement design options reviewed include climate resilient design, elevated buildings, and raise land levels.

6.3.1 CLIMATE RESILIENT DESIGN

Climate resilient design involves using retrofitting and design measures to “improve the resilience of current buildings or to apply new standards to future developments” (Griffith University Centre for Coastal Management and GHD 2012). It is a successful tool in adapting a range of impacts brought on by climate change and, in the coastal environment, is particularly useful in protecting against sea level rise, coastal erosion and storm tide inundation.

A major benefit of these design measures is that they seek to reduce the vulnerability of a home to coastal hazards, allowing residents to safely live in these communities despite the known risks. The SURE HOUSE is a great example of sustainable design and technology that allows for the development of resilient homes in coastal areas that may be at risk due to rising sea levels and more damaging storms (see Figure 15). The features include roof integrated solar panels, a photovoltaic electric hot water system, triple-paned windows and a heat recovery ventilator (SURE HOUSE 2014). The SURE HOUSE also has marine design features such as durable plastic sheathing on the exterior walls and fibre-composite storm shutters which allow it to be more resilient against coastal inundation.

Figure 20: Aerial view of SURE HOUSE (SURE HOUSE 2014)

The estimated cost of climate resilient design is highly variable and depends on the type and size of infrastructure and the materials and design elements chosen. While a climate resilient design can improve the performance of a building, this comes with increased construction costs to meet design standards and adequately mitigate the future risk (Wang, et al. 2016). There are no known adverse impacts from adopting climate resilient design as an adaptation option.

6.3.2 ELEVATED DWELLINGS

Elevated dwelling are houses which have been raised so that the living space is located above the predicted height of inundation (Federal Emergency Management Agency 2014). Elevation involves raising the building onto walls, piles or stilts and can occur either during the initial construction phase or as a retrofitting method for an existing house. This adaptation option is suitable to accommodate for rising sea levels and inundation from storm tide events.

Figure 21: Illustration of elevated dwellings in Brooke Peninsula Lowestoft project (Assael 2016)

The key advantages of elevated dwellings are that they reduce the inundation risk to the property and its contents and therefore may also lower home insurance premiums (Federal Emergency Management Agency 2014). For example, the Brooke Peninsula Lowestoft project has transformed an existing marina site into a waterfront community which incorporates 850 private houses, which are elevate dwellings (Assael 2016). These houses are constructed on three-metre-high stilts above the ground and are designed to allow floodwaters to rise and fall underneath the houses whilst also providing a natural habitat for wildlife (see Figure 16).

The estimated costs are dependent on the size and design of the building; the type of engineering elements used to elevate the structure; and the extra construction required to ensure plumbing, electrical, and the energy systems align with building codes. Aside from the high construction costs, elevated dwelling may also limit access to the property or adversely affect the structure’s appearance (Federal Emergency Management Agency 2014).

6.3.3 RAISE LAND LEVELS

Raising the level of low-lying land above a predicted inundation level can be an effective option to adapt to impacts caused by sea level rise and storm tide events (Zhu, Linham and Nicholls 2010). The purpose of raising land levels is to avoid inundation of new developed land or redevelopments within high coastal hazard areas.

An advantage of raising land level is that this response can be combined with other adaptation options such as beach nourishment to provide coastal defence benefits (Zhu, Linham and Nicholls 2010). The cost of raising land levels will depend a range of factors including individual location, adaptation needs, and availability and cost of fill. However, it is estimated to cost between $12 and $35 per square metre to raise the land level by one metre (Griffith University Centre for Coastal Management and GHD 2012). There may be some cases were Council is able to source the fill material for free.

It should be noted that any raising of land may have adverse impacts. Depending on the design and the scale of the raised land levels adverse impacts including displacement of inundation water into neighbouring properties.

6.4 PLANNING OPTIONS

Planning adaptation options are solutions which seek to control development and reduce the current urban footprint in high hazard risk areas (Griffith University Centre for Coastal Management and GHD 2012). Planning options reviewed include land use planning, development setbacks, limited development, redefining planning objectives (rezoning), land swap, land buy-back, land surrender, and compulsory land acquisition.

6.4.1 DEVELOPMENT SETBACKS

Development setbacks are defined as a prescribed distance to a coastal feature within which all or certain types of development are "restricted, prohibited or regulated by specific development controls" (Griffith University Centre for Coastal Management and GHD 2012). They provide protection against coastal erosion, sea level rise and storm tide inundation by restricting the placement of buildings, structures or uses within an area susceptible to these hazards (see Figure 17). A buffer can also be added to the development setbacks as an additional safety margin which allows for ongoing utilisation of the lot but reduces the chance of the hazard affecting the building.

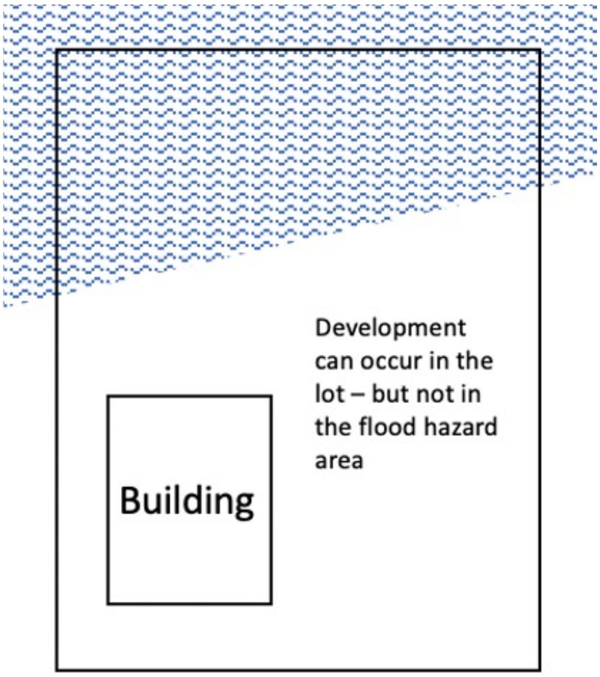

Figure 22: Diagram of development setback

Development setback are not only highly effective at minimising property damage, but they also help to maintain the shoreline access and protect the natural appearance of the coastline (Zhu, Linham and Nicholls 2010). By preventing development directly on the seafront, development setbacks serve to provide added public open space for recreation and tourism. For example, in Florida the construction of major structures is prohibited seaward of a 30-year erosion-based setback line (NOAA 2012). This development setback is determined by multiplying the average erosion rate by 30 and referencing the minimum setback distance from the seasonal high water line.

The expense of development setbacks is related to conducting a reliable technical study which is estimated to cost between $58,000 and $580,000, depending on data availability and length of the shoreline (Griffith University Centre for Coastal Management and GHD 2012). Additional costs may arise from any requirements to enforce existing policies within the developed areas.

A major disadvantage of development setbacks “is that they are vulnerable to a changing sea line and specifically sea level rise” (Risc-kit 2019). Over time, as the sea level increases the size of the buffer zone between buildings and the coastal hazard will reduce. As such “setbacks will need to be periodically reviewed to ensure that buffer zones continue to provide sufficient protection” (Climate Tech Wiki 2019). Council should also ensure that the provision of utilities and servicing to the site can still be maintained (e.g. sewerage systems).

6.4.2 LIMITED DEVELOPMENT

Councils can adopt and use time and/or trigger limited development consent conditions to accommodate for coastal risks on future development. For example, section 65 of the Planning Act 2016 states that “A development condition may (a) limit how long (i) a lawful use may continue; or (ii) works may remain in place” (The State of Queensland 2019). Time limited consents allow for continued use of coastal areas “until such times as coastal risks threaten life and property” (Department of Planning 2010). Whereas trigger limited measures often use a trigger point (i.e. the erosion receding to a calculated distance from the property boundary) to prompt the review of a development (Department of Planning 2010).

Furthermore, Council can, in their planning scheme, specify a limited development zone which restricts the ability of at-risk land to be developed for urban purposes. This was a recommendation brought forward by the Queensland Floods Commission of Inquiry (2012) who suggested that “Councils should consider using the limited development (constrained land) zone in their planning schemes for areas that have a very high flood risk”. For example, Moreton Bay Regional Council has implemented a limited development zone code into their planning scheme which seeks to:

a). “Identify land known to be affected by extremely unacceptable intolerable flood and/or storm tide risks which pose severe restrictions on the ability of land to be developed for urban purposes.
b). Limit any further urban development and promote transition of existing uses away from the areas of extremely unacceptable intolerable risk.” (Moreton Bay Regional Council 2019)

6.4.3 REDEFINING PLANNING OBJECTIVES (REZONING)

Rezoning is a process by which land or property is assigned a different category (zone) which changes the purpose and permitted uses of the property (Farlex 2019). Under the Queensland planning system, very little development is ‘prohibited’ which essentially enables a development application to be lodged for anything (Consult Planning 2017). Since there is no need to rezone land under this performance-based system, rezoning is not available in Queensland. This places the responsibility on local governments to ensure their planning schemes have clear policies to restrict or control inappropriate uses (Consult Planning 2017).

When making or amending a local planning instrument, local governments must redefine their planning objectives to ensure that a development approval can be refused in areas which are at risk from coastal hazards. Currently, local governments are required to appropriately integrate all relevant state interests in the State Planning Policy into their local planning instruments (The State of Queensland 2017). This includes the state interest of 'natural hazards, risk and resilience' which ensures that:

> *The risks associated with natural hazards, including the projected impacts of climate change, are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards. (The State of Queensland 2017)*

To achieve this, a local planning instrument should include clearly define planning objectives which control the extent or type of development in a coastal hazard area in a way which mitigates the risks to people and property.

6.4.4 LAND USE PLANNING

Land use planning is a mechanism which allows local governments to prevent inappropriate development in areas vulnerable to coastal hazards (Norman and Gurran 2016). While some of the planning options, such as development setbacks, land swap, land buy-back etc, are effective for hazards that affect small-scale areas other visionary strategic planning may be warranted for larger communities. These land use planning measures generally involve zoning, building codes (i.e. minimum floor heights) and land use permits (Climate-ADAPT 2015a).

Because of its broad scope of application and flexibility, land use planning is a valuable vehicle for implementing strategic adaptation options (Maddocks 2010). Some of the benefits include enhancing prevention and preparedness against coastal erosion and sea level rise and/or facilitating the response and recovery from a storm tide event (Bajracharya, Childs and Hastings 2011). For example, planners in the neighbourhood of North Beach Village, Fort Lauderdale, explored a range of planning scenarios - from business-as-usual and soft defence to strategic retreat and land adjustment (see Figure 18) - to address the issues of inundation through drainage infrastructure during high tide events (Huber, et al. 2017).

No additional costs will be required above that associated with the already required planning scheme revision process (see statutory instruments in Appendix A for more details). However, there is potential for a lack of information, resourcing and tools within local government to result in failure to identify and implement policies and measures to address climate change risks (Downes and Storch 2014).

Figure 23: Land use planning scenarios to address inundation in North Beach Village (Huber, et al. 2017)

6.4.5 LAND SWAP

A voluntary land swap is an adaptation measure that allows a property owner to exchange their parcel of land in an at-risk location with another parcel provided by the government. They seek to protect land ownership whilst also mitigating the impacts of coastal erosion and storm tide inundation (Zhu, Linham and Nicholls 2010). The land swap can be triggered by an extreme event (e.g. Grantham flood voluntary land swap) or through the identification of high-risk hazards (e.g. from new coastal modelling).

A land swap typically involves the exchange of land for mutually beneficial outcomes, whereby property owners receive land with improved development potential outside of the coastal hazard area and the government is provided with land which can be re-purposed for environmental and recreational uses (GHD 2016). In the Grantham example, Lockyer Valley Regional Council purchased freehold land outside a flood zone and offered land swaps to residents who were affected by the 2011 flood (see Figure 19). The land swap was done at a whole of community scale – which also provided social benefits as well as flood reduction measures (Lockyer Valley Regional Council 2012).

The estimated costs for land swap depend on the size of the land to be swapped, and the current value of properties in the local area, and the characteristics of the land or dwelling (Griffith University Centre for Coastal Management and GHD 2012).

With land swap programs there is a considerable risk that the “land may remain unused for any purpose for an extended period of time” (QFCI 2012). Appropriate planning is required to ensure a successful exchange of land, which includes decisions about the future use of the land exposed to coastal hazards.

Since land swaps are voluntary there is no legal framework for these programs in Queensland. However, the Acquisition of Land Act 1967 provides provisions for land acquisition (see Section 5.8.9).

Figure 24: House relocation during Grantham land swap program

6.4.6 LAND BUY-BACK

Land buy-back is when a property owner willingly sells his or her property, usually to the local or State government (QFCI 2012). The buy-back of properties provides a solution to mitigate the impact to existing buildings which are exposed to coastal erosion, sea level rise and storm tide inundation.

A key benefit of land buy-back is that it mitigates risk to life from inundation which in some cases may be the only feasible and economically justified adaptation option (QFCI 2012). Not only does it allow local government to ‘lock-up’ vulnerable land and protect it from future development but it also facilities the natural coastal processes in buffering the coastline against sea level rise and storm surge (Zhu, Linham and Nicholls 2010).

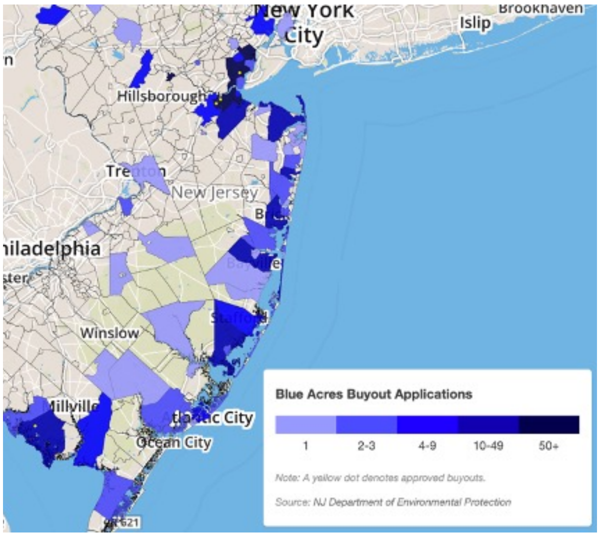

Figure 25: Blue Acres buyout applications in Philadelphia (State of New Jersey 2019)

For example, the Blue Acres program, run by the New Jersey Government (USA), has purchased over 400 homes that are deemed to be in at-risk locations (State of New Jersey 2019).

The estimated costs for land buy-back depend on the size and location of the land parcel, and the characteristics and land value of the asset to be purchased. (Griffith University Centre for Coastal Management and GHD 2012).

Since land buy-back programs are expensive, a lack of available funding is the main factor limiting their implementation as an adaptation option (QFCI 2012). For this reason, they only occur when the government deems the property to be at too high a risk to allow ongoing or future use of the land. An option for council is to recoup some of the investment of purchasing the property through leasing the property out until the hazard becomes too high a risk to manage.

The mechanisms available to a local government for land buy-back include land surrender and compulsory land acquisition (see Sections 5.4.8 and 5.8.9).

