

JANE REYNOLDS

LAKE MACQUARIE COASTAL MANAGEMENT PROGRAM

Cover image:
*Rock Women of Swansea
Heads, Jodie Reynolds*



Jodie Reynolds

Kamilaroi. Living and working on Awabakal Lands.

Rock Women of Swansea Heads 2021
(acrylic paint on canvas)

My artwork represents the Two Rock Women of Swansea Heads.

The Awabakal land is represented at the top of the piece, showing the different platforms of the landscape, it also shows the walking trails and tracks people would travel. The idea of fishing nets is also included as are the spears used for hunting.

The coal seams are represented going across the painting. More walking trails and meeting places in a larger scale representing the tribe's movement across the foreshore.

I have also incorporated the low tide line, people moving across the water, fishing from the shore and moving further into the water into fishing boats to catch their fish.

The red shapes in the water represent the many rocks, and the two most important rocks marked with a 'U' represent the two Rock Women of Swansea Heads.

The far left-hand corner represents Moon Island and the meeting place used for the Awabakal men. Down the left-hand side the coal seam that formed and the petrified forest is represented again.

The significance of this site is also highlighted by the crystalised water glistening over the area.

ACKNOWLEDGEMENT OF COUNTRY

We remember and respect the Ancestors who cared for and nurtured this Country.

Dhumaan ngayin ngarrakalu kirraanan barayidin.

It is in their footsteps that we travel these lands and waters.

Ngarrakalumba yuludaka bibayilin barayida baaduka.

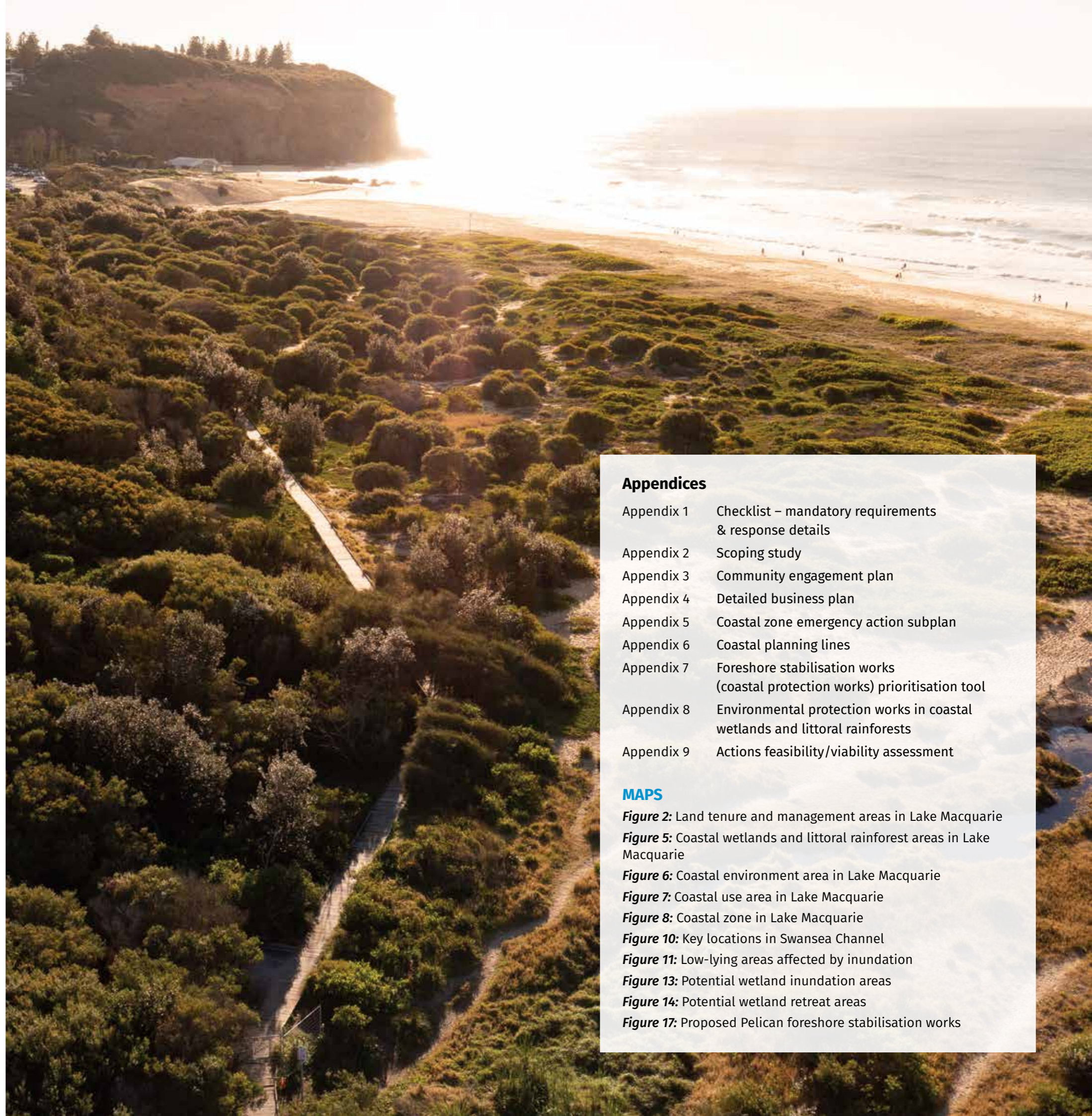
Lake Macquarie City Council acknowledges the Awabakal people and Elders past, present and future.

Lake Macquarie City Council dhumaan Awabakala ngarrakal yalawaa, yalawan, yalawanan.

Wording by the Aboriginal Reference Group and translated by Miromaa Aboriginal Language and Technology Centre.

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EXECUTIVE SUMMARY

Lake Macquarie City is located in the NSW Hunter Region, approximately 120km north of Sydney. The defining feature of the city is Lake Macquarie, the largest coastal lake in NSW. The lake is connected to the ocean and open coast via Swansea Channel.

The coastal zone of Lake Macquarie spans the lake and part of its catchment, the coastline and Swansea Channel. The southern part of the lake's foreshore and catchment area incorporates land within the Central Coast local government area. The coastline of Lake Macquarie shares a sediment compartment with the City of Newcastle to the north.

The Lake Macquarie coastal zone is ecologically rich, physically dynamic and an attractive place to visit and live. It is part of the traditional country of the Awabakal people. Awabakal people have lived around Lake Macquarie and utilised its aquatic resources for thousands of years. The natural assets in the city provide a quality lifestyle highly valued by the Lake Macquarie community. The coastal zone is heavily utilised by residents and visitors, particularly during summer.

In 2015, a Coastal Zone Management Plan (CZMP) was prepared for the Lake Macquarie Coastal Zone, in accordance with the objects of the *NSW Coastal Protection Act 1979*.

This Coastal Management Program (CMP) for the Lake Macquarie coastal zone provides an update of the CZMP and responds to the objects of the *Coastal Management Act 2016* and meets all necessary requirements identified in the Act and NSW Coastal Manual. The CMP builds on the successes of the CZMP and other previous programs, which have proven to be highly successful in restoring the health of the Lake Macquarie estuary and embedding systems to mitigate the impacts of coastal hazards, while continuing to provide healthy coastal environments enjoyed by the community.

The CMP identifies 114 priority actions across the three parts of the coastal zone: our coastline (Part A), our estuary (Part B) and Swansea Channel (Part C). While Lake Macquarie City Council is responsible for a large proportion of these actions, effective management of the coastal zone cannot be achieved by local government alone. The CMP identifies collaborative governance arrangements with all relevant stakeholders including state agencies, businesses and residents. It also includes a business plan which demonstrates the benefits of the CMP actions, and a framework to fund these actions into the future.

The CMP provides a pathway to achieve its vision of achieving "a healthy, resilient coastal zone".

VISION

A healthy, resilient coastal zone.

Marung, Birirral bunaba

Well, strong, sand place (sand being from a beach)

(Wording translated by Miromaa Aboriginal Language and Technology Centre)



MESSAGE FROM THE MAYOR



It really is no wonder Lake Macquarie City is such a highly sought-after place to settle, work and play. It has access to beaches, the lake, the bush and the mountains. Our residents and visitors can enjoy surfing, boating, fishing, walking or just exploring the city's natural beauty.

The Lake Macquarie Coastal Management Program (CMP) aims to preserve and enhance the environmental value of the coastline, estuary and channel amid increased visitation and pressure from urban development across the city, and the ever-increasing impacts of a changing climate.

The CMP has been prepared in collaboration with the NSW Department of Planning and Environment, as well as other agency and community stakeholders. This program puts forward priority actions to be implemented for our coastline, our estuary and the Swansea Channel.

Many of the actions within this CMP are the responsibility of Lake Macquarie City Council. However,

a healthy coastline, in a growing and active urban community is not achieved by the work of local government alone. The CMP highlights collaborative arrangements with state agencies, businesses and residents as key contributors to the ongoing success of coastal management within the city.

Other land managers and public authorities, including the Department of Planning and Environment, Crown Lands, Department of Primary Industries (Fisheries Division), Transport for NSW, Hunter Water Corporation, Local Land Services, and Belmont Wetlands State Park have an important role to play in delivering the actions outlined in this program.


I encourage all stakeholders to engage this plan to secure the lifestyle of the community and visitors of Lake Macquarie, and build upon the significant improvements in coastal health achieved over the last 20 years.

Councillor Kay Fraser
Mayor


INTRODUCTION

Lake Macquarie City, covering 757km², is a coastal destination featuring magnificent natural assets, including the lake, beaches and mountains.

Its main natural features include:

 the largest coastal saltwater lake in NSW, with a circumference of 174km

 32km of coastline to the east

 Watagans National Park to the west.

The city is a diverse coastal destination abundant with natural assets that provide a distinct sense of place and uniqueness. The population of Lake Macquarie is dispersed across 95 communities, with nine economic centres across the city. More than 1.36 million people visit Lake Macquarie annually (Tourism Research Australia four-year average).

The mapped coastal zone comprises 32 per cent of the Local Government Area (20 per cent of the land area) and is home to an estimated 45 per cent of the city's population.

The sustainable management of Lake Macquarie's coastal zone is required to ensure the intrinsic environmental, social, economic and recreational qualities of the coast are maintained and enhanced for the use and enjoyment of the community.

Management of the coastal zone has significant challenges. These include:

- development pressure and use of the coastal zone
- impacts from urban pollution on coastal and oceanic environments
- the impacts of climate change.

SECTION 1 - OUR COASTAL ZONE



1.1 Environmental context

The coastal zone environment is dynamic. Estuary processes operate at different time scales, varying from hours and days to decades or more. Some processes such as tides vary in predictable ways. For others, the extent and rate of change is much more uncertain.

Coastline

The Lake Macquarie coastline is part of the Newcastle Coast sediment compartment (Schedule 1 of the *Coastal Management Act 2016*). City of Newcastle and Central Coast Council (Wyong) also share this sediment compartment.

The sandy and rocky coastline is an important part of the character of Lake Macquarie City. As a physical feature, it is the interface between the marine environment and the terrestrial environment. While the Watagan Range forms the western backdrop to the city, the ocean dominates its eastern landscape.

Some of the ecological communities on the Lake Macquarie coastline are rare or endangered, including native Themeda grasslands on headlands, and littoral rainforest at Swansea Heads. In addition, many coastal habitats support high biological diversity and rare species such as endangered shorebirds and animals that live off the rock platforms. Importantly, these ecological communities together with the geomorphic structure of the coast creates a scenic landscape of beaches, headlands and shore platforms highly valued for recreation by locals and visitors.

The ecological condition and value of the coast has been affected by historical mining and extractive industries (Nine Mile Beach, Caves Beach and Catherine Hill Bay). Urban development has encroached on coastal headlands at Redhead, Swansea Heads and Caves Beach, as well as behind the coastal dunes at Redhead and Blacksmiths. Old access tracks constructed for these land uses have opened pathways for walkers, cyclists and off-road vehicles. Despite this disturbance, much of the coast is in a relatively natural condition, including land managed in National Parks, State Parks, State Conservation Areas and by Council as community land.

Estuary

Lake Macquarie, classified as a barrier lagoon in geomorphic terms, is the largest coastal lake in NSW, covering an area of approximately 110km² with a catchment of approximately 650km². It is situated between Sydney and Newcastle and is bordered by residential, industrial, rural and undeveloped land. The lake is of significant ecological value, while also providing for a range of aquatic and land-based recreational activities.

Lake Macquarie has approximately 174km of foreshore. The foreshores of the lake comprise: rock-based slopes (common along the western side), rock-based slopes of lower gradient, sandy shorelines that are back-barrier deposits, creek delta deposits, creek floodplain deposits and modified shorelines with seawalls of varying designs.

Foreshore erosion in the lake is primarily driven by wind waves, allowing wave energy to impact the shoreline. Waves over one metre high are not uncommon. Additional natural processes affecting foreshore erosion are longshore drift and incoming stream flows.

Areas affected by lake flooding occur around the entire foreshore. Issues of catchment inundation and flood risk are managed by Council through a separate program, however these management actions and objectives need to align with our coastal management program.

Presently, there is approximately 12.4km² of seagrass coverage in Lake Macquarie. This is the third largest area of seagrass in NSW. Lake Macquarie supports a variety of seagrass species. The most abundant and widely distributed species in the lake is *Zostera capricorni*, though the threatened seagrass species, *Posidonia australis* is also present. Other species found include *Halophila ovalis* and *Ruppia megacarpa*. Seagrass is the main source of primary production for the food web within the lake and is used by invertebrate species to recycle organic matter and nutrients.

Cooling water from the Eraring and Vales Point Power Station discharges into the lake, and large ash dams associated with the operation of these power stations are located close to the lake foreshore. In addition, some coal mines in the Lake Macquarie catchment are licensed to discharge mine water, which then flows into the lake. The legacy of contamination from the former Cockle Creek lead and zinc smelter also continues to impact on northern Lake Macquarie.

Water quality in the lake has improved significantly over the past 20 years, following significant investment in ecological health by local and state government. Expansion of reticulated sewerage, stormwater management, foreshore stabilisation and sediment control measures have systematically improved the ecological function of the lake environment, primarily by reducing excess nutrient loads.