6.4.7 LAND SURRENDER

Legislative provisions in the Coastal Protection and Management Act 1995 enable local government to "require the owner of prescribed land to surrendered all or part of their prescribed land to the State for coastal management." (The State of Queensland 2019) Land surrender only applies when a landowner proposes to subdivide land to create new lots (i.e. reconfiguring a lot) that is located within a declared erosion prone area and a coastal management district – also known as 'prescribed land' (DES 2018).

The advantage of land surrender is that it uses statutory mechanisms to remove the risks of coastal erosion for future development by place vulnerability land into State ownership to be used as a reserve for coastal management. There is no compensation offered for land surrendered and the landowner must also comply with all requirements (DES 2018).

6.4.8 COMPULSORY LAND ACQUISITION

The local government may exercise their power to compulsorily acquire, or resume land for various purposes (DSDMIP 2018). Section 5(b)(i) of the Acquisition of Land Act 1967 states that land may be taken and subject to the Act "where the constructing authority is a local government… for any purpose set out in schedule 1 which the local government may lawfully carry out." (The State of Queensland 2018a).

This means that local governments may compulsorily acquire land for "management, protection or control of the seashore, estuaries and land adjoining the seashore and estuaries" (Schedule 1 – Part 5) and for "flood prevention or flood mitigation" (Schedule 1 – Part 7) (The State of Queensland 2018a). This would be an effective option for councils to protect an area which is highly exposed to coastal erosion, sea level rise or storm tide inundation.

Compulsory land acquisition can be sought at any time with or without the landowner's agreement. The landowner is entitled to compensation for the land being resumed, with the amount payable based on an independent valuation of the property, principles set out in the Acquisition of Land Act 1967, and previous decisions of the Land Court of Queensland (The State of Queensland 2018b).

6.5 INSTITUTIONAL OPTIONS

Institutional options are governance arrangements and programs that seek to address the impacts of coastal hazards through the creation of policies and legal frameworks, and the allocation of resources (Nobel, et al. 2014). Institutional options reviewed include monitoring of climate change adaptation governance and maintain the status quo.

6.5.1 MONITORING OF CLIMATE CHANGE ADAPTATION GOVERNANCE

A Climate Change Governance Assessment is a framework developed by Climate Planning to understand how effectively climate change considerations are integrated into the corporate operations and governance of local governments and State agencies.

The key benefit of this assessment is that provides a consistent approach which allows local governments the ability to monitor and improve their performance over time. A good example is the Queensland Climate Resilient Councils (Q CRC) program in which LGAQ and the DEHP are working with Queensland local governments to strengthen internal council decision-making processes to respond to climate change. The framework identified a range of deficiencies in how councils were mainstreaming climate change adaptation (see Figure 21) and has allowed the Q CRC program to facilitate peer-to-peer learning and improve mainstreaming of adaptation in Queensland local governments.

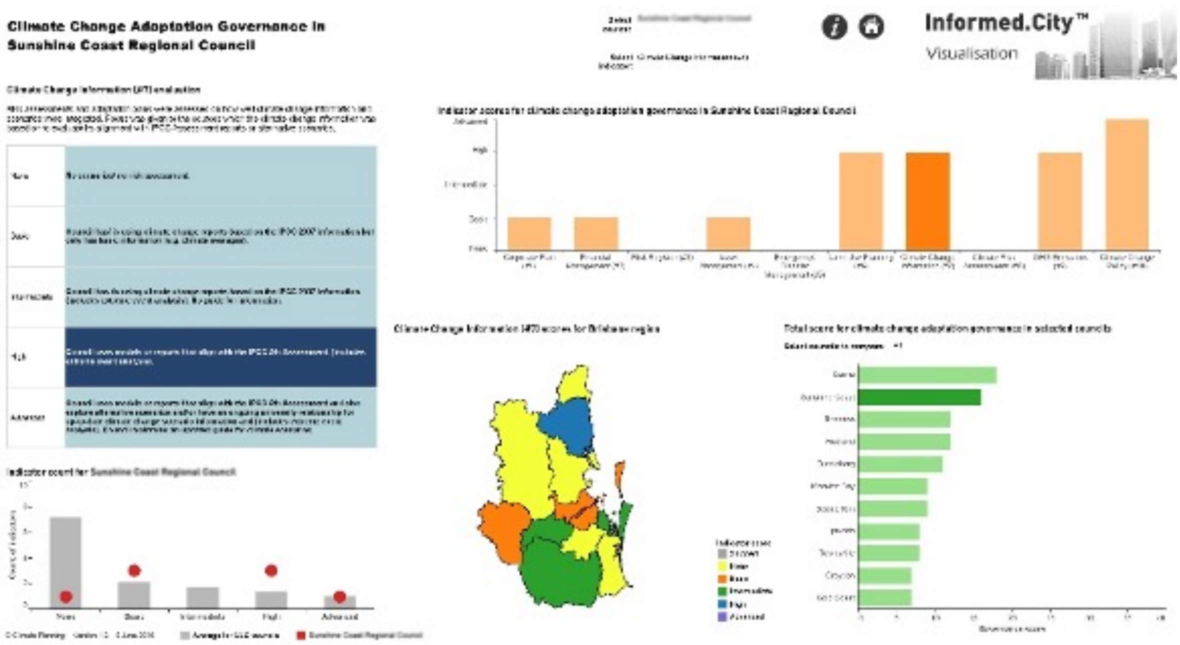

Figure 26: Visualisation of climate change adaptation governance framework (Climate Planning 2019)

6.5.2 MAINTAINING THE STATUS QUO

Maintaining the 'status quo' is where a local government "allows for continuation of the existing use in an area but prevents any further intensification of those uses" (Griffith University Centre for Coastal Management and GHD 2012). Under this approach a local government recognises that there are already existing planning controls in place to protect properties from coastal hazards, however, would not be taking any specific action (i.e. defend, accommodate, retreat) or proactively implement new activities to adapt to climate change. This adaptation option still permits landowners to apply for works to defend their land or to accommodate the impacts of coastal hazards using Council's existing planning mechanisms (Griffith University Centre for Coastal Management and GHD 2012).

The status quo will typically be maintained until there is a trigger which places pressure on a local government to respond. Such triggers may include number of cyclones within a short period of time, market shifts, changes in property insurance, decreased mortgage availability etc. In cases where defending, accommodating or retreating are not unfeasible or cost effective, maintaining the status quo may be the preferred option.

6.6 SOCIAL OPTIONS

Social options are educational, technological or serviced-based initiatives which consider vulnerability of communities to climate change and seeks to enhance their adaptive capacity (Nobel, et al. 2014). Social options reviewed include raising community awareness, knowledge sharing, hazard mapping, coastal imaging techniques, and communicating through social media.

6.6.1 RAISING COMMUNITY AWARENESS

Education and raising community awareness about climate change and coastal hazards impacts can help to build more resilient communities. Gaillard (2012) explains that most "community-based education programs focus on raising awareness, by disseminating information on climate change and related topics." A successful planned and administered education program not only achieves a high level of public awareness of climate change but also as the potential to facilitate action and social change (Gaillard 2012).

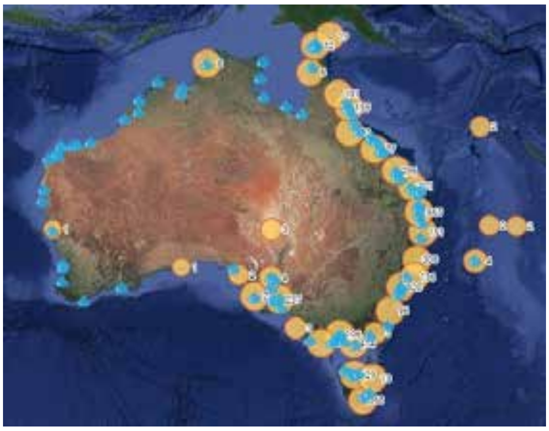

Figure 27: Diagram of development setback

The advantages of raising community awareness are that it assists scientists and decision makers to prepare for future climate change risks, enables decision making, and increases the capacity of communities to adapt (UNESCO 2019). Witness King Tides is a great example of a projects which provides people with a platform where they can be engaged about coastal hazards affecting their community. Participants are encouraged to take photographs of their local shoreline during very high tide events and upload the images to an interactive map (see Figure 22). With over 5,300 photos uploaded since 2012, the Witness King Tides has created a community narrative which can help people imagine what future coastal inundation may look like as sea levels rise (Green Cross Australia 2016).

The costs for raising community awareness are related to planning, communication, set-up and delivery of the education program or engagement event. There are no known adverse impacts from raising community awareness about climate change and the associated coastal hazard impacts.

6.6.2 KNOWLEDGE SHARING

Knowledge sharing can be described as the mutual "exchange of ideas and experiences through networks of relationships", with the goal of discovering new knowledge and insights (Blane 2009). There are a range of knowledge sharing tools which promote education and awareness of coastal hazards, engage the community about climate change risks, and facilitate decision making on adaptation options (NCCARF 2016).

Knowledge sharing is a powerful instrument for improving adaptive capacity and can have wide-reaching benefits for involved stakeholders. These include empowering community to learn about climate science, allow scientists to understand applications of their research, and encourage policy makers to consider and support all facets of the community (Sutherland 2013).

For example, in 2010 the Climate Adaptation Knowledge Exchange (CAKE) was launched by EcoAdapt "to build a shared knowledge base for managing natural and built systems in the face of rapid climate change" (EcoAdapt 2019). The online platform provides clearly organised case studies, a directory of practitioners to share knowledge and strategies, and community forums to discuss current issues on climate change adaptation (see Figure 23).

Costs are generally associated with planning, communication, set-up and delivery of the knowledge sharing platform which may take the form of an online information portal, desktop or mobile application, information session or public forum, or a permanent space for discussions (e.g. 'Lab'). There are no known adverse impacts from implementing knowledge sharing as an adaptation option.

CAKE can be accessed from: https://www.cakex.org/

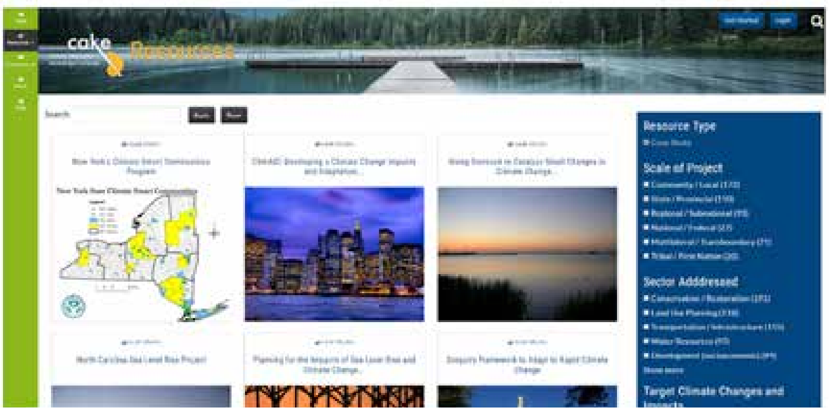

Figure 28: CAKE Resources portal (EcoAdapt 2019)

6.6.3 HAZARD MAPPING

Hazard mapping is defined as “the visual display of the spatial distribution of a natural hazard” (Champalle, et al. 2013). Maps are useful for spatially representing the distribution of current and future hazard events such as coastal erosion, sea level rise and storm tide inundation. Their purpose is to show differences in exposure of the hazards (i.e. variations in inundation depth) and consolidate knowledge of the hazards for a specific location (Champalle, et al. 2013).

Hazard maps offer a range of benefits including facilitating spatial planning, informing infrastructure design, and supporting emergency management (Champalle, et al. 2013). Recent advancements in GIS analysis techniques their integration with website interfaces have seen hazard mapping be adopted as an online decision support tool for climate change issues. For example, the Coastal Resilience project was launched in 2013 to enable communities and coastal managers to visualize the risks imposed by coastal hazards (The Nature Conservancy 2016) (see Figure 24). The web mapping tool uses Esri’s ArcGIS API for JavaScript and ArcGIS Online base maps which supports the overlay social, economic, and coastal habitat data with sea level rise and storm surge scenarios (Ferdaña 2014).

The costs for hazard mapping are related to the collection and collation of information, analysis and manipulation of data, transformation of spatial layers, and presentation of desired information and mapping in an online platform. There are no known adverse impacts from implementing knowledge sharing as an adaptation option.

Coastal Resilience Australia can be accessed from: https://maps.coastalresilience.org/australia/

Figure 29: Inundation to 1-in-100 year storm tide level for current (2009), 2040, 2070 and 2100 (The Nature Conservancy 2016)

The Whitsunday Regional Council has coastal hazard mapping available the website.

6.6.4 COASTAL IMAGING TECHNIQUES

Coastal imaging is a popular technique used by coastal manager to quantify and document coastline behaviour. It involves installing video cameras on high structure and programming them to automatically collect, analyse and store a time-series of images (Water Research Laboratory n.d.).

The key benefit of coastal imaging is that it provides 'real-time' reporting of the coastal processes and visual comparison of shoreline changes over time (Water Research Laboratory n.d.). Coastal imaging is also valuable tool for coastal managers to understand how beaches respond to environmental drivers (i.e. waves, water levels and currents) and develop strategies to better protect beaches and manage coastal assets (Blacka 2017). For example, in 2004 Water Research Laboratory installed an ARGUS coastal imaging station to monitor the beaches of the Narrabeen-Collaroy (see Figure 26). The five monitoring cameras record images of the coastline every 30 minutes (Water Research Laboratory 2019). The station has automatically mapped over 50,000 high-resolution shoreline datasets, which is the most extensive dataset of shoreline change recorded (see Figure 25).

Figure 31: Location of the Narrabeen-Collaroy coastal imaging station (Water Research Laboratory 2019)

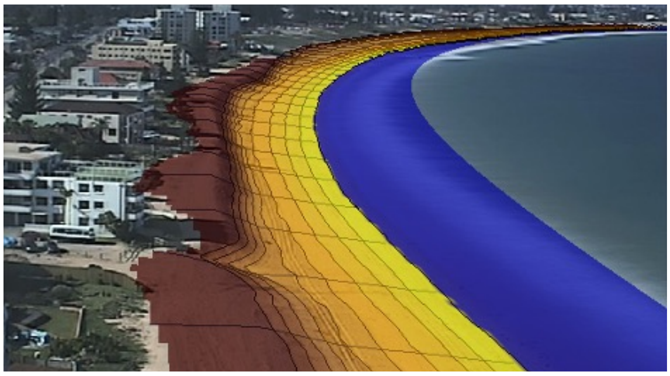

Figure 30: Tweed River Entrance Sand Bypassing Project camera locations (Water Research Laboratory 2019)

The initial costs of installing a coastal imaging station are likely to be expensive. In addition, a data technician with skills in photogrammetric processing may also be required to generate or analyse datasets, which introduces additional costs for data collection and processing (Westoby, et al. 2018). There are no known adverse impacts from conducting coastal imaging techniques as an adaptation option.