Table 1 Characteristics of Lake Macquarie and the catchment

Characteristic	Unit	Value
Lake surface area	ha	11,000
Average lake volume	ML	666,190
Max lake depth [^]	m	13
Average lake depth [^]	m	8
Length of shoreline perimeter	km	174
Area of seagrasses*	ha	1,246
Area of wetland	ha	1,961
Area of mangrove	ha	159
Area of saltmarsh	ha	78
Stream network (length creek lines in LMCC LGA)	km	2,424
Total surface flows from catchment (estimate) [#]	LM/y	85,256
Total suspended solids - TSS exported to the Lake (estimate) [#]	tonnes/y	5,577
Total nitrogen - TN exported to the lake (estimate) [#]	kg/y	139,236
Total phosphorous - TP exported to the Lake (estimate) [#]	kg/y	16,612

* Date from seagrass mapping by DPIE SEI in 2017.
[^]From bathymetry mapping by DPIE SEI in 2011.
[#] Estimated surface flow (ML/y), TSS, TN, TP loads (kg/y) are from the Lake Macquarie catchment model. Other data provided by LMCC from various mapping projects.

(Source: DPIE State of the Estuary Report 2021)

Swansea Channel

Swansea Channel connects the main body of Lake Macquarie to the ocean. The channel is located entirely within the Lake Macquarie Local Government Area. The construction of entrance breakwaters, Swansea Bridge and revetments has modified processes in the channel. Broadly, the channel can be divided in two at Swansea Bridge, which carries the Pacific Highway across the channel and connects the suburbs of Blacksmiths to the north, and Swansea to the south. The channel downstream (East) of Swansea Bridge is affected significantly by oceanic swell waves that penetrate the widely spaced breakwaters at the entrance. Upstream, the dominant coastal processes relate to tidal currents and the transport of sediment. The combination of waves downstream of the bridge and tidal currents throughout the channel has caused significant erosion (particularly in Salts Bay and between Mats Point and the entrance to Black Neds Bay) and causes sand to be transported upstream to the 'drop-over' at the lake end of the channel.

Management of the channel over the past few decades has involved repeated dredging campaigns and various works, such as partial closure of the southern entrance to Swan Bay, commonly to address issues with navigation and foreshore erosion. The channel has a persistent, dynamic nature which creates challenges for those tasked with its integrated management. The combined impact of tides and waves with future sea level rise will further complicate these challenges.

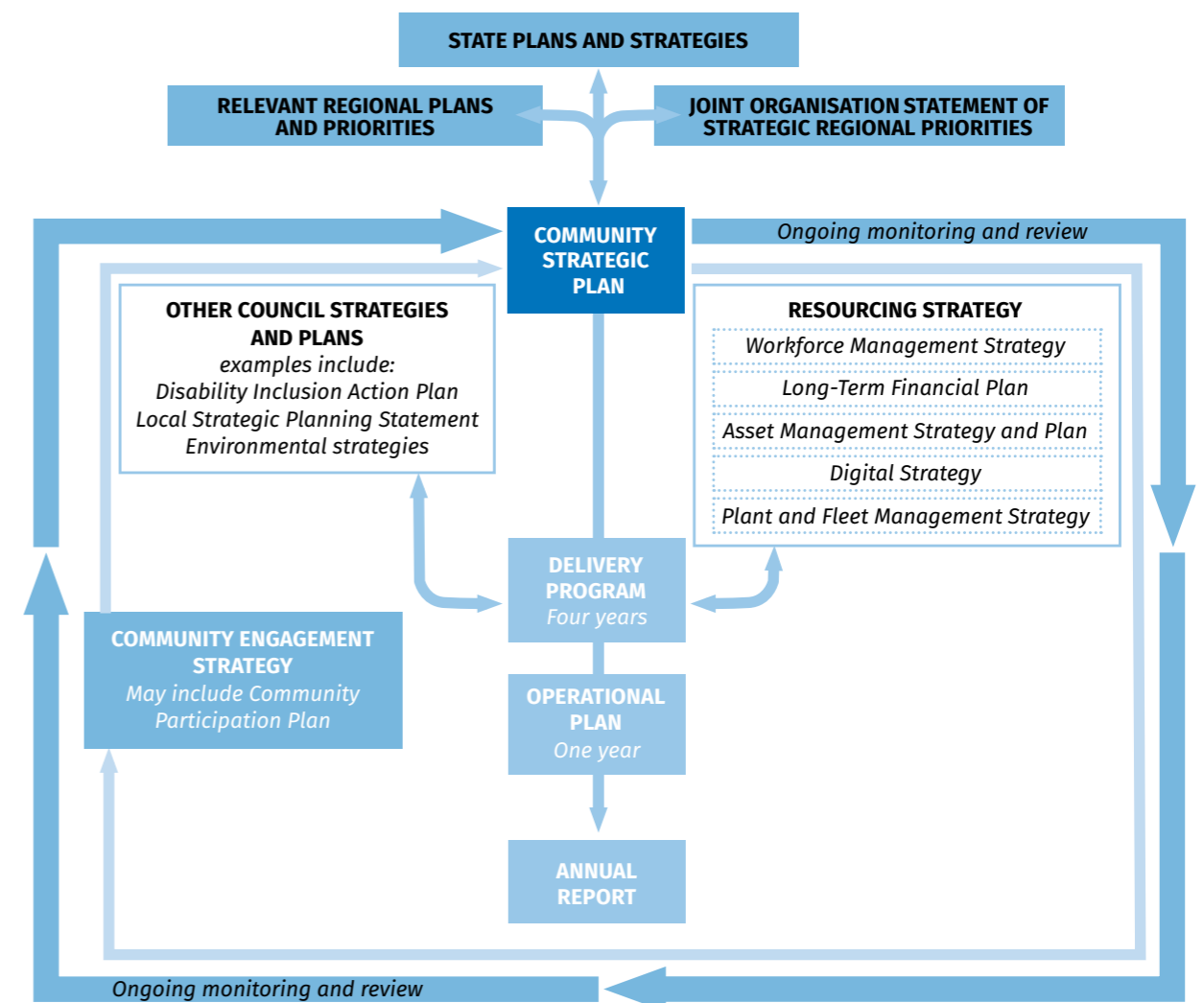
1.2 Planning context

Integrated Planning and Reporting Framework

The Community Strategic Plan specifies the city vision and community values for a 10-year period. There are seven key focus areas identified in Council's Community Strategic Plan: unique landscapes, lifestyle and wellbeing, mobility and accessibility, diverse economy, connected communities, creativity, and shared decision-making. The plan also identifies various strategies, performance measures and objectives.

The CMP is a strategic plan under the Local Strategic Planning Statement and will be delivered through Council's Delivery Program and annual Operational Plan.

Figure 1: Integrated Planning and Reporting Framework



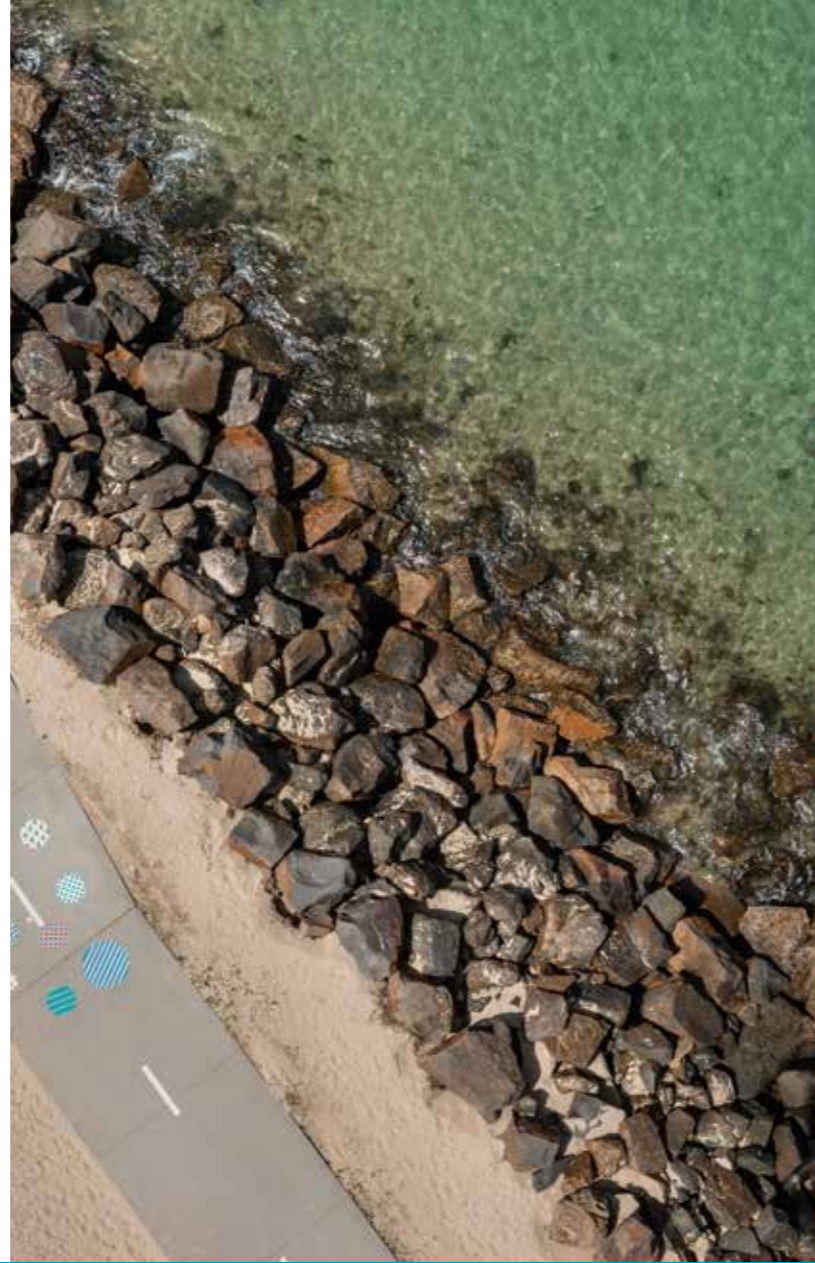
Local Strategic Planning Statement

The Lake Macquarie [Local Strategic Planning Statement](#) (LSPS) provides a strategic direction for the city, the following reference being particularly relevant to management of the coastal zone:

...the 'jewel in the crown, for the City will be the abundance of high quality indoor and outdoor spaces to connect with others, enjoy nature, relax or get active. These spaces may be bushland reserves, the lake and foreshore, parks, a quiet garden area within a busy centre, or a purpose-built area within a multi-use building.

The LSPS specifies the following actions relating to the CMP:

- 6.2 Prepare Coastal Management Program for the Lake Macquarie coastal zone to provide a strategic program for coastal, estuary and waterway management
- 6.6 Implement priority actions in the Lake Macquarie Coastal Zone Management Plan, such as continuing to prepare adaptation plans, to develop resilient coastal landscapes and communities
- 7.9 Develop and implement local adaptation plans to address current and emerging climate change risk.



1.2.1

NSW Coastal Management Framework - Whether the CMP identifies recommended changes to the relevant planning controls, including any proposed maps.

In 2016, the NSW Government established a new framework to manage the coastal environment in an ecologically sustainable way for the social, cultural and economic wellbeing of the people of NSW (Figure 2). The cornerstone of this framework, the *Coastal Management Act 2016*, requires Council to develop a long-term strategy to manage our coastal zone.

This CMP does not identify a coastal vulnerability area or propose changes to the relevant planning controls, including any proposed maps.

Figure 2: The Coastal Management Framework



Coastal Management Act 2016 and Resilience and Hazards SEPP 2021

The *Coastal Management Act 2016* (CM ACT) establishes the framework and overarching objectives for coastal management in NSW.

The purpose of the CM Act is to manage the use and development of the coastal environment in an ecologically sustainable way for the social, cultural and economic wellbeing of the people of NSW.

The CM Act also supports the aims of the *Marine Estate Management Act 2014*, as the coastal zone forms part of the marine estate.

The CM Act outlines coastal management areas. Lake Macquarie has three distinct coastal management areas (refer to Figures 3, 4 and 5):

1. coastal wetlands and littoral rainforest areas – areas which display the characteristics of coastal wetlands or littoral rainforests that were previously protected State Environmental Planning Policy 14 and SEPP 26
2. coastal use areas – land adjacent to coastal waters, estuaries and coastal lakes
3. coastal environment areas – areas that are characterised by natural coastal features such as beaches, rock platforms, coastal lakes and lagoons, headlands and marine and estuarine waters.

The CM Act refers to a fourth coastal management area:

4. coastal vulnerability area - areas subject to coastal hazards. The coastal vulnerability area is intended to cover areas subject to coastal hazards such as coastal erosion and tidal inundation. This CMP does not identify a coastal vulnerability area or propose changes to the relevant planning controls, including any proposed maps.

Lake Macquarie is subject to coastal hazards including foreshore erosion, inundation due to catchment rainfall and/or elevated ocean water levels (also termed coastal inundation), and ongoing changes in mean and tidal water levels. Inundation relating to catchment rainfall coinciding with storm event elevated ocean water levels is also managed through the NSW floodplain risk management framework.