6.6.5 COMMUNICATING THROUGH SOCIAL MEDIA

Social media is increasingly be used to communicate news and information about climate change. Such tools encourage greater knowledge sharing of climate change science, provide a platform for discusses complex issues and challenges, and facilities climate change action (Anderson 2017). Furthermore, lessons learned from natural disasters which have occurred around the world in recent years have shown social media to be an integral communication tool for emergency response (Simon et al. 2015).

A key benefit of using social media to communicate climate change is that it creates a more personalised experience about the impacts, discussion topics and current events, and therefore makes it easier for the user to engage with the issue on an individual level (Anderson 2017).

For example, during the 2010 Queensland floods residents turned to social media platforms such as Facebook and Twitter to find out information about road closures, flood warnings, offers of assistance and ways to donate. When flooding in Brisbane peaked there were up to 1,100 tweets recorded every hour on Twitter (Catriona Pollard Communications 2016) (see Figure 27). In addition, social media activity surged after the flash flooding events in Toowoomba, with 11-fold increase in the number of 'Likes' to the QPS Facebook page (Ehnis and Bunker 2012).

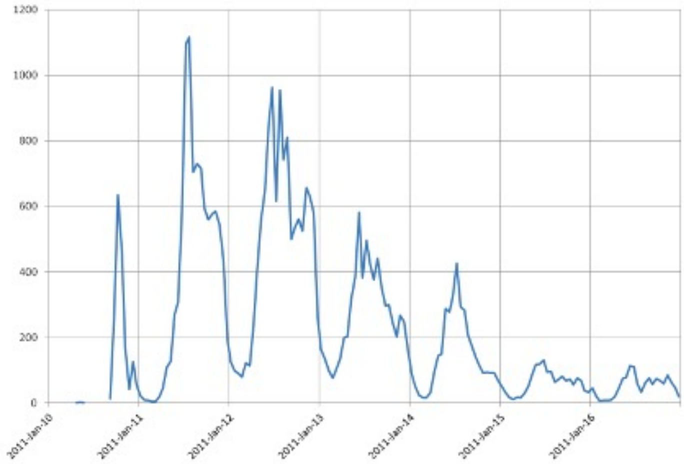

Figure 32: QPS Twitter tweets during Brisbane floods (Catriona Pollard Communications 2016)

The costs would largely depend on the purpose of the communication. It may include set up and monitoring social media platforms, online forums to increase community awareness, support during emergency events, or engagement for climate change initiatives.

The negative effects of social media are that it allows for opinion-based discussions which may not be supported by climate science and provides a place for framing of climate change from a sceptical viewpoint (Anderson 2017).

CHAS Adaptation Actions

The adaptation actions that are included in this Strategy follow four key themes:

1. Planning and governance
2. Region-wide resilience initiatives
3. Coastal infrastructure design
4. Coastal management and engineering

Theme		Adaptation Option	Description
1	**Planning and governance**	Land use planning	Preventing development in areas vulnerable to coastal hazards. This may also include development setbacks, limited development and rezoning.
		Mainstreaming climate change into Council decisions	Ensure climate change is embedded into asset management, financial planning and risk register.
		Monitoring of climate change adaptation governance	Integrating climate change into corporate operations and governance.
		Managed retreat	Planning for future relocation of a property or community. This may include land swap, land buy-back, land surrender and compulsory land acquisition.
2	**Region-wide resilience initiatives**	Raising community awareness	Raising community awareness about climate change through education program and social media.
		Knowledge sharing	Facilitating knowledge sharing and education on coastal hazards and adapting to climate change.
		Community stewardship	Developing programs and partnerships to enhance stewardship of the coastline.
		Monitoring	Monitoring changes in coastal hazard risk and effectiveness of adaptation (e.g. hazard mapping, coastal imaging)
		Explore financial options	Undertake research that explores financing adaptation. Focus on site specific options.

Theme	Adaptation Option	Description	
3	**Coastal infrastructure design**	Climate resilient design	Using retrofitting and design measures to improve the resilience of buildings
		Elevated buildings	Raising existing buildings onto walls, piles or stilts.
		Raising land levels	Raising the level of low-lying land
		Modifying critical infrastructure	Modifying drainage, raising floor levels or relocating critical infrastructure
4	**Coastal management and engineering**	Beach nourishment	Adding sand to the beach which has a sediment deficit.
		Dune protection and maintenance	Restoring natural dunes and retaining coastal vegetation
		Coastal revegetation	Planting of riparian corridors or mangrove forests
		Structures to protect against coastal erosion	Constructing hard structures to assist with sand retention (e.g. breakwaters, groynes, artificial headlands or artificial reefs)
		Structures to minimise storm tide inundation	Constructing hard structures to protect from storm surges and sea level rise (e.g. seawalls, revetments, sea dykes or levees)

Table 8 Summary of general adaptation approach for each area of interest.

	Adaptation Response			
	Current day	**2030**	**2050**	**2100**
Airlie Beach	Monitor	Mitigate (Soft)*	Mitigate (Hard)	TBC
Bowen (Queens Beach)	Monitor	Mitigate (Soft)*	Transition*	Transition*
Bowen (Rose Bay)	Monitor	Mitigate (Soft)*	Transition	Transition*
Bowen (Bowen South)	Monitor	Mitigate*	Mitigate*	Transition
Cannonvale	Monitor	Mitigate (Soft)*	Transition	Transition*
Conway Beach	Monitor	Monitor	Mitigate*	Transition
Dingo Beach	Monitor	Monitor	Transition	Transition
Hydeaway Bay	Monitor	Monitor	Transition	Transition
Shute Harbour	Monitor	Monitor	Monitor	Mitigate
Wilsons Beach	Monitor	Mitigate (Soft)	Transition	Transition

** Indicating subject to cost - benefit analysis*

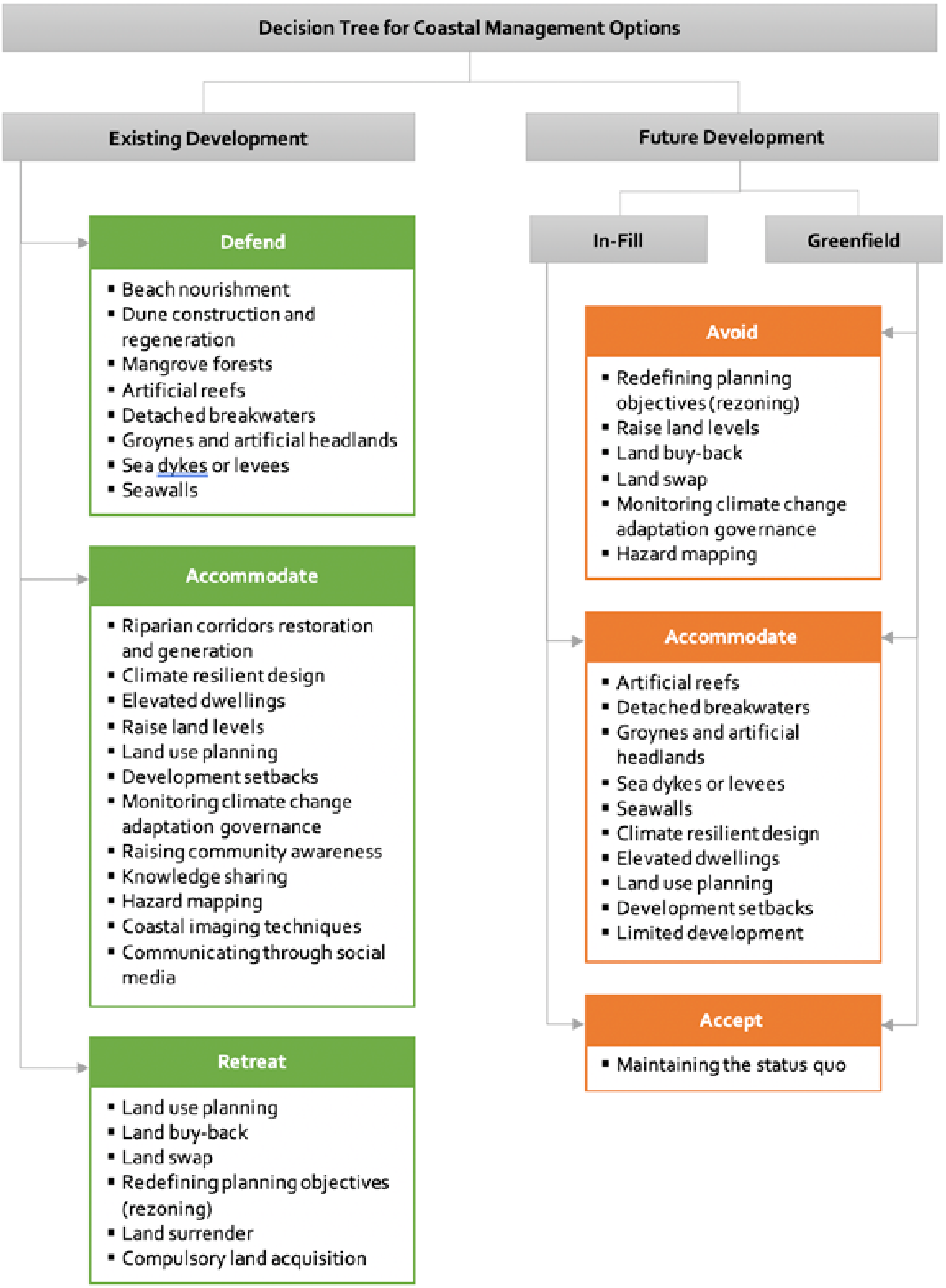

Figure 33: Decision tree for coastal hazard adaptation options

7 LOCATION SUMMARIES

The following information provides a summary of each of the key locations. The risks presented in this summaries are for the 2100 planning horizon. Other periods are provided in the supporting technical reports.

7.1 AIRLIE BEACH

Summary of risks

In Airlie Beach, there are 20 asset subclasses (65%) with no immediate risk of coastal erosion under a 2100 planning horizon (see Table 17). In addition, there are 10 assets with a 'low' risk level as well as one asset, water mains, which recorded a 'high' risk and is therefore considered a 'tolerable' risk.

Of the assets potentially exposed to sea level rise inundation in 2100, six have a 'low' risk level and another six recorded a 'medium' risk. Furthermore, seven assets in Airlie Beach have a 'high' risk including community properties, council buildings, industry properties, bridges, heritage places, Queensland Threatened Species and sandy beaches. Since water mains have an 'extreme' level of risk it has also been categorised as an 'intolerable' risk which requires immediate action to reduce the risk to sea level rise inundation in 2100.

For storm tide inundation in Airlie Beach, only nine assets (29%) show no immediate risk for all AEP scenarios. There are 10 assets which received a 'low' risk level across all storm tide inundation events, some of which include council buildings, bridges, and heritage places etc. Under a 1% AEP storm tide inundation scenario, there are nine assets in Airlie Beach which recorded a 'high' level of risk and the exposure of those assets is as follows:

- 3 community buildings exposed to a water depth 1.2m or higher
- 4 industry buildings exposed to a water depth 1.2m or higher
- 11.7% of sewer mains
- 7.3% of sewer manholes
- 50.0% of sewer pump stations
- 12.1% of storm water mains
- 5 electricity substations
- 57.9% of parks
- $740,755 in replacement costs for sandy beaches

Also, there are eleven asset subclasses which recorded a 'high' risk under a 0.5% AEP storm tide inundation event, and seven assets for the 0.2% AEP scenario. For strategic planning, the 'high' risk assets are considered to have a 'tolerable' risk which means they still require immediate to short-term action to reduce the risk to acceptable levels. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Airlie Beach.

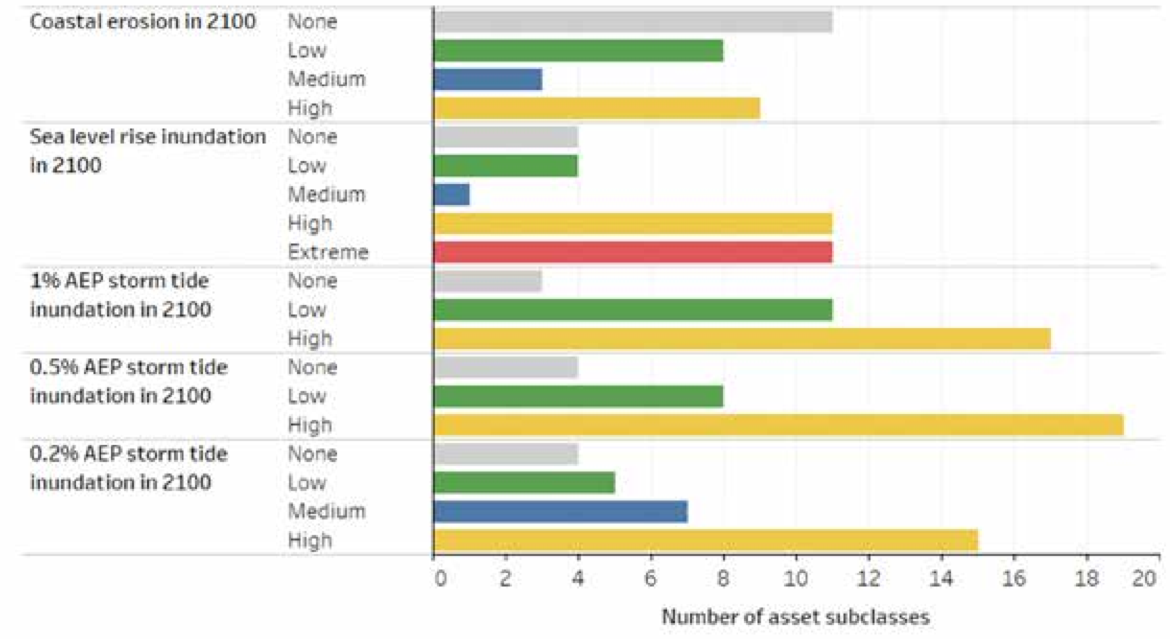

Figure 34: Number of asset subclasses at risk of coastal hazards in Airlie Beach

Community Insights

Two community workshops were facilitated in the Airlie/ Cannonvale area throughout the project. This was supported by individual interviews, an online survey and engagement over social media (Faceboook).

The community views focused on the environmental and amenity value of the area. The community indicated that they wanted adaptation responses to include awareness raising, improved land use planning, climate-resilient design and riparian corridors, revegetation and the planting of mangroves. Some residents also stated that they would like to see beach nourishment and groynes as adaptation actions.

Relevant Issues and Adaptation Actions for Airlie Beach

Airlie Beach

- Investigate the cost and effectiveness of developing an artificial reef in Airlie Bay.
- Investigate the cost and effectiveness to install a buried sea wall seaward of Airlie CBD.
- Looking further past 2100, will Airlie CBD need to be relocated to Cannonvale – abandon Airlie CBD after 2100 sometime if sea level rise continues.
- If required, the water services re-routed may cost $10-15million.
- Review the potential long-term option to build a services road, or "new" Airlie Main street landward of the CBD – behind the current buildings. This has been previously looked at by strategic planning for the Airlie Beach Master Plan.
- Review the possible development of a marina in Airlie Bay to provide protection but also functionality as a harbourage for sailing boats.
- Investigate the use of beach nourishment and its possible use for as long as cost effective and feasible.