Figure 3: Coastal wetlands and littoral rainforest areas in Lake Macquarie

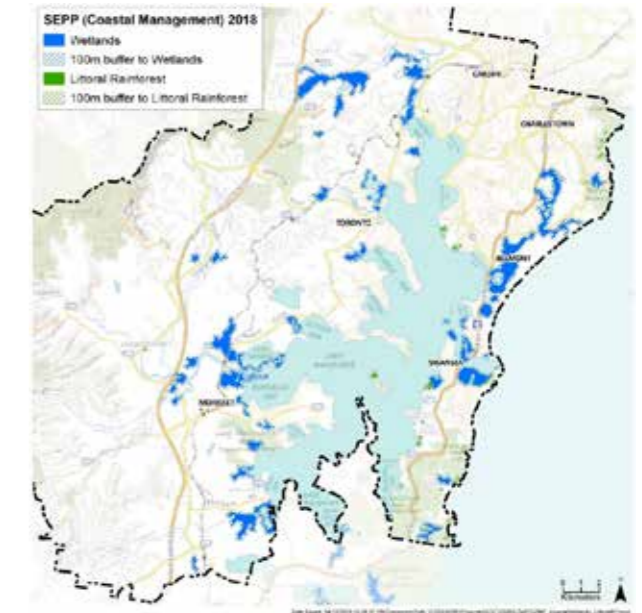


Figure 4: Coastal environment area in Lake Macquarie

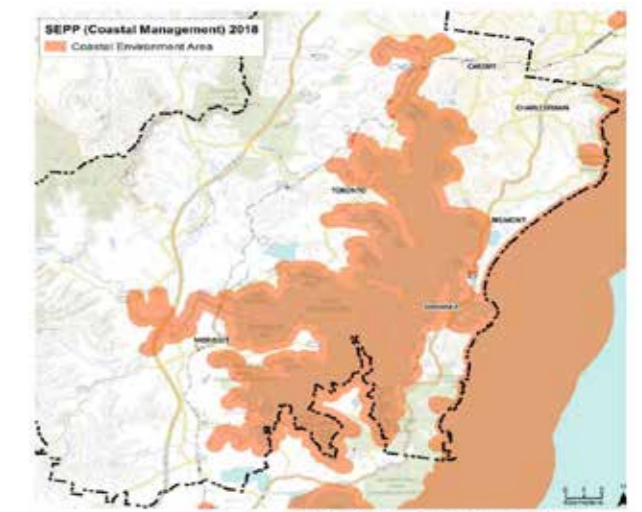
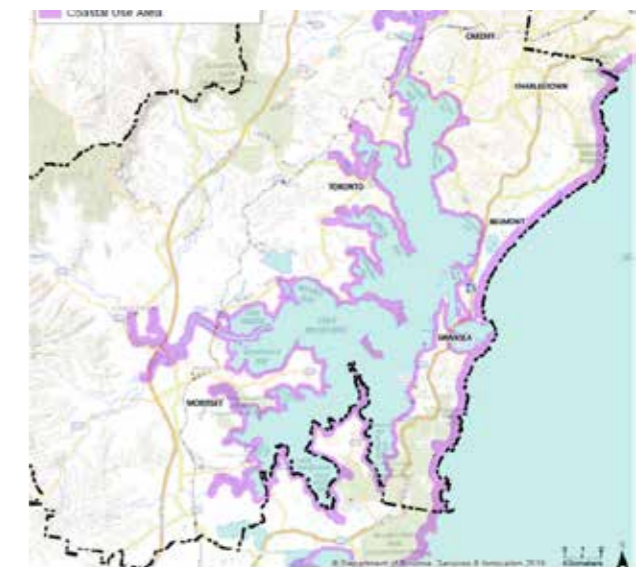


Figure 5: Coastal use area in Lake Macquarie





Glenrock Lagoon

Objects and management objectives of the Coastal Management Act 2016

The CMP considers and promotes the objects of the CM Act and management objectives of the coastal management areas.

A detailed explanation of how these objects and management objectives have been addressed is provided in Table 3 of Appendix 1.

The objects of the CM Act were also addressed in the evaluation of each of the actions contained in the implementation plan. The feasibility criteria used to evaluate actions included an assessment of how each action promotes and gives effect to the objects of the CM Act (refer to Appendix 9).

Integration with the Marine Estate Management Strategy (MEMS)

The Marine Estate Management Strategy (MEMS) (2018-2028) was developed by the Marine Estate Management Authority to respond to high risks identified in the state-wide Threat and Risk Assessment (TARA) for the Marine estate. The TARA also provides a regional scale risk assessment, with Lake Macquarie identified in the Central Region.

Overall, the TARA identified urban and rural discharges and runoff, climate change and disturbance of estuary habitats (from various

sources) as major threats. Lake Macquarie is affected by these threats, which have informed the priorities for the CMP. In the Central Region, which includes most of the densely settled urban areas of NSW, pollutants and disturbance from boating activity, sewerage systems, service infrastructure and industrial/thermal discharges are also significant threats.

The MEMS also notes the emerging threat of loss of cultural and heritage values, and emerging safety concerns around interactions of marine species and recreational/tourism waterways.

The CMP includes actions which address these issues in the local context, including a strong focus on urban stormwater, actions relating to overflows from the sewerage system, further studies of the cumulative and long term effects of historical industrial and power generation discharges, projects to investigate interactions of recreational use and the natural systems of the coast, controls on boating activity in high vulnerability seagrass communities, stronger protections for important natural areas and actions to provide further opportunities for Aboriginal community involvement.

The CMP will provide a direct contribution to better management of MEMS priorities. The high risk environmental threats identified in the Central NSW TARA (and found to be relevant to Lake Macquarie and its catchment), are shown in Table 3 of the [State of the Estuary Report](#).

1.3 Cultural and social context

Aboriginal cultural heritage

Lake Macquarie, the coast and the catchment extending to the Watagan Ranges are part of the traditional country of the Awabakal people. Awabakal people have lived around Lake Macquarie and used its aquatic resources since the early Holocene period, more than 8000 years ago. They also occupied this landscape before it arrived at its current form, when sea levels were much lower.

Awabakal ancestors were custodians of the landscape and this tradition has been passed on to Awabakal people today. Physical evidence of past Awabakal life around the estuary includes grinding groove sites, middens, campsites, scar trees and rock shelters. These sites are vulnerable to disturbance by development and recreation. The vegetation and fauna of the lake and its foreshores and catchment are also highly valued by Awabakal people and these are the resources of which they are custodians.

In June 2017, *A Commitment to the Aboriginal and Torres Strait Islander people of Lake Macquarie* was adopted by Council. This commitment recognises the contribution of Aboriginal culture to the city's landscape and to its social and cultural diversity. The Aboriginal Heritage Management Strategy sets out how Council and the local Aboriginal community will work as partners to implement the Statement of Commitment. The strategy introduces the concept of Sensitive Aboriginal Cultural Landscapes (SACL). These more sensitive landscapes are defined and mapped from known archaeological evidence, the predicted extent of archaeologically significant areas, places associated with records of traditional Awabakal stories and practices, places that conserve important traditional resources and places that are important in the shared history of the city since European settlement. SACL mapped include the lake shore, ocean shore, terraces, deltas and riparian foot-slopes along creek corridors and upper catchments, and escarpments of the Watagan and Sugarloaf Ranges.

Threats to these landscapes include:

- Historical use of the lake foreshore and lower reaches of estuarine creeks and wetlands for rail, power generation, sewerage and other infrastructure, which has destroyed middens and open campsites.
- Filling and formalisation of lake shorelines with sea walls, construction of slipways, boat sheds and residences. All these activities have

transformed the lake shore landscape, as well as damaging middens close to the lake shore. Some archaeological material remains in less formal foreshore reserves and where old houses or boat sheds are on piers rather than slab foundations.

- Foreshore and nearshore reserve management, including filling of low-lying areas, mowing, installation of playing fields and parkland equipment, which has destroyed middens and open campsites. Scarred trees have also been lost from foreshore locations and lower reaches of major creeks and their catchments, such as Dora Creek and Cockle Creek.
- Land clearing for agricultural, industrial and urban uses, which has removed scarred trees and disturbed the structure and context of open sites. Stone arrangements have also been damaged or destroyed by land-clearing activities.
- Land management within urban subdivisions, which has changed flows in creeks, increased erosion or sedimentation and encouraged invasion of culturally valued vegetation communities by weeds. Transport, water, sewerage and power infrastructure to support urban development can cause significant disturbance of long corridors across the landscape.
- Poor control of access within lake shore and bushland reserves (Crown Land, community land and private land), which has contributed to erosion, rubbish dumping and damage to vegetation associated with illegal four-wheel drive and trail bike activity.
- Industrial development along major tributary creeks (for instance in the lower freshwater and estuarine reaches of Cockle Creek), which has removed or damaged surfaces that would once have been associated with diverse Aboriginal community resources and archaeological evidence of past occupation.
- Coal mining (both open cut and underground), which has contributed to the loss of Aboriginal sites and changes to cultural landscapes, either directly through extraction or indirectly due to subsidence impacts. It should also be noted, however, that underground mining in the western part of the city has helped to maintain some relatively natural landscapes in this area.

Many of the threats to SACLs are similar to those that impact the ecological features of the estuary and therefore estuary management actions are likely to enhance cultural, as well as natural values.



European heritage

Lake Macquarie and its estuarine tributary creeks also have a strong heritage values, with European settlement from the early nineteenth century driven by the discovery of coal in the late eighteenth century originating in Newcastle, then spreading to the shores of Lake Macquarie within a few years. Lake Macquarie’s heritage includes coal mining, forestry, farming, boat building and fishing. The lake served as an important transport corridor for these industries, prior to the development of road transport.

The estuary also has an important history and continuing value as a training ground for national and international sailors. These heritage and cultural values are separate from, but associated with, the natural values and systems of the estuary.

Population demographics

Local population trends

The population of the city is growing. Over the next two decades, new urban areas and urban intensification are proposed in the north-west (Speers Point to Glendale), north-east (Charlestown), south-east (Caves Beach and Catherine Hill Bay) and south-west (Morisset and Cooranbong).

Three potential growth scenarios have been

identified. The first scenario reflects current economic, population and demographic trends. In this scenario, the population is expected to grow from approximately 210,000 in 2021 to about 225,000 by 2036. Successful attraction of investment, business activity and jobs could alter the current trend leading to higher population growth scenarios.

The second scenario sees a greater recognition of the Lower Hunter (and Lake Macquarie) as a preferred place to live and work. In this scenario, the population potentially grows to more than 250,000 by 2036.

The third scenario considers the Hunter region within the reach of the expanding global city of Sydney. Liveability pressures in Sydney, emerging remote working trends, digital connectivity, and enhanced transport links from Newcastle to Wollongong have potential to create significant growth. In this scenario, population could grow to more than 300,000 by 2036.

There are various social, economic and environmental implications associated with each of these scenarios. Related opportunities and pressures will need to be managed well. Demand for land and infrastructure along with environmental constraints of each scenario will need to be identified, monitored and responded to appropriately.

Lake Macquarie City has many of the characteristics

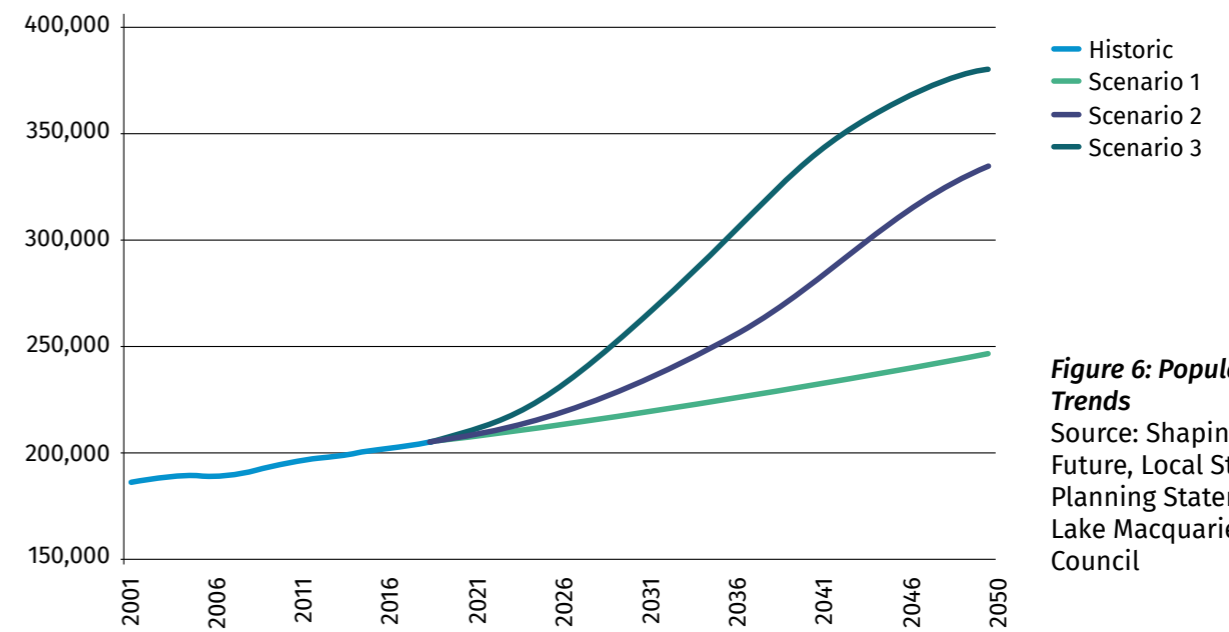


Figure 6: Population Trends
Source: Shaping the Future, Local Strategic Planning Statement, Lake Macquarie City Council

of a relatively socially conservative area, including an older population, lower education levels, strong history of mining and power generation employment (even though neither now dominate the workforce), and stable residency, with multigenerational families living in the city. The city is suburban, and village based, so for recreation, local access opportunities are important.

The lake is an important recreational asset for all growth areas, but particularly for the north-west and south-west. For these areas, Lake Macquarie is the nearest aquatic recreation place. The Lake Activation Strategy provides a strategic framework, service levels and actions to ensure community needs for lake access and foreshore infrastructure are improved over the next 10 years (Umwelt 2021).

Regional population trends

Demand for recreational access to Lake Macquarie also comes from our regional neighbours. This includes Newcastle and other cities and towns across the Lower Hunter, as well as the Central Coast and Sydney. Regional visitors are the largest group of day and overnight visitors to Lake Macquarie. Lakeside centres likely to receive increasing regional visitors include the Morisset Peninsula, Toronto, Rathmines, Wangi Wangi, the Booragul to Speers Point area in the north and the Belmont to Swansea area in the east.

There are strong flows of people between Newcastle and Lake Macquarie. Focal destination centres include Charlestown, Speers Point, Warners Bay, Croudace Bay and Belmont, across the northern and eastern shores of Lake Macquarie.

Over the next decade, Newcastle Airport will be upgraded to receive international air traffic, which will increase accessibility to Lake Macquarie for overseas travellers.

Lake Macquarie community values

The lake and coastline are important natural features of our city. Climate change and projected

sea level rise are two global challenges that our city needs to consider for future planning in these areas. Community engagement is vital to ensuring the history, values and knowledge of local areas are embedded within the decision-making of policy and plans.

Past and current planning for coastal areas and the lake have used community representative groups, workshops, drop-in sessions and online and postal surveys to engage local residents and key stakeholders to share their knowledge. As part of the development of the CMP's scoping study, community members provided information about what is important to them and what they thought should be included in a vision for the coastal zone. Comments provided have been used to inform the vision for Lake Macquarie's CMP, and have also been translated into coastal values, along with the addition of items included in the Marine Estate Management Authority Threat and Risk Assessment (TARA) final report.

The table below indicates the primary economic, social and environmental community coastal values. These have been considered in the context of state-wide risk issues (as identified in the *Marine Estate Management Strategy 2016*).

Table 2: Community coastal values and cumulative state-wide risk issues

Economic	Social	Environmental
Proactive management of coastal climate risks	Educated community	Healthy coastal zone
Strong tourism economy	Good public access	Stable and resilient channel
Accessible surf breaks	Surf amenity	Healthy, sustainable, resilient estuary
	Culturally respectful activities	Clean and healthy lake supporting natural ecosystems
	Resilient & accessible lake	Wildlife refuge
	Aboriginal cultural heritage and use	Healthy connection between lake and ocean
		Data accessibility
		Fisheries – fish assemblage management & uncertainty of impact of fishing activities
		Estuaries – role as receiving water quality environment & holistic management
		Threatened Species (Biodiversity Conservation Act)
		Climate Change – practical adaptation/resilience building actions

Source: Lake Macquarie City Council Coastal Management Program Scoping Study 2020



1.4 Economic context

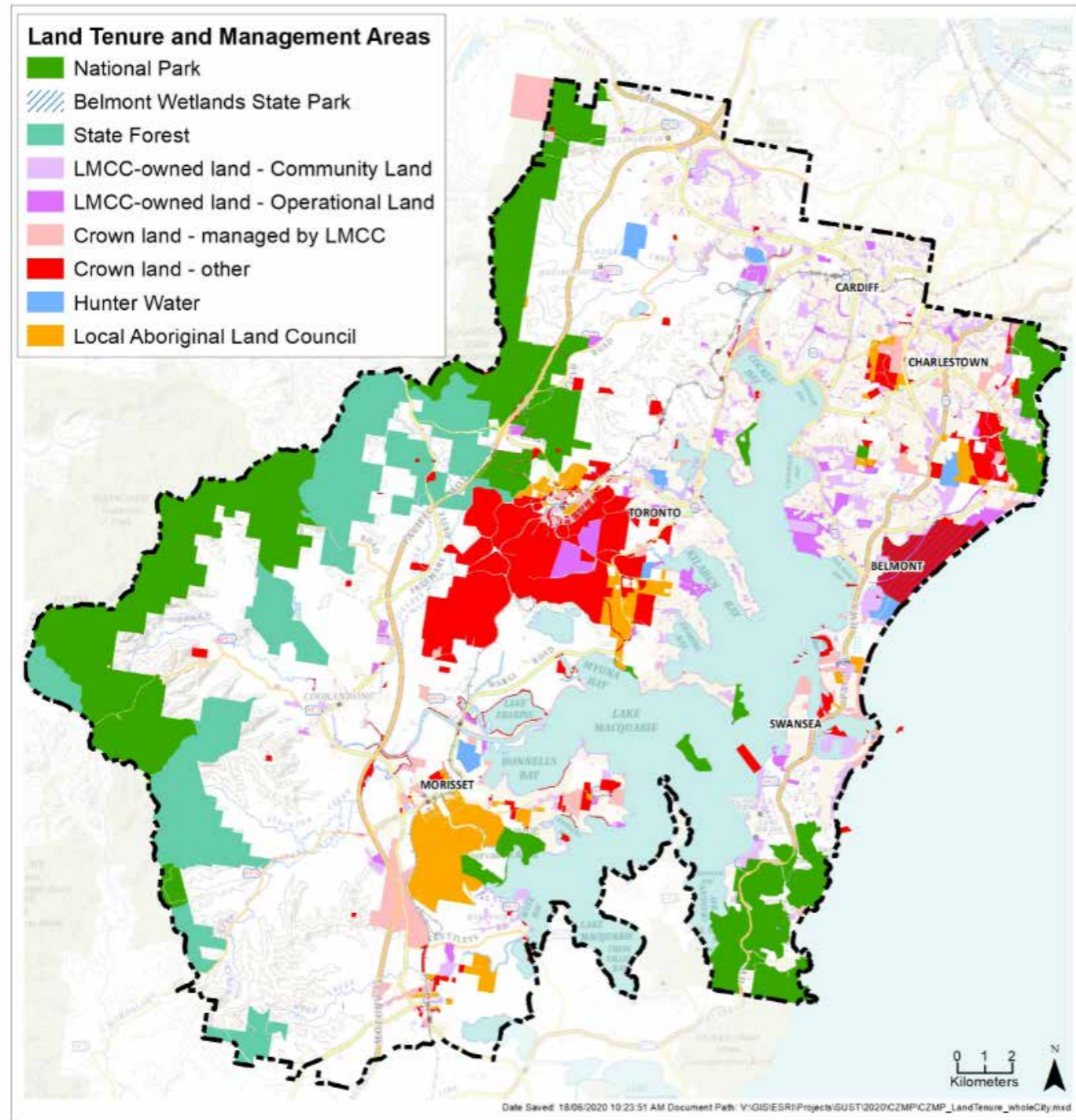
The Lake Macquarie City Economic Development Strategy identifies the vision for Lake Macquarie's economic future as:

In 20 years, Lake Macquarie will be one of the top 10 most liveable cities in Australia.

It includes the strategic objectives: identity, investment, infrastructure and innovation.

This strategy sets targets for the city well beyond growth forecasts provided by the NSW Department of Planning and Environment.

Figure 7: Land tenure and management areas in Lake Macquarie



1.5 Governance context

Shared responsibility

The coastal zone is owned and/or managed by a number of different government agencies, private individuals and other organisations. Council recognises the key role of the city's Sustainable Neighbourhoods Alliance, Landcare Network and other community groups in sustainability project collaboration.

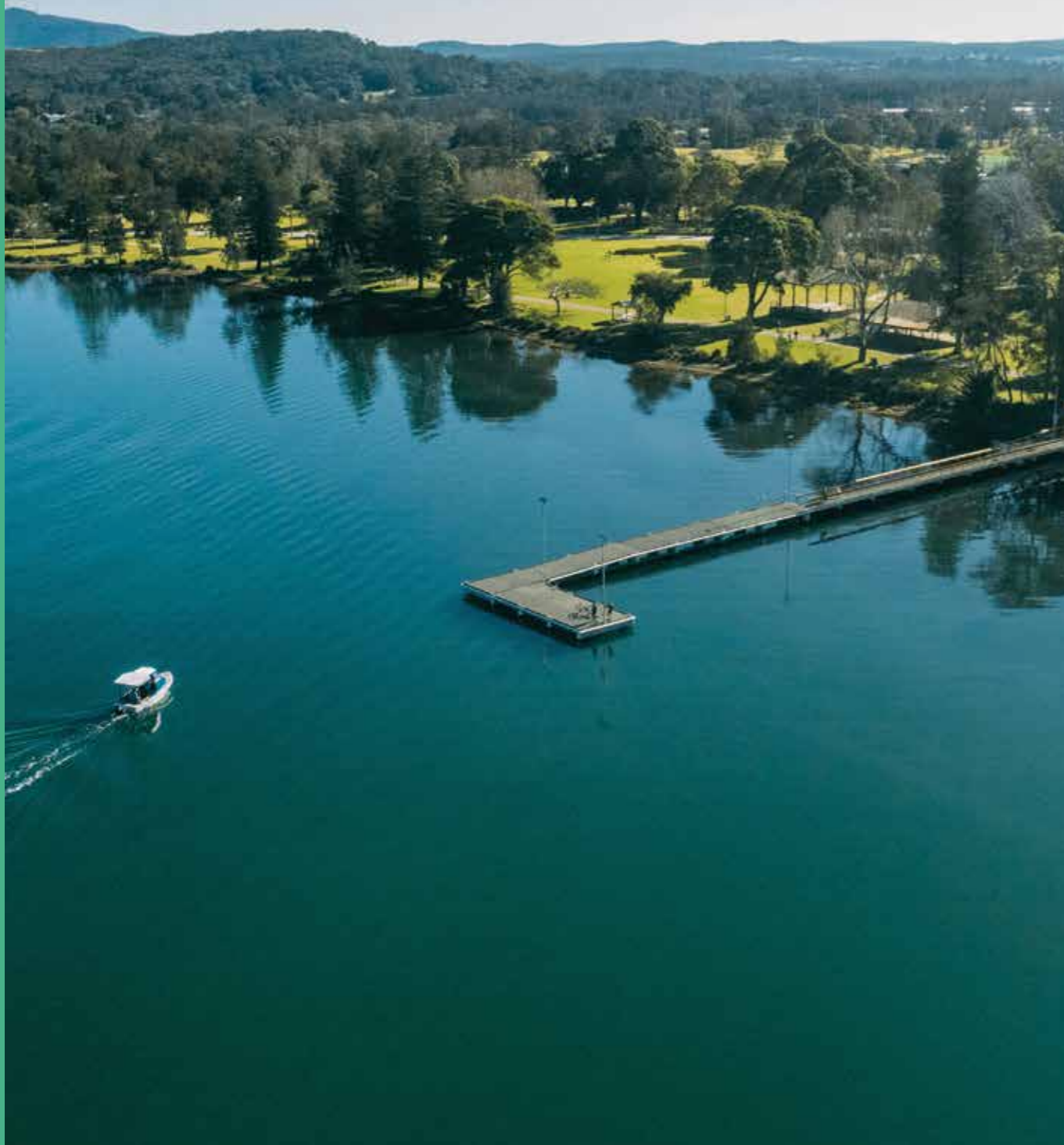
The map below indicates the land tenure and management areas for the coastal zone in Lake Macquarie.

Sustainable Development Goals (SDGs)

Council's decision making in the CMP has been guided by the framework of the Sustainable Development Goals (SDGs), in accordance with Council's Sustainability Policy. United Nations SDGs have been mapped to the actions in this CMP as detailed in the Implementation Plan (section 4.4). The main SDGs addressed in this plan are:



SECTION 2 - THE A, B AND C OF LAKE MACQUARIE'S COASTAL ZONE



Lake Macquarie's Coastal Management Program (CMP) area has three zones:

Part A: Coastline (beaches, dunes, rock platforms, headlands and wetlands)

Part B: Estuary (and its tributaries: Cockle Creek, LT Creek, Stony Creek, Dora Creek, Wyee Creek and North Creek) and part of catchment area including wetlands and part of the mapped coastal zone within the Central Coast local government area bordering the Lake Macquarie estuary.

Part C: Swansea Channel

This area provides for an integrated coastal zone management approach across the whole local government area. This area is equivalent to that contained in the Lake Macquarie Coastal Zone Management Plan 2015, maintaining consistency for our local community and other stakeholders.

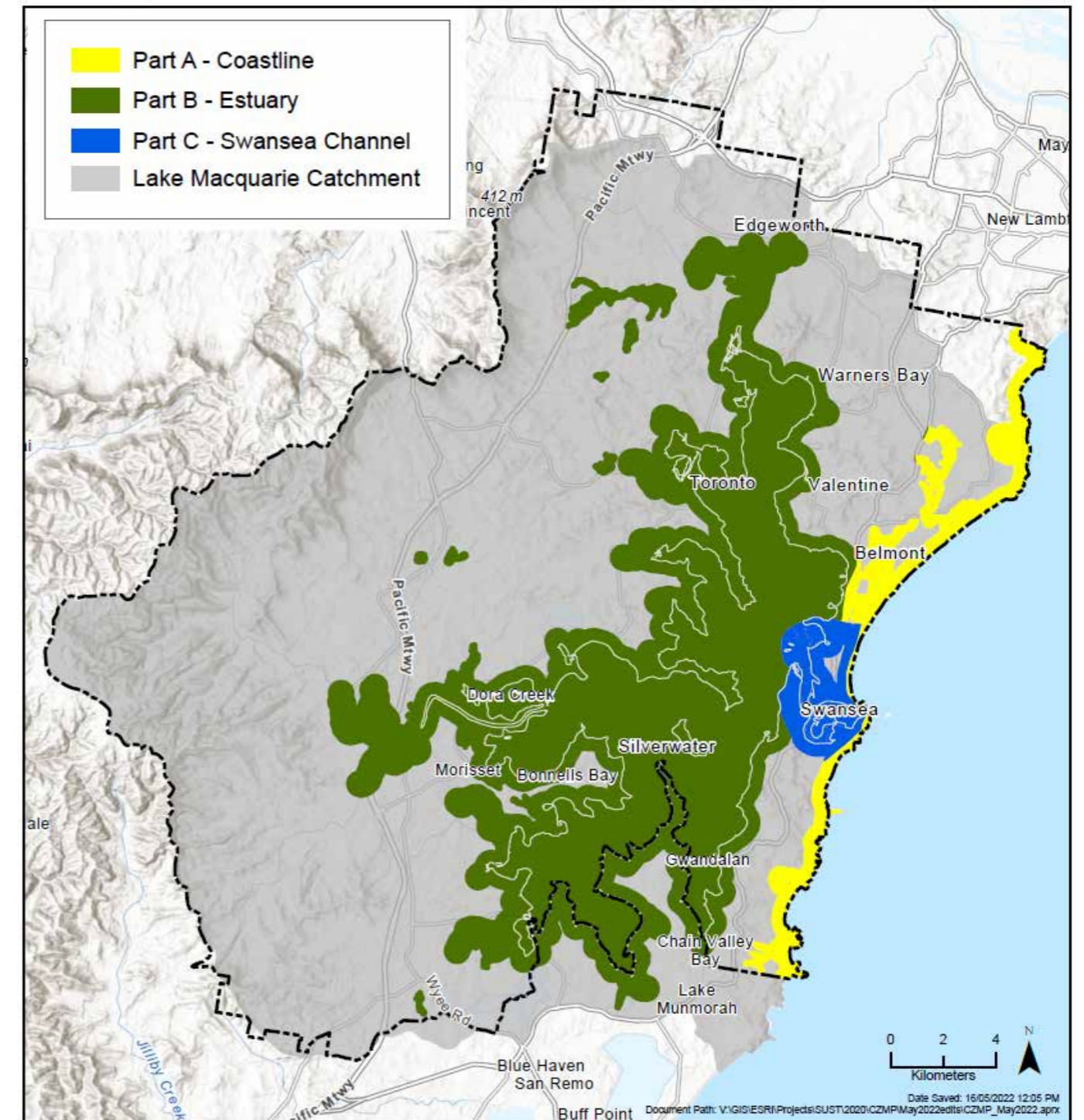


Figure 8: Coastal zone in Lake Macquarie

This section summarises the issues and challenges in the three parts of CMP that have been reflected in the implementation plan (section 4.4). Council has developed, evaluated, prioritised and costed corresponding management actions to address these issues and challenge.