7.2 BOWEN

Vulnerability assessment findings

Bowen's high vulnerability compared to all other CHAS study areas is driven predominantly by factors that impede the population's ability to cope and both adjust proactively and reactively to coastal hazards. In particular, lower economic indicators show a level mostly unable to both finance and affect change if required. This is potentially further exacerbated by the relatively large proportion of single parents in the areas of interest; a demographic associated with lower access to financial resource. The Bowen area does appear to have a high proportion of new residents however. This demographic is often associated with lower understanding of local conditions and hence greater susceptibility to hazards. Additionally, whilst only at 5.7% the proportion of those people requiring assistance could complicate any efforts to evacuate the area thus increasing vulnerability further.

Summary of risks

In Bowen there are 11 asset subclasses (35%) with no immediate risk of coastal erosion under a 2100 planning horizon (see Table 18). There are eight assets with a 'low' risk level and three asset subclasses which recorded a 'moderate' risk. Additionally, nine assets in Bowen have a 'high' risk including community properties, residential properties, footpaths, roads, water mains, community facilities, electricity substations, parks and sandy beaches.

Figure 34b: Queens Beach sea wall from the 1940's

Bowen has the greatest risk to sea level rise inundation in 2100 of all the areas of interest. There are four asset subclasses with a 'low' risk level, one asset with a 'moderate' risk, 11 assets which recorded a 'high' risk, and another 11 assets that were considered an 'extreme' risk.

This means that 70% of Bowen's assets are require immediate to short-term action to reduce the risk to acceptable levels. Furthermore, the exposure of those assets in Bowen with an 'extreme' risk level is as follows:

- 10 community buildings
- 97 residential buildings
- 8,002m of roads
- 5 sewer pump stations
- 106 water mains
- 4 community facilities
- 9,353m of electricity cables
- 10 electricity substations
- 78.7ha of parks
- 10 cultural sites
- $5,006,790 in replacement costs for mangroves and saltmarshes

For storm tide inundation in Bowen, only three assets (10%) show no immediate risk for all AEP scenarios. There are five assets which received a 'low' risk level across all storm tide inundation events, some of which include kerbs and channels, breakwaters and heritage places. Under a 1% AEP storm tide inundation scenario, there are 17 assets (55%) in Bowen which recorded a 'high' level of risk. In addition, there are 19 asset subclasses which recorded a 'high' risk under a 0.5% AEP storm tide inundation event, and 15 assets for the 0.2% AEP scenario. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Bowen.

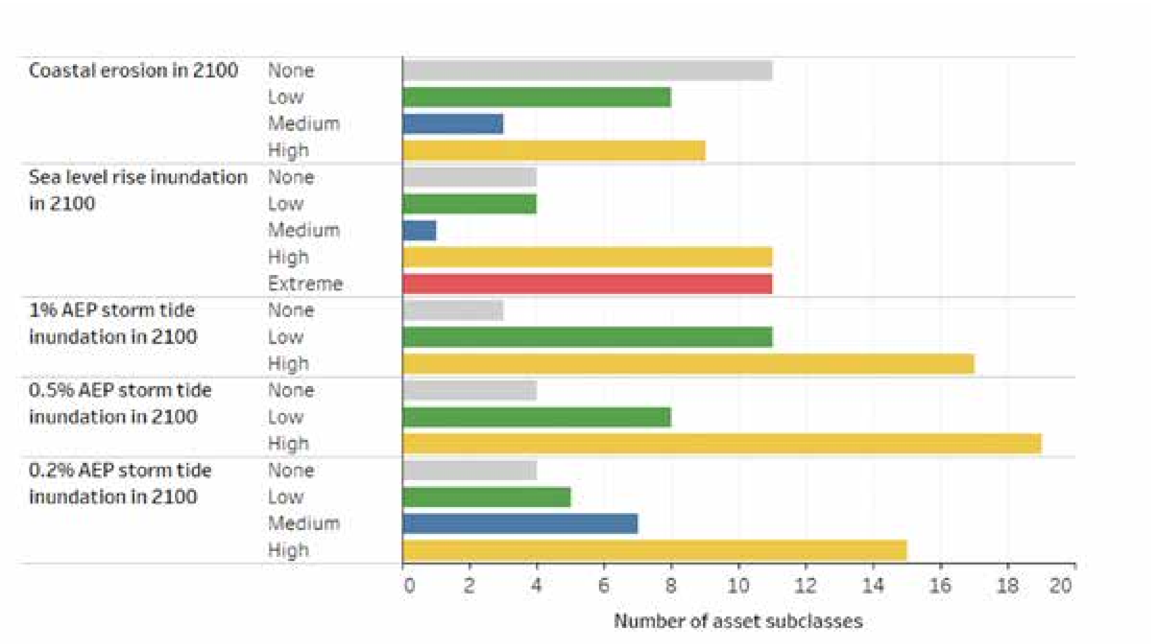

Figure 35: Number of asset subclasses at risk of coastal hazards in Bowen

Community Insights

Two community-based workshops were facilitated in Bowen throughout the project. This was supported by individual interviews, an online survey and engagement over social media (Faceboook).

The community recognised the natural environment. Results from various community engagement approaches showed a strong preference for natural based solutions that protected / enhanced the scenic amenity and supported recreation activities.

Figure 35b: Community consultation meeting at Queens Beach.

Cost-benefit Analysis

A detailed cost-benefit analysis was carried out for Bowen. The results identified that defending all areas at risk would cost in excess of $290 million if commenced now. This would result in a negative net benefit, even if the work commenced at a later date. Please refer to the Griffith University (2020) report for detailed analysis.

Site-specific Adaptation Actions for Bowen

For the entire Bowen area the key general actions over the next 5 years involve further details studies and on-going maintenance. The results of these further studies will determine the future application of the CHAS. It should be recognised that Bowen does face considerable coastal hazard risks and as such the area should be a priority action for Council consideration. Specific investigation for the whole of Bowen includes:

1. Undertaking a ground water reliability investigation – to understand how sea level rise may affect various sites, especially on the southern areas.
2. Explore opportunities for artificial reefs.
3. Undertake a land use suitability study for cropping and other uses.
4. Investigate floor levels design requirements for residential properties in predicted sea level rise areas. For example identify if an 300mm above Q100 flood levels is warranted and how that could be implemented in the planning mechanisms.
5. As with the rest of the CHAS risks in Bowen should be reviewed every 5 years with improvements in data, science and politics. The review should also include a communication plan to ensure that risks are effectively disclosed to the community.

Due to the size of Bowen and the fact that there are three distinct locations that differ in risk profile and broader context the site-specific actions were also workshopped for Bowen CBD, Rose Bay and Queens Beach.

The adaptation actions for those locations are presented below.

Bowen CBD

1. The adapt and modify pathway should be implemented to accommodate the Brisbane Street and Port area. The port area should be prioritised for implementation of any resilience measures. Intensification of the Port area could help justify the modification/ adaptation of the area and help contribute to the costs of defending the access road to the port.
2. The Thomas Street area is likely to be an area that requires a specific transition strategy that includes planned retreat over the coming decades. In the first instance an interim a limited development zone should be explored for this area.
3. Due to cost effectiveness sand nourishment on main beach is ruled out as a solution, even for interim purposes. Sand nourishment has been used along Front Beach as a buffer over the last 10-15 years.
4. For Front Beach accommodation of sea level rise is the preferred option.
5. Explore the option of a broader “limited Development zone” where future development does not intensify use over the next 50+ years unless costed adaptation actions have been included in any master plan assessment.

Rose Bay Area

1. Council’s preference is to accommodate the projected sea level rise in Rose Bay.
2. Lift the access road and adapt servicing after 2050. This is to be reviewed as part of Council’s usual capital works program.
3. Permanent inundation in Rose bay is not so much an issue. Few residences are expected to be affected by Permanent Inundation due to the underlying granite bedrock.
4. Consider the potential need to re-route Horseshoe Bay Road in long-term planning.

Queens Beach

1. Recognise that with rising sea level the impact of erosion coastal may worsen and storm surge will impact further landward.
2. Undertake further studies to investigate the cost of accommodation with sea dykes. Failing the viability of sea dykes to protect the at risk areas then the development a staged of transition plan over the next few decades should be developed as a priority.
3. Investigate off-shore options (e.g. artificial reefs) for the management of erosion.
4. Consider storm tide in future investigation as well and environmental and social impact for Queen’s Beach. Nature based solutions should be looked at for Queen’s Beach. However, it should be noted that sand nourishment has been utilised along Queens Beach intermittently over the past 15 years with minimal sand retention – meaning it may be cost prohibitive as a long-term solution.
5. The cost of maintaining the rock wall on the Don River should be included in future investigations.
6. The parking near the mouth of the Don in will need to be relocated or abandoned – this should be reflected in the asset management plan.
7. Investigate the development of a land levee south of Horseshoe Bay Road along low lying sections.
8. Undertake an investigation the Euri Creek catchment groundwater as an alternative source of ground water if groundwater intrusion from saltwater becomes worse over-time.

7.3 CANNONVALE

In Cannonvale, over half (55%) of assets have no immediate risk of coastal erosion under a 2100 planning horizon (see Table 19). Also, there are 10 assets with a 'low' risk level, two assets with a 'medium' risk, and another two assets (residential properties and water mains) which received a 'high' risk.

Figure 35c: Cannonvale Beach coastal erosion

Of the assets potentially exposed to sea level rise inundation in 2100, three have a 'low' risk level, seven assets recorded a 'medium' risk and 1o assets have a 'high' level of risk. However, the two assets with the greatest risk to sea level rise in Cannonvale are water mains and sandy beaches, both of which scored 'extreme'. In Cannonvale, it is estimated that the present value of loss of sandy beaches from sea level rise inundation in 2100 will reach over $2 million.

For storm tide inundation in Cannonvale, nearly one-third (32%) show no immediate risk for all AEP scenarios. Also, there are 15 assets which received a 'low' risk level across all storm tide inundation events, some of which include council buildings, roads, and storm water mains etc. Under a 1% AEP storm tide inundation scenario, there are four assets in Cannonvale which recorded a 'high' level of risk and the exposure of those assets is as follows:

- 3.7% of sewer mains
- 42.9% of sewer pump stations
- 1 cultural site
- $2,274,433 in replacement costs for sandy beaches

Also, there are five asset subclasses which recorded a 'high' risk under both a 0.5% AEP storm and 0.2% AEP storm tide inundation event, which are considered to have a 'tolerable' risk and require immediate to short-term action to reduce the risk to acceptable levels. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Cannonvale.

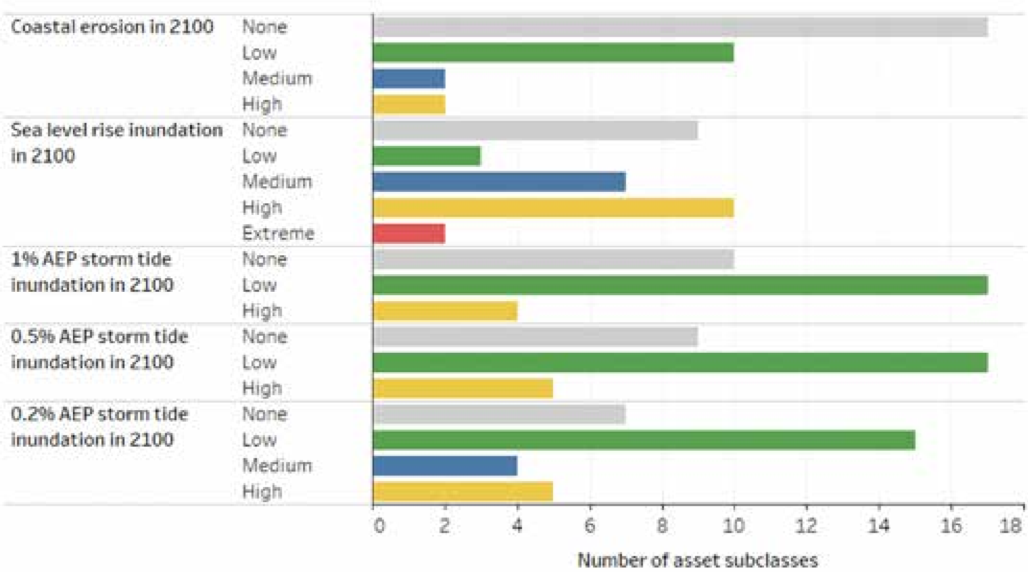

Figure 36: Number of asset subclasses at risk of coastal hazards in Cannonvale

Community Insights

Two community Airlie / Cannonvale-based workshops were facilitated throughout the project. This was supported by individual interviews, an online survey and engagement over social media (Faceboook).

The community views focused on the environmental and amenity value of the area. The community indicated that they wanted adaptation responses to include awareness raising, improved land use planning, climate-resilient design and riparian corridors, revegetation and the planting of mangroves. Some residents also stated that they would like to see beach nourishment and groynes as adaptation actions.

Relevant Adaptation Options for Cannonvale

Cannonvale

- Water mains in the area will be impacted.
- The Cannonvale school was not identified as being at high risk.
- There may be 8 residential properties potentially impacted along Coral Esplanade – western end of Cannonvale beach. It is unlikely or financially feasible that engineered protection for these residential buildings could be implemented. A long term action may include accommodate at first then transition away from the risk.
- The Cannonvale waste facility and Council depot – maybe inundated around 2050. The preference here is to relocate these services, not defend.
- The Cannonvale foreshore park will eventually be inundated – accommodate naturally as required – there is a buffer of mangroves along this section now. Allow mangroves to naturally colonise when required.
- It should be recognised that if the Cannonvale beach area is turned to mangroves in the long term, then there will be no beach, which will affect the social utilisation of the area.

7.4 CONWAY BEACH

Vulnerability assessment findings

Conway Beach's relatively higher income is potentially available to aid residents adapt to changing conditions. This is potential is hindered by a relative concentration of jobs in those regional industries most vulnerable to coastal hazards: tourism and agriculture. In combination, this could well represent an AOI with relatively lower capacity to change jobs and hence derive income should agricultural and tourism employment decrease. In addition, whilst the AOI contains one of the most stable and physically mobile of populations, its relative attraction to visitors represents the presence of a demographic segment typically sensitive to hazards due to their ignorance about local conditions and characteristics.

Summary of Risks

In Conway Beach, there are 21 asset subclasses (68%) with no immediate risk of coastal erosion under a 2100 planning horizon (see Table 20). Also, there are seven assets with a 'low' risk level and three assets (residential properties, electricity substation and sandy beaches) with a 'high' risk.

Of the assets potentially exposed to sea level rise inundation in 2100, two have a 'low' risk level, one asset recorded a 'medium' risk, and another received a 'high' level of risk. However, the asset with the greatest risk to sea level rise in Conway Beach is sandy beaches which scored 'extreme'. In Conway Beach, it is estimated that the present value of expected losses of sandy beaches from sea level rise inundation in 2100 will exceed $16 million. This is deemed to be an 'intolerable' risk which requires immediate action to reduce the risk to acceptable levels.