2.1 Snapshot of issues

Part A: Coastline

Defining features of the Lake Macquarie coastline

- A diverse coastal landscape with high sandstone and conglomerate cliffs, sea caves, shore platforms, long barrier beaches (up to 13km), pocket beaches and coastal dune systems of Holocene and late Pleistocene age
- A predominantly high energy coast, with highest waves associated with east coast low events and active frontal dune processes during storm events, but relatively low risk due to setback of development from the beach
- Historical records indicate a stable, sandy coastline with periodic erosion and accretion, and slight rotation on longer beaches
- A key coastal risk area at Blacksmiths where there is potential for interaction of coastal erosion/recession and lake inundation over the next century
- An entrance to Lake Macquarie with control structures (training walls) that have been affected by coastal processes since the late nineteenth century
- Potential for block failure on coastal cliffs
- Part of Newcastle coastal sediment compartment (shared also by City of Newcastle and Central Coast Council)
- Rare or endangered ecological communities, including Themeda grasslands on the headlands and the littoral rainforest at Swansea Heads
- High biological diversity and rare species such as endangered shorebirds and animals that live off the rock platforms
- Ecological communities combined with the geomorphic structure of the coast in a scenic landscape of beaches, headlands and shore platforms, highly valued for recreation by locals and visitors
- Ecological condition and coastal value affected by historical mining and extractive industries
- Urban development encroachment on coastal headlands at Redhead, Swansea Heads and Caves

Beach as well as behind the coastal dunes at Redhead and Blacksmiths beaches

- The majority of the coast in a relatively natural condition, including land managed in National Parks, State Parks, State Conservation Areas and by Council as community land

Key management issues and challenges for the coastline

- Land tenure of areas such as Nine Mile Beach (multiple agencies responsible)
- Balancing recreational use: four-wheel driving, surfing amenity, informal access with the need for ecosystem protection
- Coastal erosion, wave overtopping, dune health, beach rotation and coastal inundation



Part B: Estuary

Defining features of Lake Macquarie's estuary

- The Largest coastal lake in NSW, covering an area of about 110km², with a catchment of about 650km², formed over the past 6000 years from flooding of coastal zone by sea level rise
- Significant ecological values, providing for a range of aquatic and land-based recreational activities (refer to Table 1 for more information about the characteristics of the Lake Macquarie catchment)
- Complex estuary hydrodynamic processes and responses
- Small tidal range of about 100mm each tidal cycle (range can be wider with rainfall and offshore tidal condition changes)
- Approximately 174km of foreshore
- Foreshore erosion mainly due to wind waves
- Rising sea level and lake levels
- Local government areas of Lake Macquarie, Central Coast, Wollongong, Shoalhaven and Rockdale identified as having greatest risk of inundation from sea level rise (to 1.1m), (Department of Industry, Science, Energy and Resources 2009) representing more than 50 per cent of residential buildings at risk in NSW

- Areas affected by flooding around entire foreshore
- 12.4km² of seagrass coverage in Lake Macquarie (third largest area of seagrass in NSW), with most abundant species being *Zostera capricorni*. Threatened species *Posidonia australis*, as well as *Halophila ovalis* and *Ruppia megacarpa*, also present.
- Cooling water from Eraring and Vales Point power stations discharge into Lake Macquarie
- Some coal mines licensed to discharge mine water at the surface, flowing into the lake
- Improvement in water quality over the past 20 years, mainly by reducing nutrients and sediments entering the lake
- Mix of shallow sand nearshore areas, deeper rocky foreshores and shorelines thinly mantled with muddy sands
- Strong influence from catchment on the health of the estuary
- Extensive urban and industrial development, particularly low-lying development
- Increasing demand for land and water based recreational opportunities



Figure 9: Conceptual model of estuary processes



Second Creek, Redhead

Key management issues and challenges

- Controls on catchment yields of sediments, nutrients and organics are key strategies for managing the ecological health of Lake Macquarie
- Minimising the impact of stormwater pollution
- Areas respond differently to the inflows of stormwater from development in the immediate catchment, with long reaches of poorly flushed estuarine creeks affected by both sediment load and impacts of development on riparian vegetation
- Delivering a whole-of-government approach with improvement in managing coastal issues across local government boundaries
- Funding uncertainty for ongoing lake and catchment improvement works
- Monitoring of climate change impacts on foreshore improvement assets (particularly foreshore stabilisation assets)
- Balancing recreational demand with the need to manage impacts on the estuarine environment.

Part C: Swansea Channel

Defining features of Swansea Channel

- Connects main body of Lake Macquarie to the ocean
- Broadly divided in two at Swansea Bridge, which carries traffic across the channel and connects Blacksmiths and Swansea – see Figure 10
- Downstream impacted by oceanic swell waves
- Upstream, dominant coastal processes relate to tidal currents and transport of sediment
- Increased flow velocity and scour upstream resulting in failure of foreshore protection works
- Rapid shoaling upstream of the entrance to Swan Bay
- Highly modified entrance with training walls constructed in the 1890s
- Waves downstream of bridge, tidal currents and upstream transport of sand have caused erosion
- Significant erosion in Salts Bay and between Mats Point and entrance to Black Neds Bay
- Important shallow seagrass habitats for fish breeding and migratory birds, particularly from Belmont through to Swansea Flats
- Variable tidal range, decreasing from 1.7m at the entrance, 1.3m at Swansea bridge to less than 0.2m at the western end of the channel



Swansea Heads and Blacksmiths

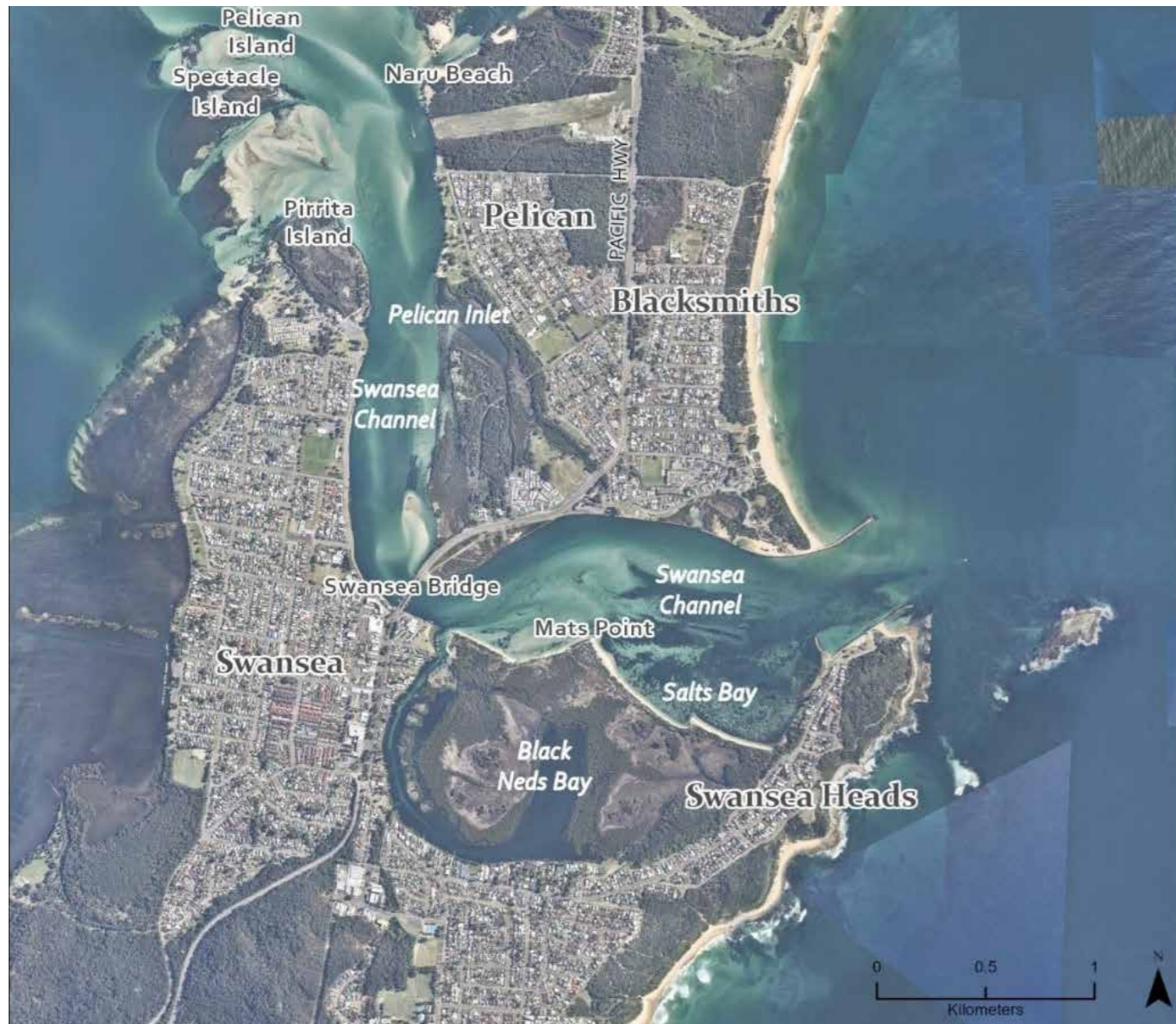
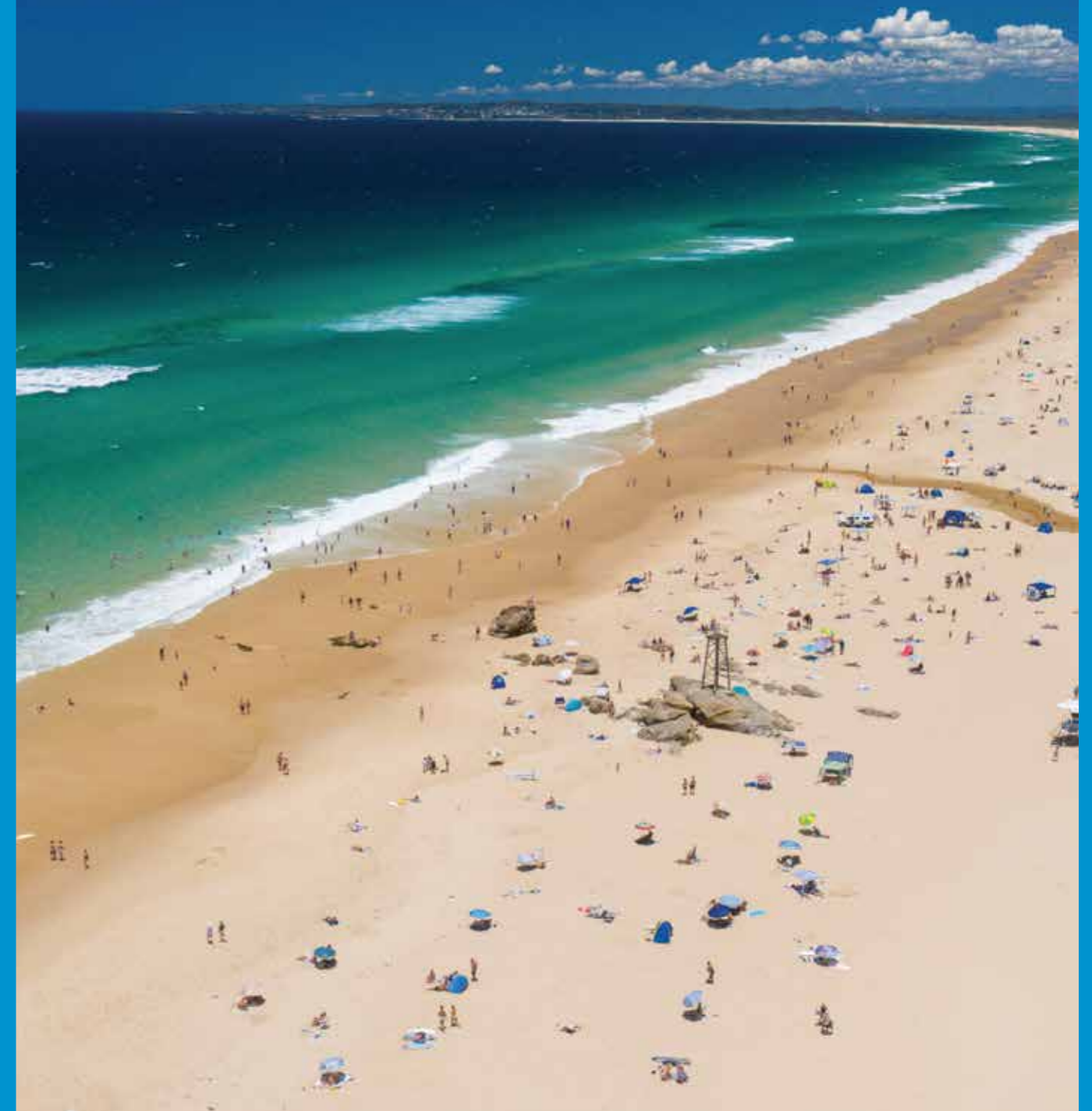


Figure 10: Key locations in Swansea Channel

Key management issues and challenges for Swansea Channel

- Differing objectives regarding the use, funding and ecological health of Swansea Channel
- Defining responsibilities for dredging, foreshore works and maintenance of coastal protection assets
- Effective management of hydrodynamic processes to achieve appropriate long-term management
- Channel depth can impact the boating recreation sector and opportunities for the lake to become a significant tourism destination
- Impacts of training walls
- Dynamic nature of channel form, especially foreshore erosion
- Repeated dredging and works such as partial closure of southern entrance to Swan Bay over the past decade as part of channel management
- Channel evolution – channel gradually changing over time
- Vulnerability of the suburbs surrounding the channel to inundation
- Competing needs of multiple stakeholders and finite funding
- Impacts of tides and waves, combined with future sea level rise
- Dynamic nature, presents challenges for integrated management
- Structures, such as Swansea Bridge, bank protection works, dredge spoil islands and extensive works at the entrance to Swan Bay have contributed to modified hydrodynamic conditions and channel characteristics

SECTION 3 - COASTAL ZONE RISKS AND HAZARDS



3.1 Risk assessment

In preparing the CMP, environmental and socio-economic threats for the coastal zone were assessed and rated. Threats rated high and extreme are indicated in Table 5 below.