For storm tide inundation in Conway Beach, there are 22 asset subclasses (71%) which show no immediate risk for all AEP scenarios. Also, there are six assets which received a 'low' risk level across all storm tide inundation events, some of which include council buildings, roads, and heritage places etc. Under a 1% AEP storm tide inundation scenario, there are three assets in Conway Beach which recorded a 'high' level of risk and the exposure of those assets is as follows:

- 1 electricity substation
- 62.2% of parks
- $16,367,363 in replacement costs for sandy beaches

Also, there are three asset subclasses which recorded a 'high' risk under both a 0.5% AEP storm and 0.2% AEP storm tide inundation event which include electricity substations, parks and sandy beaches. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Conway Beach.

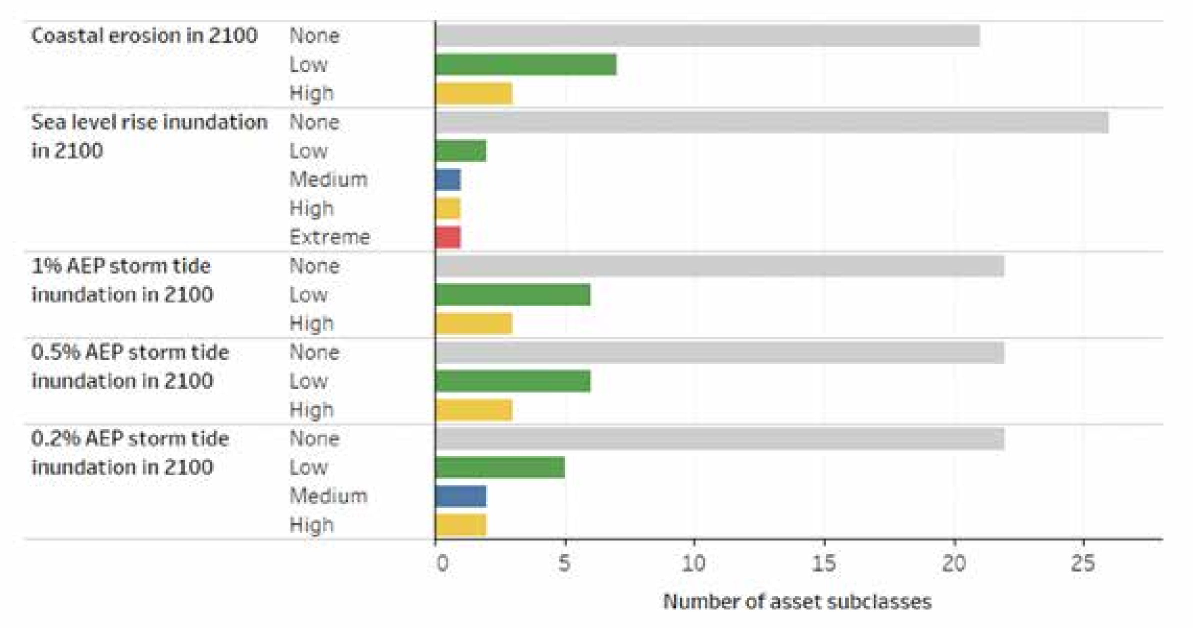

Figure 37: Number of asset subclasses at risk of coastal hazards in Conway Beach

Relevant Adaptation Options for Conway Beach

- The sea wall already protects Conway, the wall was designed to 2050, as such a review closer to 2050 will be warranted
- Investigate the cost of raising Conway Road to enable access from 2050 and review all of Conway's road to identify low points and future threats for transport and access.
- Monitor sand and rates of erosion at Conway over-time.

7.5 DINGO BEACH

In Dingo Beach there are 19 asset subclasses (61%) with no immediate risk of coastal erosion under a 2100 planning horizon (see Table 21). Also, there are six assets with a 'low' risk level and another six recorded a 'high' risk. These 'high' risks include community properties, residential properties, storm water mains, parks, cultural sites, and sandy beaches.

Of the assets potentially exposed to sea level rise inundation in 2100, five have a 'low' risk level and two assets received a 'high' risk. Since cultural sites have an 'extreme' level of risk it has also been categorised as an 'intolerable' risk which requires immediate action to reduce the risk to sea level rise inundation in 2100.

For storm tide inundation in Dingo Beach, 18 assets (58%) show no immediate risk for all AEP scenarios. There are six assets which received a 'low' risk level across all storm tide inundation events, some of which include roads, electricity cables, heritage places etc. Under a 1% AEP storm tide inundation scenario, there are six assets in Dingo Beach which recorded a 'high' level of risk and the exposure of those assets is as follows:

- 2 residential buildings exposed to a water depth 1.2m or higher
- 8.2% of storm water mains
- 47.2% of parks
- 1 cultural site
- 1 endangered (EPBC Act) species and 2 vulnerable (EPBC Act) species
- $1,896,529 in replacement costs for sandy beaches

Also, there are seven asset subclasses which recorded a 'high' risk under a 0.5% AEP storm tide inundation event, and five assets for the 0.2% AEP scenario. For strategic planning, the 'high' risk assets are considered to have a 'tolerable' risk which means they still require immediate to short-term action to reduce the risk to acceptable levels. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Dingo Beach.

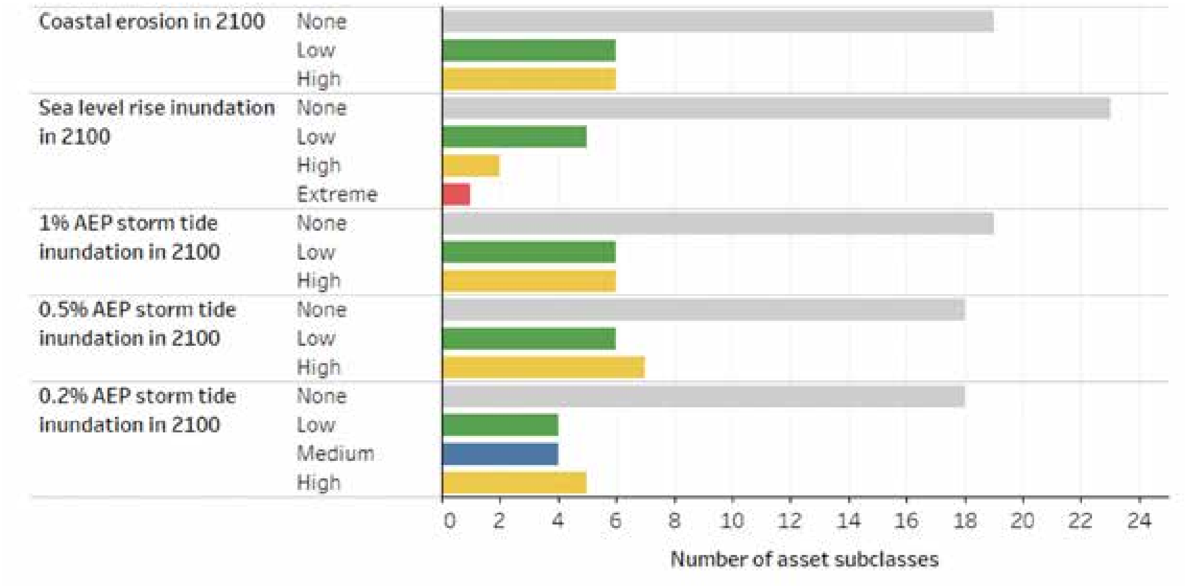

Figure 38: Number of asset subclasses at risk of coastal hazards in Dingo Beach

Community Insights

Two community-based workshops were facilitated at Dingo beach throughout the project. This was supported by individual interviews, an online survey and engagement over social media (Faceboook).

The community views focused on the recreational, environmental and amenity value of the area. The community indicated that they wanted adaptation responses to include awareness raising, dune reconstruction and regeneration, revegetation and beach nourishment.   Some residents also stated that they would like to see hazard mapping and climate resilient design.

Figure 38a: Dingo Beach Community meeting (November 2019)

Relevant Adaptation Options for Dingo Beach

- Explore cost-benefit of beach nourishment. Include longevity, cost, effectiveness for coastal defence.
- Review functioning of sceptic system and determine when they may become human health / environmental nuisance.

7.6 HYDEAWAY BAY

In Hydeaway Bay, there are 23 asset subclasses (74%) with no immediate risk of coastal erosion under a 2100 planning horizon (see Table 22). Also, there are five assets with a 'low' risk level, two assets which recorded a 'medium' risk, and one asset (residential properties) with a 'high' risk.

Of the assets potentially exposed to sea level rise inundation in 2100, three have a 'low' risk level and one asset received a 'medium' risk, which suggests that the overall risk to this hazard in Hydeaway Bay is 'tolerable/ acceptable'.

For storm tide inundation in Hydeaway Bay, there are 21 asset subclasses (68%) which show no immediate risk for all AEP scenarios. Also, there are five assets which received a 'low' risk level across all storm tide inundation events, some of which include storm water mains, parks, and coastal forests etc. Only residential properties received a 'high' level of risk, with one building exposed (to a water depth 1.2m or higher) for a 0.5% storm tide inundation event and two buildings inundated under a 0.2% AEP scenario. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Hydeaway Bay.

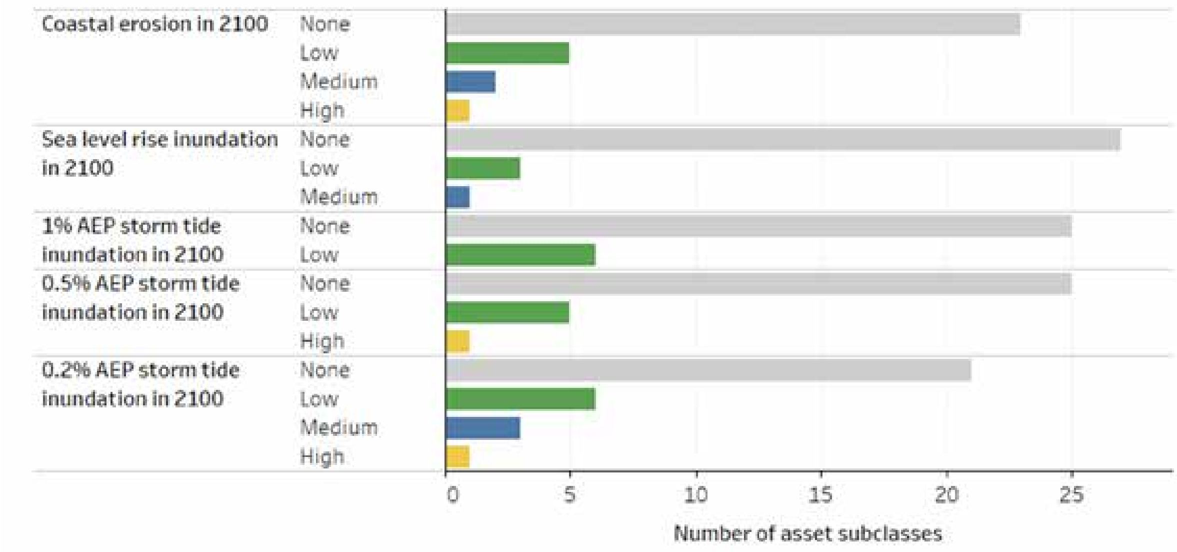

Figure 39: Number of asset subclasses at risk of coastal hazards in Hydeaway Bay

Figure 39b: Role of vegetation to stabilise dune system at Wilson's Beach

Community Insights

Figure 39c: Hydeaway Bay community meeting

One community-based workshop was facilitated at Dingo beach during the project. This was supported by individual interviews, an online survey and engagement over social media (Faceboook).

The community views focused on the recreational, and visual amenity value of the area. The community indicated that they wanted adaptation responses to include awareness raising, dune reconstruction and regeneration, revegetation and beach nourishment.

7.7 SHUTE HARBOUR

There is no immediate risk to any assets in Shute Harbour under a 2100 coastal erosion event (see Table 23).

Of the assets potentially exposed to sea level rise inundation in 2100, five have a 'low' risk level, one asset recorded a 'moderate' risk and three assets have a 'high' level of risk. However, the two assets with the greatest risk to sea level rise in Shute Harbour are sewer manholes and water mains, both of which scored 'extreme'. Therefore, these assets are an 'unacceptable/ intolerable' risk which requires immediate action to reduce the risk to sea level rise inundation in 2100.

For storm tide inundation in Shute Harbour, 19 asset subclasses (61%) show no immediate risk for all AEP scenarios. In addition, there are seven assets which received a 'low' risk level across all storm tide inundation events, some of which include parks, heritage places, and mangroves and saltmarshes etc. Under a 1% AEP storm tide inundation scenario, there are five assets in Shute Harbour which recorded a 'high' level of risk and the exposure of those assets is as follows:

- 1 community building exposed to a water depth 1.2m or higher
- 1 council building
- 19.1% of roads
- 8.8% of sewer mains
- 22.2% of sewer manholes

In addition, there are two asset subclasses which recorded a 'high' risk under a 0.5% AEP storm tide inundation event, and one asset for the 0.2% AEP scenario. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Shute Harbour

7.8 WILSON BEACH

In Wilson Beach there are 21 asset subclasses (68%) with no immediate risk of coastal erosion under a 2100 planning horizon (see Table 24). In addition, there are seven assets with a 'low' risk level, one asset which recorded a 'moderate' risk, and two assets (residential properties and sandy beaches) with a 'high' level of risk.

Figure 39d: Wilson's Beach foreshore

Of the assets potentially exposed to sea level rise inundation in 2100, three have a 'low' risk level, one asset recorded a 'moderate' risk, and five received a 'high' level of risk. However, the assets with the greatest risk to sea level rise in Wilson Beach are residential properties and sandy beaches, both of which scored 'extreme'. There are 19 residential buildings in Wilson exposed to sea level rise inundation in 2100. Furthermore, it is estimated that the present value of expected losses of sandy beaches from sea level rise inundation in 2100 will exceed $16 million in Wilson Beach. These are deemed to be an 'unacceptable/ intolerable' risk and require immediate action to reduce the risk to acceptable levels.

For storm tide inundation in Wilson Beach, there are 19 asset subclasses (61%) which show no immediate risk for all AEP scenarios. In addition, there are five assets which received a 'low' risk level across all storm tide inundation events, some of which include council buildings, sea walls, coastal forests etc. Under a 1% AEP storm tide inundation scenario, there are seven assets in Wilson Beach which recorded a 'high' level of risk and the exposure of those assets is as follows:

- 25 residential buildings exposed to a water depth of 50cm - 1.2m
- 51.0% of roads
- 64.0% of electricity cables
- 1 electricity substation
- 66.9% of parks
- $1,166,523 in replacement costs for mangroves and saltmarshes
- $9,521,823 in replacement costs for sandy beaches

In addition, there are seven asset subclasses which recorded a 'high' risk under a 0.5% AEP storm tide inundation event, and four assets for the 0.2% AEP scenario. Under a 2100 planning horizon, there were no 'extreme' risks identified for storm tide inundation in Wilson Beach.