Extreme threats for the Lake Macquarie coastal zone were identified for: ecosystems' impacts from climate change and coastal hazards (coastline) and social and economic impacts from climate change and coastal hazards (Swansea Channel). Water quality impacts were rated as a priority threat across both the environment and social/economic impacts.

This risk assessment process was adapted from the Australian Standard Risk Management Principles and Guidelines ISO 31000:2009. It is consistent with the Marine Estate Threat and Risk Assessment (TARA) (Section 5) and, where possible, consistent terminology has been applied.

The risk assessment has been conducted for four planning horizons: present day, 2040, 2070 and 2120. The trajectory for future planning horizons assumes no management action taken beyond current practices.

Further details with respect to the likelihood and consequences assessment are provided in the Scoping Study (Appendix 2):

It considered the impact of the threat across the following risk categories:

- **Environmental** – impact resulting in harm to ecosystems, loss of biodiversity and unsustainable use of natural resources.
- **Socio-economic** – impacts to community services, liveability, culture and well-being, businesses, employment, property values, visitor economy.

Documented information was used in conjunction with local knowledge to assign a risk level. Risk assessment results were reviewed by Council's Coastal Zone Management Committee, interdepartmental Council staff as well as government agencies and community members who are part of the project stakeholder group.

Refer to Appendix 2 Scoping Study for a summary of risk ratings for the environmental and socio-economic threats applicable to the coastal zone in Lake Macquarie.

3.2 Coastal hazards

Section 4(1) of the CM Act defines seven coastal hazards which affect coastline, estuary and channel in different ways. Lake Macquarie coastal zone is subject to a range of these hazards as detailed below.

A detailed hazard and risk assessment formed part of the 2015 CZMP for Lake Macquarie. Consideration of the work done as part of this initial assessment informed the level of hazard analysis required in this CMP.

In addition to climate change, this section specifically considers inundation, combined flooding and inundation, coastal and beach erosion, coastal inundation due to wave overtopping, the impact of sea level rise on wetlands, coastal cliff and slope stability, and the evolution and stability of the Swansea Channel entrance.

It also considers the plans and strategies already in place to mitigate these risks.

Refer to Table 5 in the Scoping Study (Appendix 2): for a list of studies relating to coastal hazards in the Lake Macquarie coastal zone.

Climate change

The Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS) identifies some of the key impacts of climate change on the Hunter and Central Coast regions, including increased sea levels, higher average and extreme temperatures, and increased intensity and frequency of extreme events, including storm events.

Given the geography of the coastal zone, with a significant portion of land adjacent to the coast, estuary, and channel being relatively low-lying, a key concern is sea level rise. With the lake being connected to the open coast, the issue broadens to also include lake level rise.

In 2009, The Department of Climate Change (2009) (now the Department of Industry, Science, Energy and Resources) identified the local government areas of Lake Macquarie, Wyong, Gosford, Wollongong, Shoalhaven and Rockdale as having the greatest risk of inundation from sea level rise (to 1.1m) collectively representing over 50 per cent of residential buildings at risk in NSW. It was determined that between 5100 and 6800 buildings in the Lake Macquarie LGA may be affected by sea level rise and storm tide inundation by 2100, with the upper range representing approximately 10 per cent of the 2009 residential building stock.

The 2016 NSW Estuary Tidal Inundation Exposure

Assessment identified that “on a proportion-of-area basis, the Central Coast region is the most exposed in the state and Lake Macquarie is the most exposed individual estuary. Overall, the Hunter and Central Coast regions contribute 18 per cent each to the statewide exposure across all scenarios. Here extensive development has occurred on the low-lying areas adjacent to the coastal lake systems” (OEH 2016).

Inundation (CM Act – Coastal Hazards D, F & G)
The 2012 Lake Macquarie Waterway Flood Risk Management Study and Plan identified a number of areas around the lake already experiencing the effects of inundation and property damage and highlighted the need to plan for projected sea level rise.

Council currently has a Waterway Flooding and Tidal Inundation Policy that sets a planning level benchmark of 2.82m Australian Height Datum (AHD) for the year 2100. This factors in a 1:100-year lake flooding event (inundation heights are impacted by both elevated ocean conditions coincident with heavy catchment rainfall) with a sea level rise of 0.9m by 2100. Coastal hazard and risk studies are based on these adopted levels. However, with the ongoing review of climate change projections, the understanding of coastal risks also changes. The CMP

will be reviewed in 10 years to ensure development of the most suitable solutions, based on current advice from the Intergovernmental Panel for Climate Change (IPCC) and Federal and State Governments.

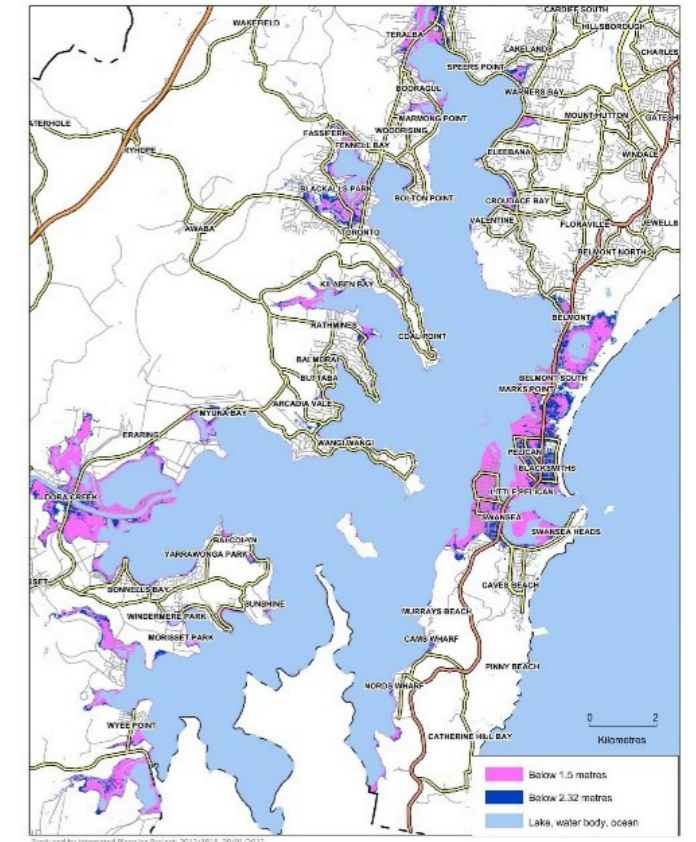


Figure 11: Low-lying areas affected by inundation

Threat	CURRENT RISK			FUTURE RISK 2040			FUTURE RISK 2070			FUTURE RISK 2120		
	Estuary	Coastline	Swansea Channel	Estuary	Coastline	Swansea Channel	Estuary	Coastline	Swansea Channel	Estuary	Coastline	Swansea Channel
ENVIRONMENT	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E	Risk L, M, H, E
1 Ecosystem impacts from climate change and coastal hazards	Medium	Medium	High	High	Extreme	High	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
2 Water quality impacts	High	Low	Low	High	Low	Low	High	Low	Low	High	Low	Low
3 Catchment vegetation modifications	High	Medium	Medium	High	Medium	Medium	High	High	Medium	High	High	Medium
4 Waterway modifications	High	Medium	High	High	Medium	High	High	Medium	High	High	Medium	High
SOCIAL AND ECONOMIC												
5 Social and economic impacts from climate change and coastal hazards	High	High	Extreme	High	High	Extreme	High	High	Extreme	Extreme	High	Extreme
6 Water quality impacts	High	High	Medium	High	High	Medium	High	High	Medium	High	High	Medium
7 Access to marine estate	Medium	Medium	Medium	High	High	High	High	High	High	High	High	High
8 Governance	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Table 4: Assessment for current and future risks to the coastal zone

Council uses the following water levels and associated controls to manage inundation hazards:

Level	Measure	Basis of Calculation	Planning & Development Conditions
0.10 mAHD	Year 2011 lake mean still water level	Approx 30 years lake tide gauge average (Flood Study – Reference 6)	
< =1.00 mAHD	Below Year 2100 lake mean still water level	Hazard to land use, infrastructure, buildings, and services from progressive rise in permanent lake levels to Year 2100	High hazard permanent lake inundation area and high hazard lake flood area (flood fringe)
1.00 mAHD	Year 2100 lake mean still water level	Year 2011 lake level + 0.9 m sea level rise	
1.23 mAHD	Year 2011 20 year Annual Recurrence Interval (ARI) flood	Flood Study – Reference 6	
< =1.50 mAHD	Below Year 2011 100 year ARI flood	Assessment of depth/velocity of Year 2100 100 year ARI flood and other hazard factors	High hazard lake foreshore area (flood fringe)
1.50 mAHD	Year 2011 100 year ARI flood	Flood Study – Reference 6	
1.61 mAHD	Year 2050 20 year ARI flood level	Flood Study – Reference 6	Flood planning level for non- habitable buildings with Year 2050 asset life
1.50 mAHD – 2.32 mAHD	Between high hazard flood level and Year 2100 100 year ARI flood level		Low hazard lake foreshore area (flood fringe)
1.86 mAHD	Year 2050 100 year ARI flood level	Flood Study – Reference 6 – includes 0.4 m sea level rise	
2.10 mAHD	Year 2100 20 year ARI flood level	Flood Study – Reference 6 – includes 0.9 m sea level rise	Flood planning level for non- habitable buildings with Year 2100 asset life
2.32 mAHD	Year 2100 100 year ARI flood level	Flood Study – Reference 6 – includes 0.9 m sea level rise	Flood planning level for habitable buildings with Year 2050 asset life
2.36 mAHD		Year 2050 Flood Planning Level	Year 2050 100 year ARI flood level + 0.5 m freeboard
2.45 mAHD	Year 2011 Probable Maximum Flood (PMF)	Flood Study – Reference 6	
2.81 mAHD	Year 2050 PMF	Flood Study – Reference 6 – includes 0.4 m sea level rise	
2.82 mAHD	Year 2100 Flood Planning Level	Year 2100 100 year ARI flood level + 0.5 m freeboard	Flood planning level for habitable buildings with Year 2100 asset life
<=3.00 mAHD	Year 2100 Flood Planning Level “rounded up”	Year 2100 100 year ARI flood level +0.5 m freeboard “rounded up” to allow for plus-or-minus 0.15 m margin in aerial survey	Nominated as “flood control lot” for purposes of Exempt and Complying Development Codes SEPP
3.27 mAHD	Year 2100 PMF	Flood Study – Reference 6– includes 0.9 m sea level rise	Flood planning level for “sensitive development” such as hospitals, aged-care facilities

Table 5 Lake Macquarie waterway levels relating to sea level rise

Local adaptation planning

One of the key recommendations of the CZMP and Lake Macquarie Waterway Flood Risk Management Study and Plan was to prepare Local Adaptation Plans (LAPs) for priority areas/catchments to guide future decisions by Council and the community in adapting to climate change.

A LAP was developed for Marks Point and Belmont South in 2016 (Marks Point & Belmont South LAP) that outlined methods to manage the risk of current and future flooding and permanent tidal inundation resulting from rising lake levels. The LAP provided residents with increased certainty about future development in the area and included a range of measures, including raising and improving the design of infrastructure such as drains and roads, constructing new buildings with floor levels above projected flood levels and raising homes if required.

In 2021, a LAP for Swansea and surrounds was prepared to help the community to plan for the worst and act when necessary in response to flooding and sea level rise (Swansea and surrounds LAP). The intent of this LAP is for actions to be trigger-based, particularly for larger, complex and/or costly actions. That is, actions can be planned and implemented depending on whether they are triggered by an event, such as rising water levels which reach a predefined threshold. Trigger-based action will avoid maladaptation, and actions will be implemented when and where necessary. The preparation for these actions should be completed in advance; i.e. ‘shovel-ready’ actions.

The LAP includes 30 actions ranging in scale and complexity. Some actions can be managed within Council’s existing operational frameworks, while others require extensive planning, stakeholder engagement, analysis, design and even piloting to understand the technical, social, ecological, and/or economic feasibility and suitability.

There are two timescales:

- **10-year action plan**

During the first 10 years of this LAP, there are no actions that are expected to be triggered by rising sea levels. This is mostly because climate change and sea level rise occur over a longer period. This 10-year action plan is the first stage of a longer-term strategic plan to adapt to climate change and sea level rise.

- **Longer-term strategic plan**

In the longer term, trigger values will play an important role in determining when actions

will be implemented as rising water levels begin to have a larger impact on these communities. Triggers for the hazard of flooding and sea level rise were adopted for the purposes of the economic feasibility study as shown in Table 2.4. In the future, if a specific flood event (e.g. 10 per cent Annual Exceedance Probability (AEP), one per cent AEP etc.) reaches the base of a property or asset, this would trigger an action to raise the land and asset. The triggers used in the economic feasibility study will be reviewed and updated as part of the 10-year action plan.

Option	Trigger to raise land
AC1 - Raise and fill residential areas (house sites and yards)	10% AEP
AC2 - Raise transport infrastructure (over and above gradual raising of roads through maintenance)	this option was not trigger based – requires investigation
AC3 - Raise other infrastructure (power, water, sewer, stormwater, telecommunications)	This option was not trigger based – requires investigation
AC4 - Raise and fill education land (schools)	1% AEP
AC5 - Raise and fill public recreation land such as foreshore reserves and playing fields	This option was not trigger based – requires investigation
AC6 - Raise and fill Swansea Holiday Park	18% AEP
AC7 - Raise and fill commercial land in the Central Business District (CBD)	1% AEP

For further details on options in table above please see the economic feasibility study undertaken as part of the LAP (The CIE, 2020).

AEP = Annual Exceedance Probability and means the probability (%) an inundation event (m AHD) would occur in any year.

Table 6: Triggers addressing inundation in Swansea & surrounds LAP

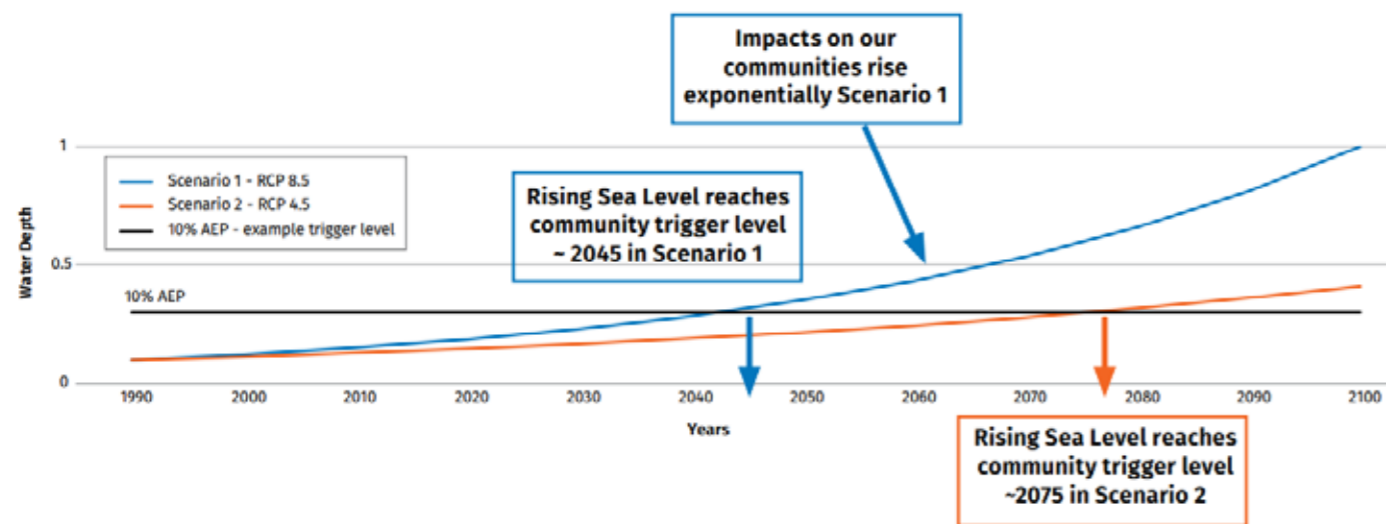
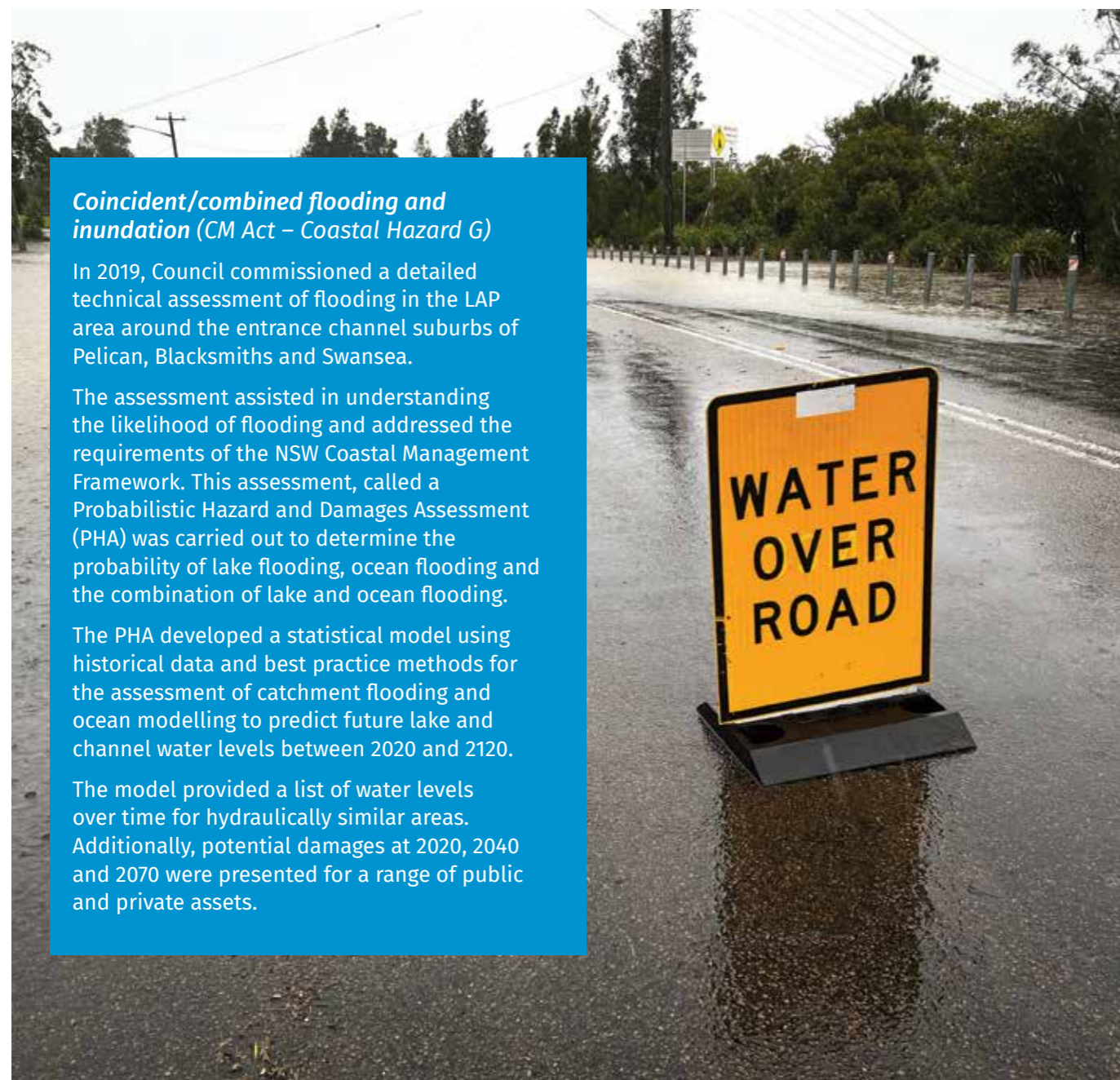


Figure 12: Longer term triggers



Beach erosion and coastal recession (CM Act – Coastal Hazards A & B)

During severe storms or a series of storms, increased wave heights and elevated water levels result in wave attack of the beach berm and foredune region. Storm events generate transport of sand offshore, with sand eroded from the beach face and transported to the seabed to form a sand bar roughly parallel to the shoreline. Sand is also transported along-shore (i.e. along the beach) either up-coast or down-coast depending on wave direction.

The result is erosion on the beach face that may pose a hazard to back beach land and assets. The short term storm related cross shore sand transport and longshore drift occur simultaneously. Their effects are additive, although the beach itself (above mean sea level) will erode predominantly during storm events.

Beach accretion may occur where longshore transport brings in more sand than is taken away. Shifts in transport direction can also result in a shift in sand from one end of the beach to the other and a slight change in beach alignment between the controlling headlands. During calmer weather, sand slowly moves onshore from the nearshore bars to the beach, forming a wave built berm under the action of swell waves. From the berm, wind blows sand to form incipient dunes and foredunes.

As part of developing Lake Macquarie’s CZMP, BMT WBM (2015) assumed the average net regional longshore sediment transport rate to be

approximately 20-30,000 m³/year in Newcastle. The studies indicated clearly a northwards net littoral transport under the predominant south easterly waves at beaches south of the Hunter River, and it is assumed this would also be the case along the Lake Macquarie coast. For Lake Macquarie, a regional longshore transport rate of 21,000 m³/year was adopted as the upper limit scenario.

The severity of wave attack at the dune is dependent on wave height, elevated water level (the combination of tide, storm surge and wave setup) and preceding beach condition (i.e. if the beach is accreted or eroded prior to the storm). In addition, depending on the orientation of the coastline relative to the direction of the incoming storm, the beach may either experience unimpeded wave power and severe erosion, or may be shadowed and protected from incoming wave energy.

Beaches can be subject to longer term trends of erosion or accretion associated with the gradual net removal or addition of sand to the active nearshore profile. Long term recession is frequently associated with a longshore sediment transport differential, where the supply of sediment into the system is less than the sediment losses from the system.

Recession of the shoreline is also expected to occur in response to sea level rise. In this case, there is an upward and landward translation of the entire beach and dune position as the shoreline reaches a new equilibrium with the new sea level position.

<i>Immediate Beach Erosion Hazard</i>	Almost Certain	Unlikely	Rare
Catherine Hill Bay (+Moonee, Pinny, Stinky Pt & Dudley)	25 m	40 m or limit of bedrock	65 m or limit of bedrock
Caves, Hams (+Crabs)	20 m	50 m or limit of bedrock	75 m or limit of bedrock
Blacksmiths Beach	20 m	65 m	85 m
Redhead Beach	40 m	100 m	140 m

Table 7: Adopted immediate beach erosion extents

The Lake Macquarie Coastal Zone Management Plan (2015) also took into consideration the effects of climate change in each of the three study areas: the open coast, the estuary, and the channel, with the objective to encourage and promote plans and strategies for adaptation in response to coastal climate change impacts. In evaluating the three zones in the CZMP, climate change considerations were made in assessing the coastal hazards, with parameters such as rainfall intensity and frequency, sea level rise, change in storm waves, and change in wave direction.

The CZMP also included triggers for enhanced management intervention along the coastline.

Table 8 below provides an overview of proposed change action triggers for development along the coastline of Lake Macquarie.

Type of development	Triggers for enhanced management intervention		Explanation
	Commence planning for management change (Risk is increasing)	Commence on ground works (Risk of continuing current management is unacceptable)	
Major infrastructure	Immediately, with reviews at five-year intervals until the 'commence on-ground works' trigger condition is met.	When actual coastal recession reaches the 2050 Coastal Risk planning Line (2050 'unlikely' hazard line) as currently mapped.	Long term planning is required because of complexity of issues and significance to community wellbeing; extremely high investment required (e.g. for waste water treatment plant or Swansea Channel training walls – see also Part C), so long term budget planning also required.
Local roads, water supply and sewerage reticulation	When actual erosion or recession reaches 2050 Coastal Risk Planning Line (2050 'unlikely' hazard line) as currently mapped.	When actual erosion and recession reaches the 2050 'rare' hazard line, or is no more than 15m from the infrastructure alignment; or the infrastructure is inundated by marine processes during events estimated to have a one in 20-year recurrence interval; or infrastructure reaches its asset life.	These assets service existing development. The triggers are intended to recognise the costs of maintaining functioning infrastructure in situ, as opposed to relocating/ redesigning at the end of the assets life.

Type of development	Triggers for enhanced management intervention		Explanation
	Commence planning for management change (Risk is increasing)	Commence on ground works (Risk of continuing current management is unacceptable)	
Existing dwellings	When actual erosion or recession reaches the 2050 Coastal Risk Planning Line (2050 'unlikely' hazard line), as currently mapped; or the property is inundated by marine processes having a one in 20-year recurrence interval	When actual erosion or recession escarpment is no more than 20m from the dwelling; or the dwelling is inundated by marine processes at intervals of less than two years.	New dwellings can have consent conditions linked to the triggers. For existing development, the consent provisions cannot be used. However, a similar trigger for retreat would apply because the dwelling would cease to be occupiable.
Other existing buildings (commercial and industrial)	When actual erosion/ recession reaches the 2050 Coastal Risk Planning Line; or the property is inundated by marine processes having a one in 20-year recurrence interval.	When actual erosion or recession is no more than 20m from the building.	As above
Recreation infrastructure such as pathways, lookouts	Review of designs should commence immediately, to allow the seaward toe of access ways to adjust. Emergency closures should commence immediately, when required for safety.	Review situation at intervals of ten years or at asset life/major review. Relocate landward as necessary and feasible, when the erosion or recession reaches to no more than 5m (along the beach) pathways and lookouts.	The triggers are linked to expected asset life of this infrastructure.
Recreation infrastructure – facilities in coastal reserves	Review of landscape plans should commence immediately, to incorporate dune enhancement works and appropriate access ways. Locate picnic facilities, new amenities etc. landward of the immediate Coastal Risk Planning Line.	Review landscaping plans and designs of facilities with asset life of these facilities – likely to be at ten-year intervals.	Trigger is linked to asset life of facilities in public reserves and to review periods for Plans of management for reserves.
Private recreation – Belmont Golf & Bowls	Planning for fairway and green design and planting that accommodates coastal processes should commence now and be gradually introduced.	Seaward parts of the course would be abandoned when the cost of maintaining fairways and greens exceeds the value obtained from use. Likely to be linked to sand and/or wave inundation of the seaward part of the golf course at intervals of not more than two years. Indicatively, this could occur by 2050.	Trigger to be confirmed by Golf Club executive and members.

Table 8: Triggers for enhanced management intervention for the Lake Macquarie coastline

Coastal Risk Planning Lines and periods for development controls

Since 2016, Council has implemented planning controls for certain types of development in areas seaward of the 2050 and 2100 Coastal Risk Planning Lines. These planning controls are consistent with the NSW government guidelines for land use planning in coastal risk areas. The aim of these controls is to limit the risks for land holders and also limit emergency response requirements during severe coastal storms that drive rapid erosion and cause inundation from wave overtopping of frontal dunes.

Council's planning controls are based on the asset life of different types of development, whether infrastructure provides a critical service for community wellbeing, and the sensitivity of the land users. Table 9 shows the Coastal Risk Planning Line relevant to different types of development.

Land use	Estimated asset life	Relevant Planning Line	Rationale
Critical utilities:	100 years	2100 (rare)	These are major infrastructure developments, and once in place, the assets are difficult to retrofit or relocate without major disruption. Community risk from disruption of services due to erosion impacts is very high, with many people affected.
Essential community facilities (e.g. Hospitals, hospices)	100 years	2100 (rare)	These facilities have a long asset life and provide services for the frail, ill or elderly. Very high emergency management requirements if the facilities are impacted by an erosion or inundation event.
Aged care facilities (e.g. Nursing homes, hostels)	100 years	2100 (rare)	These facilities have a long asset life and provide services for the frail, ill or elderly. Very high emergency management requirements if the facilities are impacted by an erosion or inundation event.
Subdivision	100 years	2100 (unlikely)	New subdivisions provide the planning context and direction for subsequent development.
Medium density housing	100 years	2100 (unlikely)	These are more complex developments and have a higher density than single unit dwellings, so risks are higher
Seniors housing	100 years	2100 (unlikely)	These are more complex developments and have a higher density than single unit dwellings, so risks are higher
Mixed use development	100 years	2100 (unlikely)	These are more complex developments and have a higher density than single unit dwellings, so risks are higher
Dual occupancies	50 years	2050 (unlikely)	Dwelling footprint of new dual occupancy dwellings (i.e. dwellings that are replacing an existing dwelling or are infill development in an existing subdivision)
Residential (single dwellings)	50 years	2050 (unlikely)	Dwelling footprint of new dwellings (i.e. dwellings that are replacing an existing dwelling or are infill development in an existing subdivision)
Commercial/ retail/ industrial	50 years	2050 (unlikely)	In general, such development will require large area slab foundations, so it is difficult to adapt to climate change impacts over time.
Tourism development	50 years	2050 (unlikely)	E.g. Hotels, resorts or other tourism-based development

Land use	Estimated asset life	Relevant Planning Line	Rationale
Private recreational buildings and facilities	50 years	2050 (unlikely)	E.g. RSLs, bowling club buildings, golf course club houses, golf courses, tennis courts, bowling greens
Public recreational facilities	40 years	Immediate (unlikely) (Note: Structures that provide an essential access for safety purposes, can be located seaward of the Immediate Planning Line)	E.g. Parks, public open space/recreation, cycleway/ shared pathways, lifeguard towers

Table 9 Coastal Risk Planning Lines and periods for development controls

Refer to Appendix 6 for a map showing Planning Lines for the Lake Macquarie coastline.