Community Insights

One community-based workshop was facilitated at Wilsons Beach during the project. This was supported by individual interviews, an online survey and engagement over social media (Faceboook).

The community views focused on the recreational, and visual amenity value of the area. The community indicated that they wanted adaptation responses to include awareness raising, dune reconstruction and regeneration, revegetation and beach nourishment.

Adaptation Actions for Wilsons Beach

- The cost of protecting the Wilsons Beach community from coastal hazards is estimated to be in excess of $33 million, over $1 million per property.
- Explore cost-benefit of beach nourishment. Include longevity, cost, effectiveness for coastal defence.
- Review functioning of sceptic system and determine when they may become human health / environmental nuisance.

8 GENERAL ADAPTATION ACTIONS AND WAY FORWARD

The effects of climate change combined with natural processes mean coastal hazards will become an ongoing issue for Whitsunday. This will especially become more apparent in the coming decades as sea level rise projections show a non-linear increase after 2050 if global greenhouse gas emissions cannot be contained.

The findings of this project have identified a number of pressing and longer-term coastal risks. The actions identified in this strategy are more than likely to change over time, in response to changing regulatory requirements, market expectations and community needs.

The most fundamental element of this Strategy is for Whitsunday Regional Council to maintain a focus on the coastal environment.

This means that Council will likely be incorporating management of coastal hazards (and climate change) in its key governance mechanisms.

The community will be informed throughout the journey. The community have indicated through this project that the top three considerations when adaptation to climate change are impact on the natural environment, impact on homes and businesses, and effectiveness over time. Council will use these community preferences to help guide its decisions.

Figure 40: Whitsunday community indications of the most important considerations when adapting to climate change (Griffith University)

There are a number of difficult decisions that the community will face in the coming years and these include identifying what to do if a location is no longer able to be protected. At present Whitsunday Regional Council is developing an implementation strategy that it can resource and focus on over the next few years.

The key principals on the Coastal Hazard Adaptation Strategy Implementation Plan will include:

- Council is committed to facilitating a resilient community and economy.
- Council recognises that coastal hazards require a dynamic and ongoing response.
- Council will only implement actions that are financially viable.
- It is assumed that Whitsunday ratepayers will be primarily required to financially support any future works to protect or modify the urban coastline. It is assumed that there will be limited State and Federal funding available in the future for urban coast protection work.
- Council commits that all ratepayers will share an equal burden of risk management, regardless of location or risk type. However, how the future protection measures will be funded will need further investigation.
- Council will continue to lobby the State and Commonwealth Government for relevant support.
- Council will only plan for coastal hazards and sea level rise options for land zoned urban.
- Council recognises that some parts of the local government area are more at risk than others and it will not approve any development that results in a long-term increased burden on the ratepayers.
- Beach nourishment will be a preferred interim action to provide protection for community assets in urban areas which require interim protection against storm surge.
- That this Strategy will be reviewed and revised in five years time using more current scientific data and community views.

As responding to coastal hazards require a dynamic approach the following triggers will result in a review of the CHAS:

- Any increase in sea level rise projections or planning allowances
- If a tropical cyclone crosses the Whitsunday coast more than two times in a decade
- If banks change loan-to-asset ratios or indicate other restrictions in response to coastal hazards
- If Council identifies that some locations may not be serviceable (e.g. water, sewerage, vehicle access)
- If Queensland regulations associated with coastal hazards change

Council will develop key metrics and key performance indicators to monitor over time to help identify triggers for change. Key metrics include:

- Number of homes that are exposed to coastal hazards
- Number of extreme coastal events each year
- Annual expenditure in defending against coastal hazards
- Cost of Council's insurance
- Number (and value) of council assets exposed to coastal hazards
- Changes to coastal property values
- Number and expense of coastal hazard-related litigation (including planning challenges)
- In 2021/22 the urban coastline will be mapped to determine a bench mark for future coastal erosion.

Refer to Appendix I for the detailed 2021-2025 Implementation and Action Plan.

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10 APPENDICES

APPENDEX I

Whitsunday Regional Council Coastal Hazard Adaptation Strategy (CHAS) Implementation and Change Management Plan

17 April 2021 v1.0

ABOUT

This document is the implementation and change management plan for the implementation of actions associated with Whitsunday Regional Council's Coastal Hazard Adaptation Strategy (CHAS) and supporting information.   The CHAS was funded by a partnership of Queensland Government and LGAQ. An implementation plan is are requirement under the project's minimum standards and guidelines, which Council.

The implementation plan is a dynamic plan that can will be updated on an annual basis – or in response to a range of triggers (see Section 2. This implementation plan covers the following themes:

- Governance
- Adaptation response by locality
- Five year action plan (2021-2025)
- Triggers for change

1. GOVERNANCE

Over time Council will improve the consideration of coastal hazards and climate change into its core governance mechanisms. It will draw on the findings from the climate change governance assessment carried out as part of the LGAQ Queensland Climate Resilient Councils (Q CRC) initiative. Council's will build on from the most recent assessment results (Figure 1) – with the initial focus being on the Corporate Plan and Financial Management Plan. During any review of core governance mechanisms Council will identify opportunities to incorporate coastal hazard management in line with the CHAS.

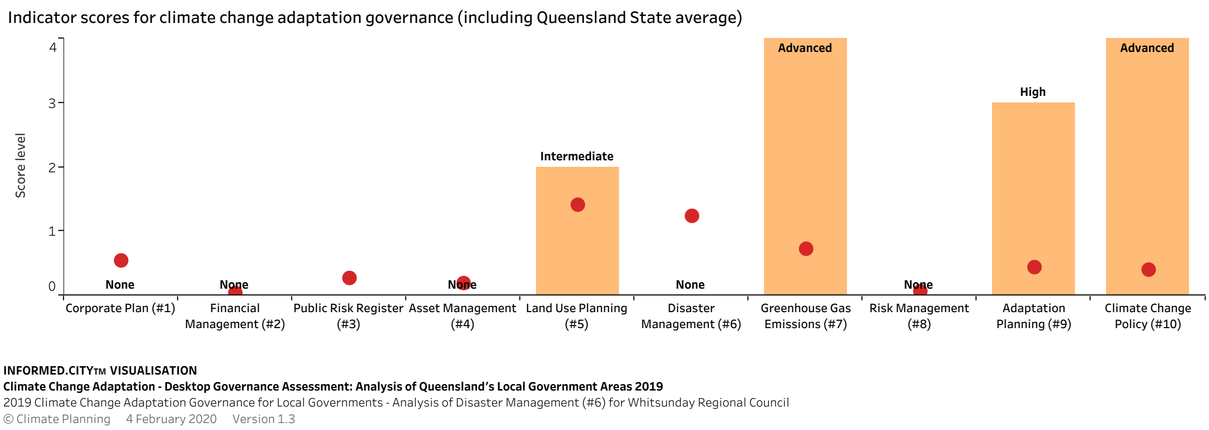


Figure 1: Whitsunday Regional Council Q CRC climate change governance assessment (2019)

2. SUMMARY OF ADAPTATION RESPONSE BY LOCALITY

Council will align its planning and activities to the broad adaptation responses listed below. These will be adjusted as new information or relevant triggers emerge (see Section 3).

Council recognises that each area of interest is unique and has differing risk profiles. These include:

- The nature of the hazard type (e.g. permanent inundation, storm surge and coastal erosion)
- The number of assets and/or properties exposed
- The technical and financial viability of adaptation options
- The timing of risk (some face risks now – other areas after 2050)

Due to the differing risk profile Council has developed a first-pass response to guide the direction of its adaptation response. These are presented in the following pages.

Table 1 General short-long term direction for adaptation in each location

	Adaptation Response			
	Current day	2030	2050	2100
Airlie Beach	Monitor	Mitigate (Soft)*	Mitigate (Hard)	TBC
Bowen (Queens Beach)	Monitor	Mitigate (Soft)*	Transition*	Transition*
Bowen (Rose Bay)	Monitor	Mitigate (Soft)*	Transition	Transition*
Bowen (Bowen South)	Monitor	Mitigate*	Mitigate*	Transition
Cannonvale	Monitor	Mitigate (Soft)*	Transition	Transition*
Conway Beach	Monitor	Monitor	Mitigate*	Transition
Dingo Beach	Monitor	Monitor	Transition	Transition
Hydeaway Bay	Monitor	Monitor	Transition	Transition
Shute Harbour	Monitor	Monitor	Monitor	Mitigate
Wilsons Beach	Monitor	Mitigate (Soft)	Transition	Transition

* A transition response may be appropriate for limited areas within the locality

Tables 2 to table 5 summarise the tasks and their priority for each location over the next 5 years to 2026.

Planning and Governance

Table 2 Planning and governance responses

PLANNING AND GOVERNANCE				
	Land use planning	Mainstreaming climate change into Council decisions Mainstreaming climate change into Council decisions	Monitoring of climate change adaptation governance	Transition research
Airlie Beach	Priority	Relevant/feasable	Relevant/feasable	Not applicable
Bowen (Queens Beach)	Priority	Priority	Priority	Priority
Bowen (Rose Bay)	Priority	Priority	Priority	Priority
Bowen (Bowen Beach and CBD)	Priority	Priority	Priority	Priority
Cannonvale	Priority	Relevant/feasable	Relevant/feasable	Priority
Conway Beach	Priority	Relevant/feasable	Relevant/feasable	Priority
Dingo Beach	Priority	Relevant/feasable	Relevant/feasable	Priority
Hydeaway Bay	Priority	Relevant/feasable	Relevant/feasable	Priority
Shute Harbour	Priority	Relevant/feasable	Relevant/feasable	Relevant/feasable
Wilsons Beach	Priority	Relevant/feasable	Relevant/feasable	Priority

Legend ● Relevant/feasable ● Priority ○ Not applicable

Region-Wide Resilience Initiatives

Table 3 Region-wide resilience initiatives

PLANNING AND GOVERNANCE					
	Raising community awareness	Knowledge sharing	Community stewardship	Monitoring	Exploring financial options
Airlie Beach	🟢	🟠	🟢	🟢	🟠
Bowen (Queens Beach)	🟠	🟢	🟢	🟠	🟠
Bowen (Rose Bay)	🟠	🟢	🟢	🟠	🟠
Bowen (Bowen Beach and CBD)	🟠	🟢	🟢	🟠	🟠
Cannonvale	🟢	🟢	🟢	🟢	🟠
Conway Beach	🟠	🟢	🟢	🟢	🟢
Dingo Beach	🟢	🟠	🟢	🟠	🟢
Hydeaway Bay	🟠	🟢	🟢	🟠	🟢
Shute Harbour	🟢	🟠	🟢	🟢	🟢
Wilsons Beach	🟠	🟢	🟢	🟢	🟠

Legend 🟢 Relevant/feasable 🟠 Priority ○ Not applicable

* If accommodate is preferred

Coastal Infrastructure Design

Table 4 Coastal infrastructure design for each location

COASTAL INFRASTRUCTURE DESIGN				
	Climate resilient design	Elevated buildings	Raising land levels	Modifying critical infrastructure
Airlie Beach	● (green)	● (green)	● (green)	● (orange)
Bowen (Queens Beach)	● (orange)	● (green)	● (green)	● (orange)
Bowen (Rose Bay)	● (green)	● (green)	● (green)	● (orange)
Bowen (Bowen Beach and CBD)	● (orange)	● (orange)	● (orange)	● (orange)
Cannonvale	● (green)	● (green)	● (green)	● (orange)
Conway Beach	○	○	○	● (green)
Dingo Beach	○	● (green)	● (green)	● (green)
Hydeaway Bay	○	○	○	● (green)
Shute Harbour	● (green)	● (green)	○	● (orange)
Wilsons Beach	● (green)	● (green)	● (green)	● (green)

Legend ● (green) Relevant/feasable ● (orange) Priority ○ Not applicable

Coastal Management and Engineering

Table 5 Coastal management and engineering for each location

COASTAL MANAGEMENT AND ENGINEERING					
	Beach nourishment	Dune protection and maintenance	Coastal revegetation	Structures to protect against coastal erosion	Structures to minimise storm tide inundation
Airlie Beach	Priority	Not applicable	Not applicable	Relevant/feasable	Not applicable
Bowen (Queens Beach)	Priority	Relevant/feasable	Relevant/feasable	Priority	Priority
Bowen (Rose Bay)	Not applicable	Relevant/feasable	Relevant/feasable	Priority	Priority
Bowen (Bowen Beach and CBD)	Not applicable	Priority	Relevant/feasable	Priority	Not applicable
Cannonvale	Priority	Not applicable	Not applicable	Relevant/feasable	Not applicable
Conway Beach	Priority	Not applicable	Not applicable	Relevant/feasable	Relevant/feasable
Dingo Beach	Priority	Relevant/feasable	Not applicable	Priority	Relevant/feasable
Hydeaway Bay	Priority	Relevant/feasable	Not applicable	Priority	Not applicable
Shute Harbour	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Wilsons Beach	Priority	Relevant/feasable	Not applicable	Relevant/feasable	Priority

Legend ● Relevant/feasable ● Priority ○ Not applicable

Location	Timeframe	Action	Responsibility	Financial Ramifications	Priority*
Council Wide	2021-2022	Review key governance documents, such as the Council Planning Scheme to identify where and how the consideration of coastal hazards should be incorporated. Consider the extension of Council's climate change policy to incorporate relevant aspects of the CHAS.	Corporate Services and Community	Likely to achieve in existing budget	Very High
	2021-2022	Review actions in this plan to quantify line-item budget allocations.	Corporate Services and Community	Likely to achieve in existing budget	Very High
	2021-2023	Identify key metrics and key performance indicators to enable ongoing assessment of risk exposure and risk management performance.	Corporate Services and Community	May require additional budget (~$10k)	Very High
	2021-2022 then ongoing	Create a platform for internal reporting and external disclosure of climate change risk for assets.	Corporate Services and Community	Likely to require additional budget (~$30-$40k)	High-Very High
	2021-2025	Work with the Hub to identify project synergies and research / collaboration priorities.	Hub Corporate Services and Community	Likely to achieve in existing budget	High-Very High
	2021-2023	Review old Beach Protection Authority coastal surveys to determine old coast line to develop a rate of dune erosion at various coastal locations where this data exists.	Corporate Services and Community	Likely to achieve in existing budget	High-Very High
	2021-2023	Identify capacity and capability needs to implement the CHAS.	Corporate Services and Community	Likely to achieve in existing budget	Very High
	2021-2022	Survey coastline at each of the 9 sites to establish a 2021 coast line as a bench mark to monitor coastal erosion. Lidar may be used to define the coastline for this task.	Corporate Services and Community	Likely to achieve in existing budget	Very High
Airlie Beach	2021-2022	Review critical infrastructure for coastal risk to identify adaptation needs. Quantify adaptation cost differential and report each cost to CFO (for audit trail).	Infrastructure Services Corporate Services	Likely to achieve in existing budget	Very High
	2021-2023	Explore cost-benefit of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Community	May require additional budget	High-Very High

Bowen (Queens Beach)	2021-2023	Explore the creation of a "limited development zone" at Thomas Street and other high risk locations to define the limitations of land use within at risk locations.	Development Services	May require additional budget	Med - High
	2021-2023	Explore cost-benefit of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Community	May require additional budget	High-Very High
	2021-2022	Review critical infrastructure for coastal risk to identify adaptation needs. Quantify adaptation cost differential and report each cost to CFO (for audit trail).	Infrastructure Services Corporate Services	Likely to achieve in existing budget	Med-High
	2021-2023	Investigate off-shore options (e.g. artificial reefs) for the management of erosion.	Hub	Additional funding required. Identify grant funding / co-funding / university outreach opportunities	Med-High
	2011-2025	Increase foreshore planting to stabilise dune systems. Explore environmental solutions for coastal defenses.	Community	Likely to achieve in existing budget	High-Very High
Bowen (Rose Bay)		Explore the creation of a "limited development zone" to define the limitations of land use within at risk locations.	Development Services	May require additional budget	
	2021-2023	Explore cost-benefit of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Infrastructure Services	May require additional budget	High-Very High
	2025	Model the potential need to re-route Horseshoe Bay Road in long-term planning.	Infrastructure Services Corporate Services	May require additional budget	Med
	2021-2022	Review critical infrastructure for coastal risk to identify adaptation needs. Quantify adaptation cost differential and report each cost to CFO (for audit trail).	Infrastructure Services Corporate Services	Likely to achieve in existing budget	High-Very High
Bowen (Front Beach and CBD)	2021-2022	Explore the creation of a "limited development zone" to define the limitations of land use within at risk locations.	Development Services	May require additional budget	High
	2021-2025	Investigate off-shore options (e.g. artificial reefs) for the management of erosion.	Hub	Additional funding required. Identify grant funding / co-funding / university outreach opportunities	High-Very High
	2021-2023	Explore CBA of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Community (NRM)	May require additional budget	High-Very High
	2021-2022	Review critical infrastructure for coastal risk to identify adaptation needs. Quantify adaptation cost differential and report each cost to CFO (for audit trail).	Infrastructure Services Corporate Services	Likely to achieve in existing budget	High-Very High

Cannonvale	2021-2025	Investigate artificial reef pilot to explore viability of shoreline protection.	Community (NRM)	May require additional budget	High
	2021-2022	Explore the creation of a "limited development zone" to define the limitations of land use within at risk locations.	Development and Planning	May require additional budget	High-Very High
Conway Beach	2021-2023	Monitor and review beach nourishment projects.	Community (NRM)	May require additional budget	High-Very High
Dingo Beach	2021-2023	Explore CBA of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Community (NRM)	May require additional budget	High-Very High
	2021-2023	Review functioning of sceptic system and determine when they may become human health / env nuisance.	Community (NRM)	May require additional budget	High-Very High
Hideaway Bay	2021-2023	Explore CBA of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Community (NRM)	May require additional budget	High-Very High
	2021-2023	Review functioning of sceptic system and determine when they may become human health / env nuisance.	Community (NRM)	May require additional budget	High-Very High
Shute Harbour	2021-2025	Monitor coastal damage after events to ensure current design specs are on par with what is materialising.	Community (NRM)	Likely to achieve in existing budget	Low
Wilsons Beach	2021-2023	Explore CBA of beach nourishment. Include longevity, cost, effectiveness for coastal defence.	Community (NRM)	May require additional budget	High-Very High
		Review functioning of sceptic system and determine when they may become human health / environmental nuisance.	Community (NRM)	May require additional budget	High-Very High
Council Wide	2021-2025	Carry out a yearly review of actions to determine if any triggers have been reached and urgency / timeframe changes are required.	Community (NRM)	Likely to achieve in existing budget	Very High

*** Priority**

Very high – Key task: A range of actions are depended on this activity being complete.

High – Key task: To inform body of work likely to require additional allocation of expenses and/or an important decision.

Medium – Not time dependent. Would be good to know – but not required within 5+ years. However, would help advanced resilient planning and identify grant funding.

Low – Can be pushed out beyond ten years. Useful now if additional resourcing becomes available.

4. TRIGGERS FOR CHANGE

As responding to coastal hazards require a dynamic approach the following triggers will result in a review of the CHAS:

Threshold	Current status	Action if changes
Regulatory: SPP	SPP states that climate change must be considered	Ensure Strategic Plan considers climate change to at least minimum extent
Regulatory: SLR height	Currently 0.8m	Update WRC Climate Policy
Funding: Grants available	Awarded $500k for CHAS	Have project outlines / key focus areas already prepared if more funding becomes available
Extreme Events: Tropical cyclone	Currently exposed to 1-2 TC per year in the LG area	Consider bringing options forward if TC intensity or frequency increases
Market: changes to insurability	Currently no insurance available for coastal risks	N/A – review if other insurance for other events is hard to obtain (e.g. TC risk)
Market: changes to lending	Signal from CBA. Review each top four bank annual reports for climate change.	Consider bringing options forward if this materializes into property value impacts
Governance: Q CRC Review	Q CRC Review identified governance gaps	Action recommendations from QCRC report
Services	Council servicing is becoming expensive in some areas or risk is increasing	Consider bringing options forward if this continues (e.g. service charges, change to service levels, retreat options)
Science: IPCC, QLD modelling	IPCC AR6 due 2020	Review upper bounds SLR presented in AR report and determine if SLR considerations should go beyond minimum SPP
3 meter deviation or 100m3 of sand lost	Boundary at 2021 (from survey)	Nourish beaches to maintain 2021 level

Grays Bay foreshore

APPENDIX II

Appendix: Draft CHAS Community Consultation

INTRODUCTION

Whitsunday Regional Council (WRC) consulted with residents across the region to have their say on the draft Coastal Hazards Adaptation Strategy (CHAS). One of the key activities under the CHAS is to engage the community, raising the awareness of climate change impacts and describing the range of climate change adaptation options. Consultation on the draft CHAS was open for a period of 4 weeks online at Your Say Whitsunday between Friday 30 April and 5pm, Friday 28 May 2021.

METHODS OF THE COMMUNITY CONSULTATION

The consultation period was advertised online on the corporate website, Facebook page, newspaper public notices and by email to key stakeholders. A series of maps and fact sheets were developed for each coastal community and made available on the website.

Six public displays were held across several coastal communities, with council officers visiting parks and community halls in each area over two weekends with copies of maps, fact sheets, surveys and feedback forms. The six public displays were held across the Region in coastal communities who had previously been engaged in the CHAS. The displays were held at the following locations and times:

- Bowen on Saturday 8 May –
    - 8am to 10am at Queens Beach / Gideon Pott Park
    - 11am to 1pm at Rose Bay beach carpark
    - 2pm to 4pm at Front Beach near the Catalina carpark

- Conway Beach / Wilsons Beach on Sunday 9 May –
    - 10am to 12pm at Wilsons Beach picnic shelter

- Dingo Beach / Hydeaway Bay on Sunday 9 May –
    - 2pm to 4pm at Gloucester Sport and Recreation Facility

- Cannonvale / Airlie Beach on Saturday 15 May –
    - 10am to 12pm at Cannonvale Beach foreshore

Queens Beach, Bowen

Rose Bay, Bowen

Front Beach, Bowen

Wilsons Beach / Conway Beach

Cape Gloucester

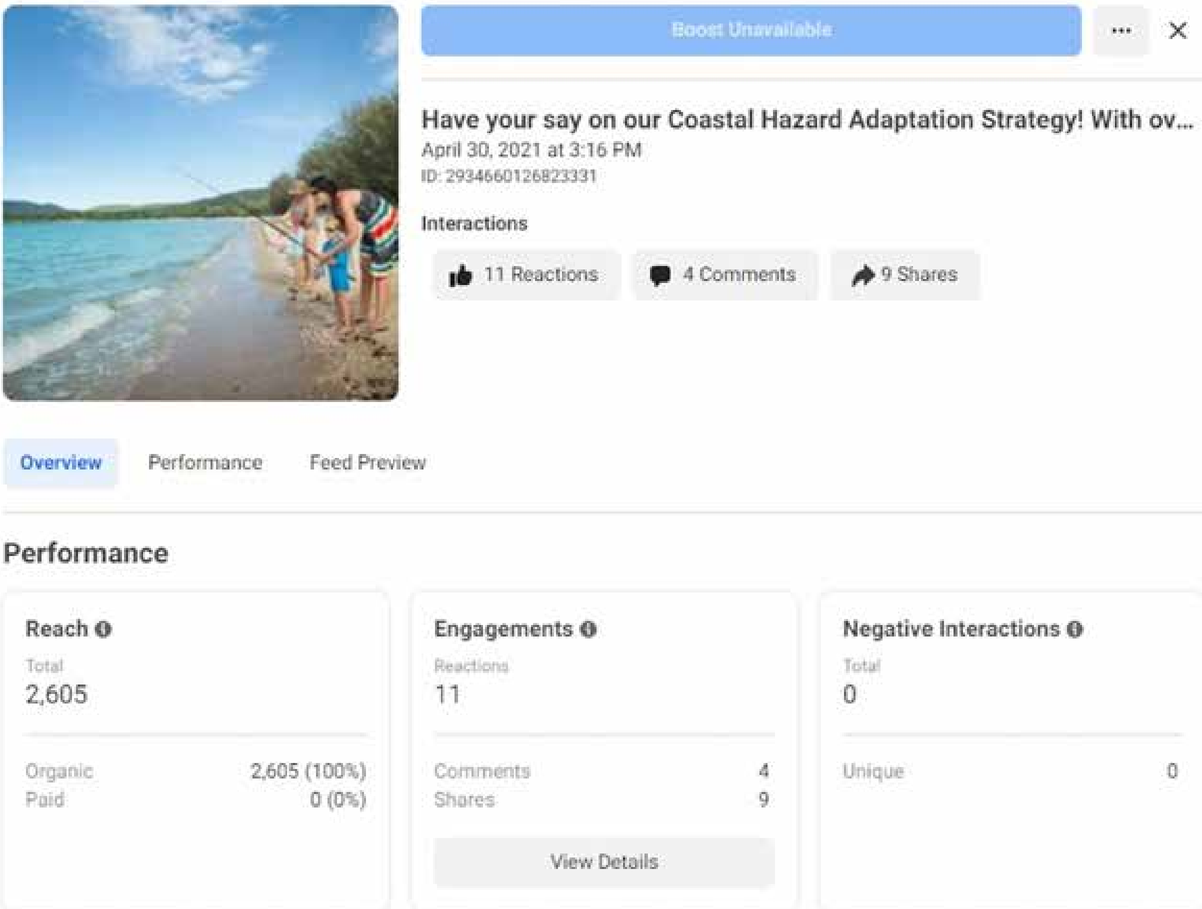
Airlie Beach / Cannonvale

RESULTS OF THE COMMUNITY CONSULTATION

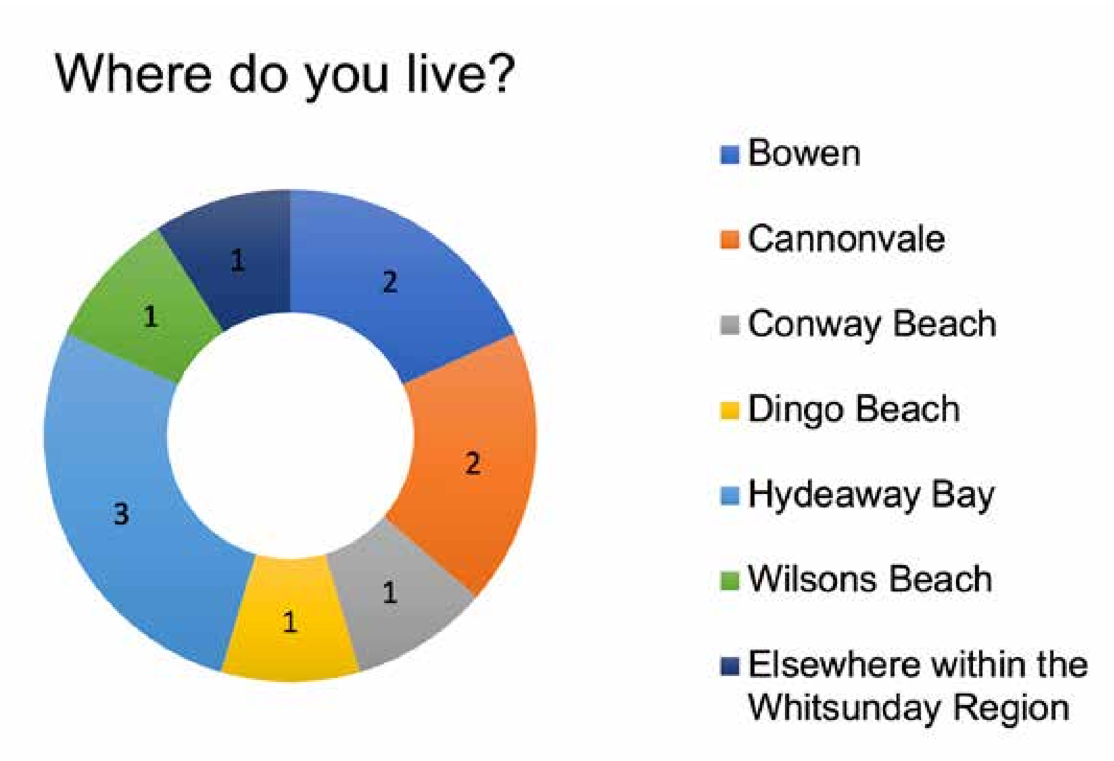
The consultation was promoted with a Facebook post at the beginning of the consultation period on 30 April. This post had a reach of 2,605 people, with 24 likes/shares/comments and 91 link clicks through to the Your Say Whitsunday website.

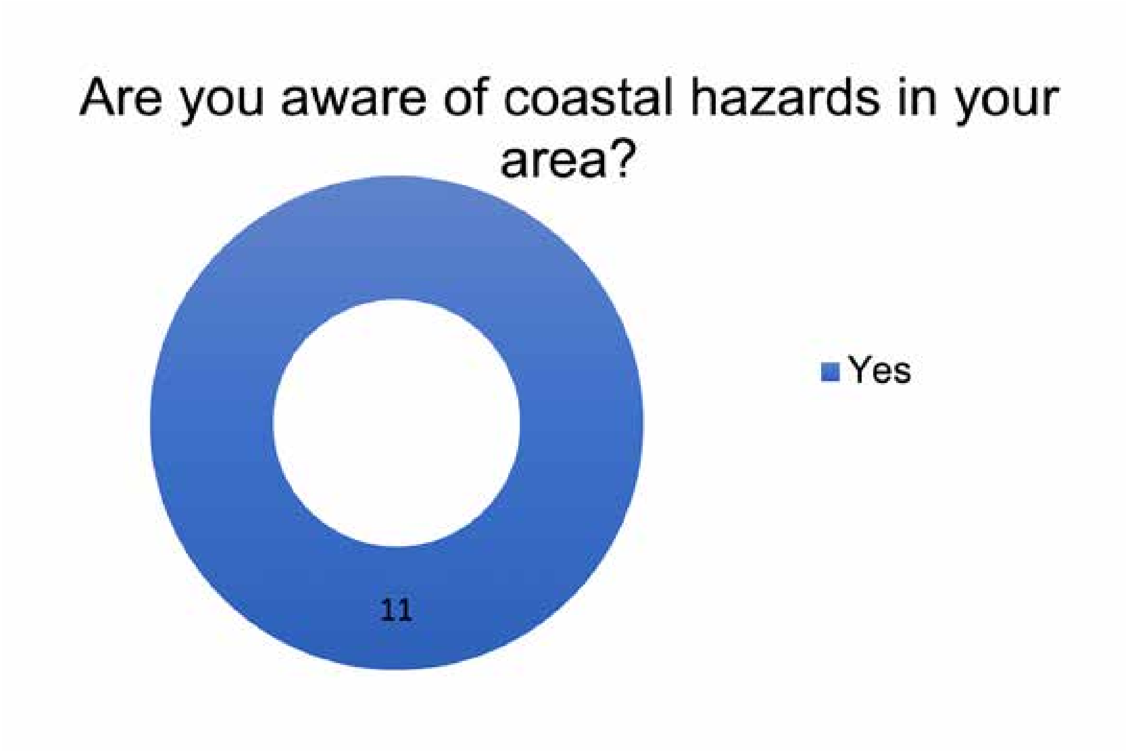
A total of 16 submissions were received during the consultation period and a range of general feedback during the public displays. While there was general support for the intentions and goals of the CHAS in protecting communities for the future, there is a clear divide in public opinion. Several residents queried the scientific evidence provided in the CHAS regarding projections for future sea level rise. Other residents want WRC to act more quickly than outlined in the CHAS by introducing limited development zones and coastal plans now. While expected, this divide in support for the scientific basis of the CHAS means further education and awareness campaigns should be developed to inform residents.

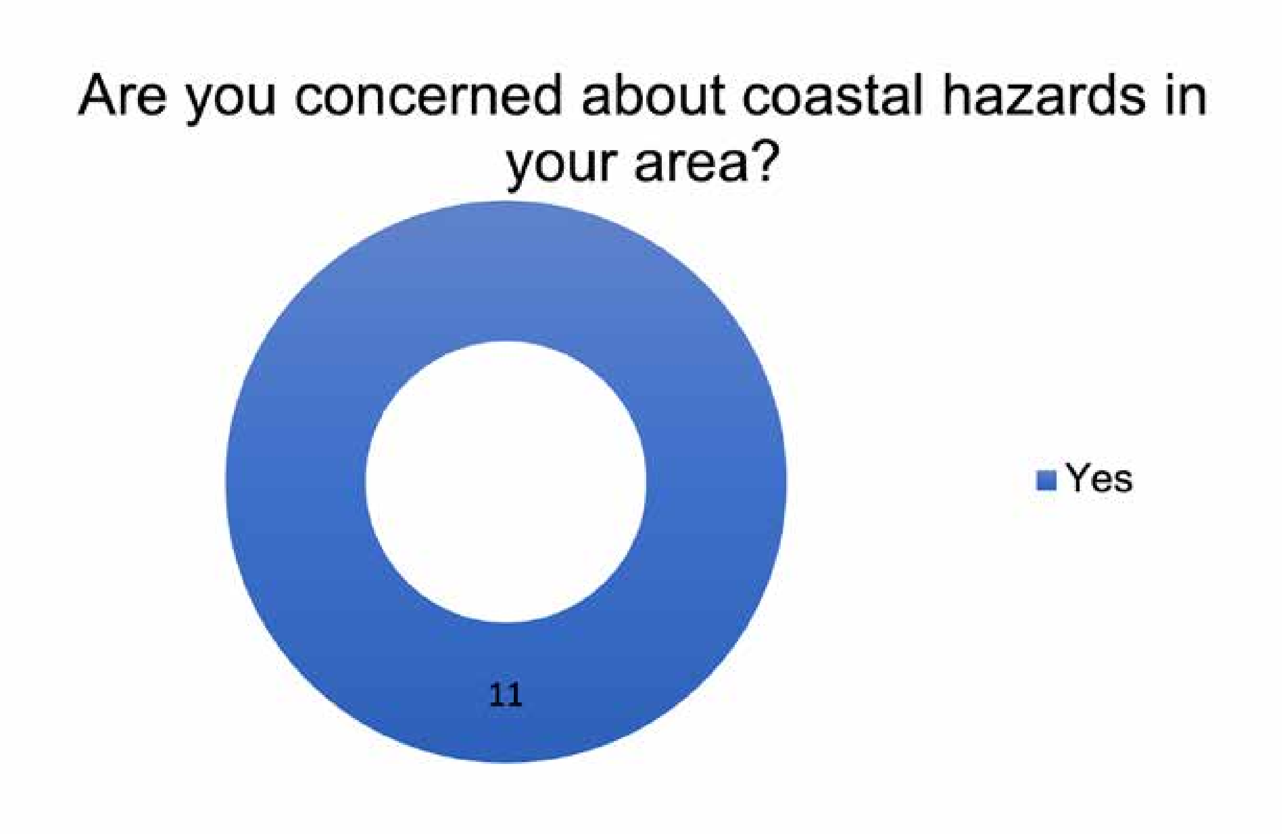
There were 54 residents who visited the six information stalls during the consultation period.

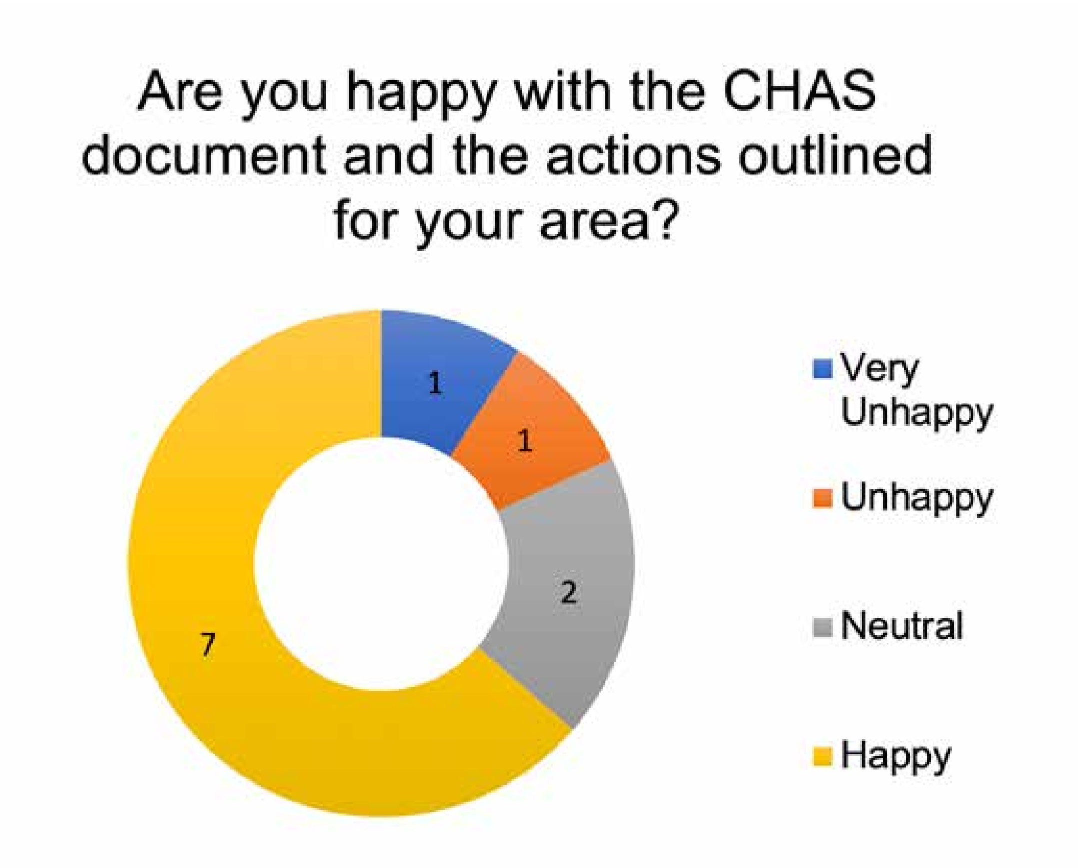


A total of 11 individuals completed the online survey during the consultation period, and the results from the survey questions are outlined below.

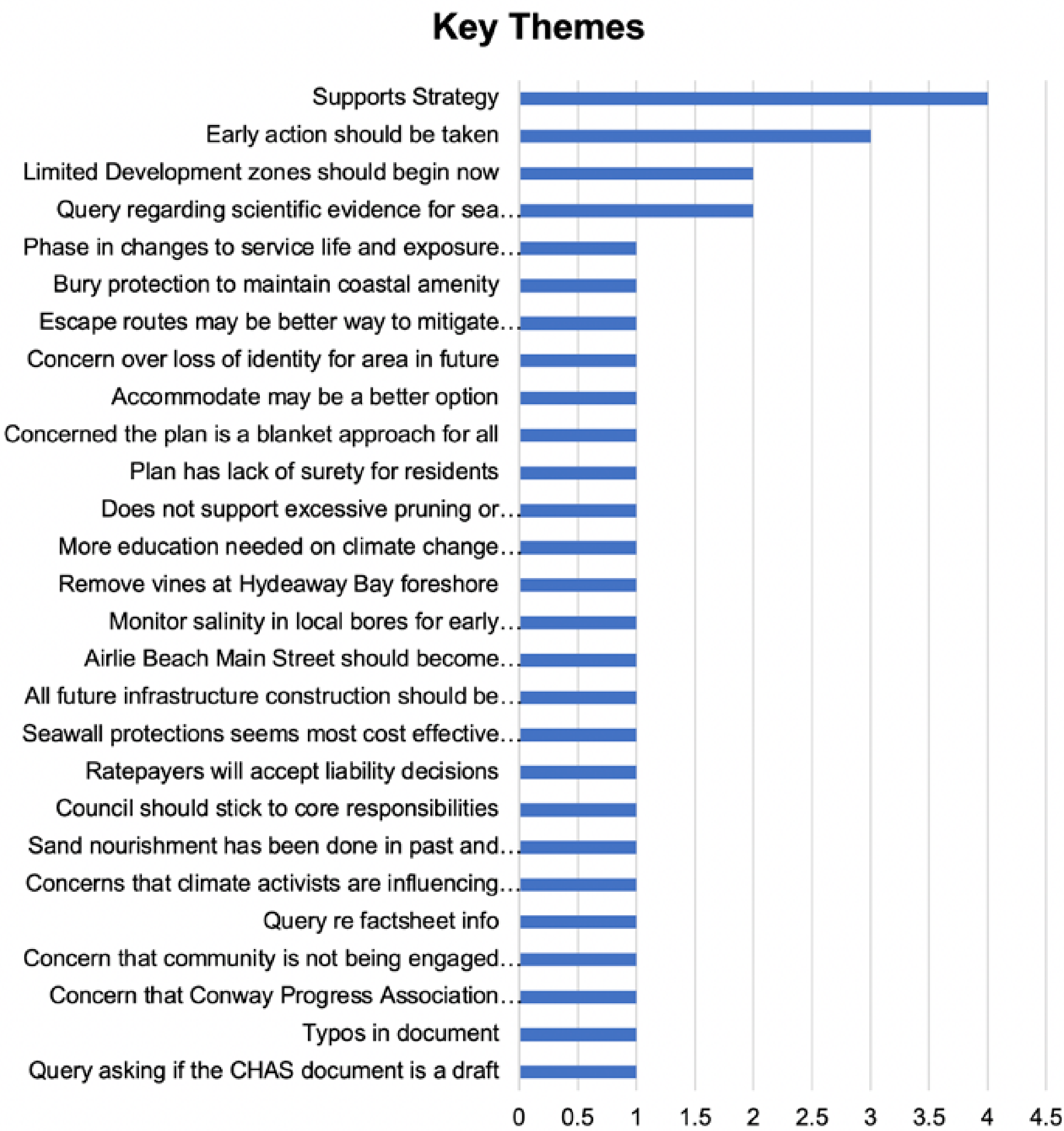





Are you concerned about coastal hazards in your area?
11
Yes


Are you happy with the CHAS document and the actions outlined for your area?
1
1
2
7
Very Unhappy
Unhappy
Neutral
Happy

All submissions have been collated and analysed into 'Key Themes' from the written feedback received during the consultation process.



CONCLUSION

It is recommended the feedback submitted during the consultation process is considered by WRC during the finalisation of the CHAS.

While opinions vary on the future impact of permanent sea level rise and coastal hazards, all participants expressed concern over the predicted outcomes. It is recommended that ongoing education and awareness of coastal hazards continues, and WRC continues to engage and inform residents in coastal communities.

The most popular suggestions in all feedback, with more than one mention, include:

- Support for the Strategy;
- Early action should be taken;
- Limited development zones should begin now; and
- Query regarding scientific evidence for sea level rise.

This feedback demonstrates the divide in public opinion, with some residents demanding action sooner and others questioning the science behind the strategy. While expected, this divide needs to be addressed in future communications, with more education around the scientific process and modelling.

Future communications to the public will outline the key results of the consultation and address any changes required in the Plan. The final version of the CHAS document will be made available on WRC's website and promoted to the wider community.

Ongoing communication and engagement about the project will keep the community informed of any updates and demonstrate that WRC has listened to the feedback provided in this report.

11 SUPPLEMENTS

The following supplements to this plan are available from Whitsunday Regional Council.

- Supplement A: Fact Sheets
- Supplement B: Whitsunday coastal story
- Supplement C: Coastal hazard mapping
- Supplement D: Adaption actions summary sheets

12 ACKNOWLEDGMENTS

Council would like to acknowledge and thank all members of the Stakeholder Advisory Group for their input into the Strategy development, including:

- Climate Planning
- Progress Associations
- Community Natural Resource Management Groups

Whitsunday Regional Council

Permanent Inundation

Airlie Beach Cannonvale 2100

N
W E
S

Legend:

Permanent Inundation

2100

Created By:
Julie Giguere

Date created :
08/10/20

This data set is an extract from Queensland's Digital Cadastral Database. Use of this data set may be approved with the written permission of the Director General, Department of Natural Ressources and Mines. (c) The State of Queensland (Dept. of Natural Resources and Mines). No liabiity accepted for any loss or damage that may arise from the use of or reliance on this data.

NOTE: For further information regarding risk, please refer to the Whitsunday Regional Council " Coastal Hazard Adaptation Strategy Risk Assessment" Report (May 2019) by Climate Planning.

0 5 10
kilometers

Legend:

Permanent inundation

2100

Permanent Inundation Bowen 2100

Created By: Julie Giguere

Date created : 03/12/2020

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0 5 10

kilometers

N W E S

Legend:

Permanent inundation

2100

Permanent Inundation Bowen 2100

Created By: Julie Giguere

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0 5 10
kilometers

N
W E
S

Permanent Inundation

Wilsons Beach 2100

N W E S

Legend:

Permanent Inundation

2100

Created By:
Julie Giguere

Date created :
08/10/20

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0 5 10
kilometers

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