Coastal inundation due to wave overtopping (CM Act – Coastal Hazard D)

Stage One of the development of the CMP (scoping study) identified wave overtopping as an information gap. During Stage Two of the CMP, a Wave Overtopping Assessment was prepared. Refer to section 4.3.1 for details on this assessment.

Impacts of sea level rise on wetlands (CM Act – Coastal Hazards F and G)

In 2010, an inventory of all low-lying wetlands in Lake Macquarie LGA was compiled from existing data and field investigation. This inventory was then used to analyse the likely impacts of sea level rise on wetlands (up to the 90cm benchmark adopted by the NSW Government at the time) and these wetlands' capacity for retreat.

The results of the sea level rise analysis indicated that approximately 680ha or 28 per cent of the current extent of low-lying wetlands will be inundated with 90cm sea level rise by 2100. However, the impact of sea level rise differs greatly between wetland types. Spatially, the areas to experience the most significant inundation of wetlands are Dora Creek, Cockle Creek, the eastern coastal areas around Swansea and low lying lake foreshore areas. Saline wetlands are likely to be the most affected. Wetlands that occur at higher elevations were predicted to experience less frequent saltwater inundation and therefore are at lower risk of material changes to existing status (Umwelt, 2015).



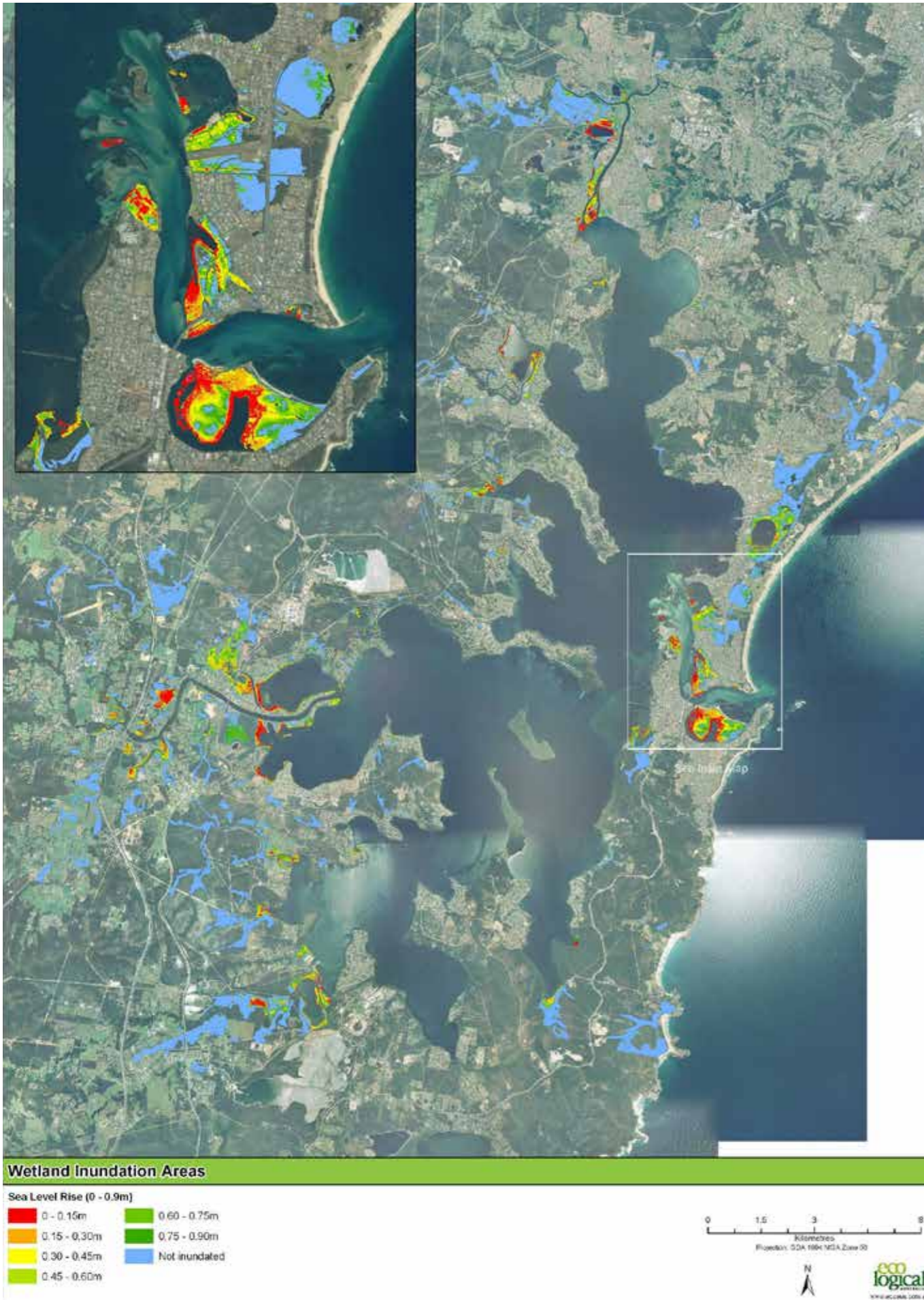


Figure 13: Potential wetland inundation areas

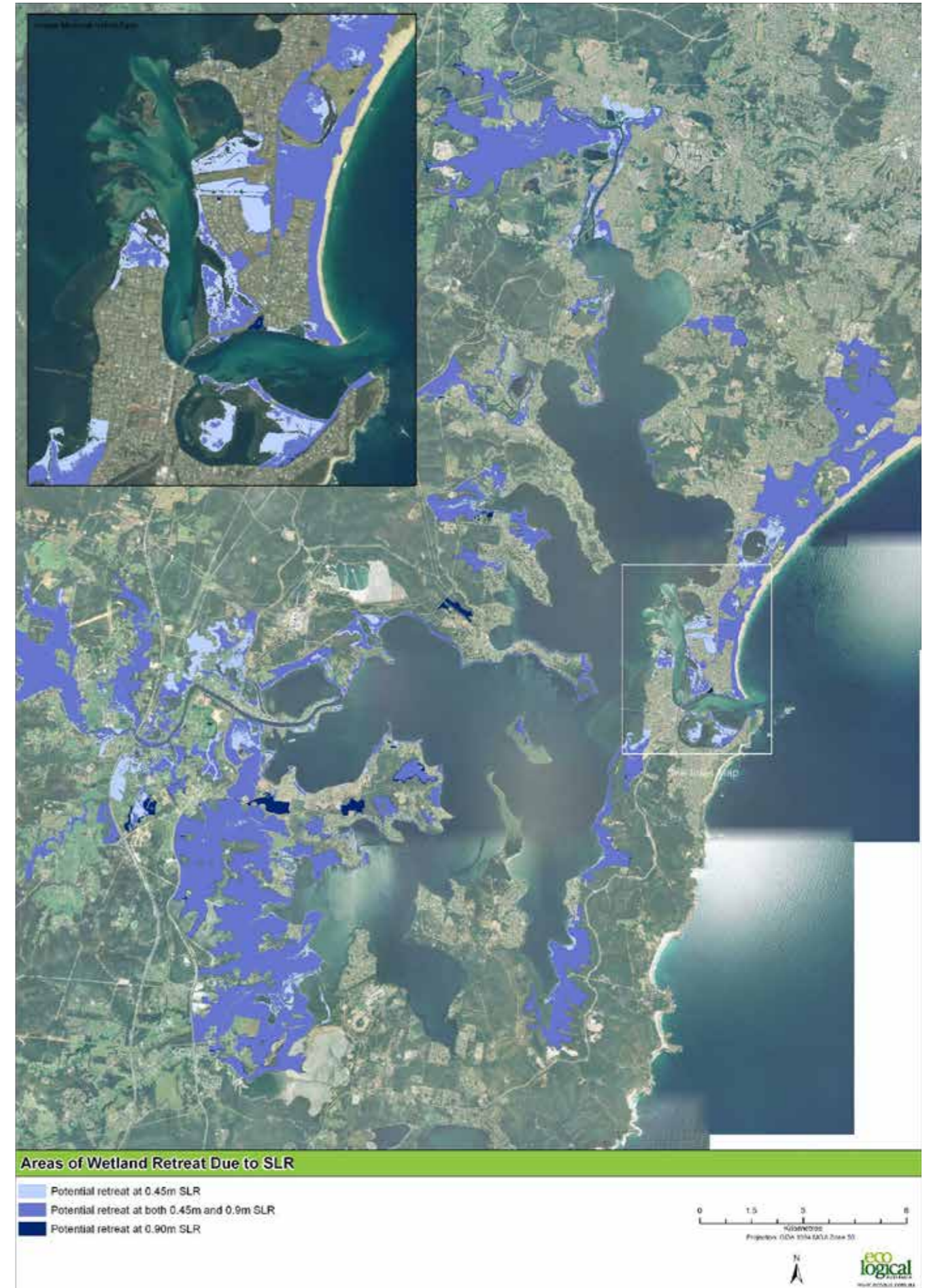


Figure 14: Potential wetland retreat areas

Wetland communities may have the capacity to retreat (upslope) from rising sea levels, such that some or all of their current aerial extent is preserved. For most wetland types, the potential retreat area is over 10 times greater than the area that will be inundated with sea level rise. There is potential for wetlands to migrate upslope as sea levels rise, and some climate change impacts may be able to be mitigated with the exception of mangroves.

The potential retreat areas in Lake Macquarie are concentrated in three main locations – in the coastal dune system around Belmont, along the floodplain of Cackle Creek and in the south-western foreshore and floodplain of Lake Macquarie around Morisset and Wyee Point. These regions are the largest patches of vegetation at low elevation (Eco Logical Australia, 2010).

Saltmarsh is particularly vulnerable to the impacts of sea level rise due to its position in the landscape and the nature of saltmarsh as a community. Saltmarsh requires particular gradients, salt to maintain a competitive advantage and a location in the intertidal range. It is vulnerable to threats such as weed invasion, fire and fragmentation. It is also readily invaded by mangroves in dynamic estuarine situations.

Coastal cliff and slope stability (CM Act – Coastal Hazard E)

The hazards posed by coastal cliff instability have been previously assessed in the CZMP and other studies including: Preliminary Landslide Risk Zoning of Coast Line Cliffs and Slopes (RCA 2013) report, Coastal Cliff Stability and Safety Assessment (Cardno 2015) and Geotechnical Assessment - Cliff-top Stability in High Hazard Coastal Locations (Cardno 2017).

The focus of these studies has been locations at Redhead Bluff, Swansea Head, Caves Beach South, Spoon Rocks South, Middle Camp Beach centre headland and Catherine Hill Bay south headland.

Council manages these hazards through the application of Coastal Planning Lines (Appendix 6) which include identified cliff stability hazards in the immediate planning line. As a result of the CZMP, work was undertaken to reduce hazards at several priority locations with the installation of safety fencing, rockfall catch-fences, access controls and safety signage (noting that ongoing works will be required to maintain and upgrade measures into the future).

Entrance channel stability and evolution (CM Act – Coastal Hazard C)

Research indicates that over time, Swansea Channel will deepen and widen, increasing tidal inflows so the tidal range in Lake Macquarie (the height of high and low tides) will become more similar to the ocean.

The geology, geomorphology and future evolution of Swansea Channel has been the subject of significant study over many years. A summary of historical information was compiled in the Swansea Channel Hazard Study and Risk Assessment (BMT 2015) that informed the CZMP. This included information on the ongoing increase in depth and width of the channel as it evolves to reach equilibrium with the configuration of the entrance breakwaters, which are generally accepted being constructed too far apart.

A series of papers has been published by Nielsen and Gordon (2008, 2011, 2015, 2017), dealing with the stability and behaviour of the trained entrances to lake systems along the NSW coast, including Lake Macquarie. Nielsen & Gordon (2008) stated that: *Without geomorphological constraints, the channel area could continue to scour some five-fold, allowing for the tidal range in the lake to reach 77 per cent of the full ocean tidal range, at current rates of change, this could take some 650 years.*

Watterson et al. (2010) undertook numerical modelling of Swansea Channel to study how it may respond to sea level rise. They found that the tidal range in the

lake could double by 2100, with a sea level rise of 0.91m, corresponding to a tidal prism increase of 225 per cent.

The work by Nielsen and Gordon and Watterson et al. has generally agreed that:

- the “stable equilibrium” entrance cross sectional area is around 5000-8000m²
- at this stable equilibrium area, the tidal range in Lake Macquarie will be close to that in the ocean

Further analysis was undertaken by Wainwright et al. (2022) as part of the Pelican Foreshore Stabilisation Project, including recalculation of parameters affecting the modelled rate of channel evolution, particularly the potential of morphological change to accelerate in a strongly non-linear manner.

This work indicates: *With the analysis presented here that at recently measured or ‘current’ rates of change, the entrance would take hundreds of years to evolve to its so-called equilibrium. Based on the data presented here, we would estimate a value of around 480 years if current rates are followed. The issue with this assessment is that, as velocities through the channel increase, morphological change will accelerate in a strongly non-linear manner, as represented by the model of Larson et al. (2020). When the acceleration is considered, a five to six-fold increase of the channel area could be expected within a substantially shorter period based on the present analysis.*

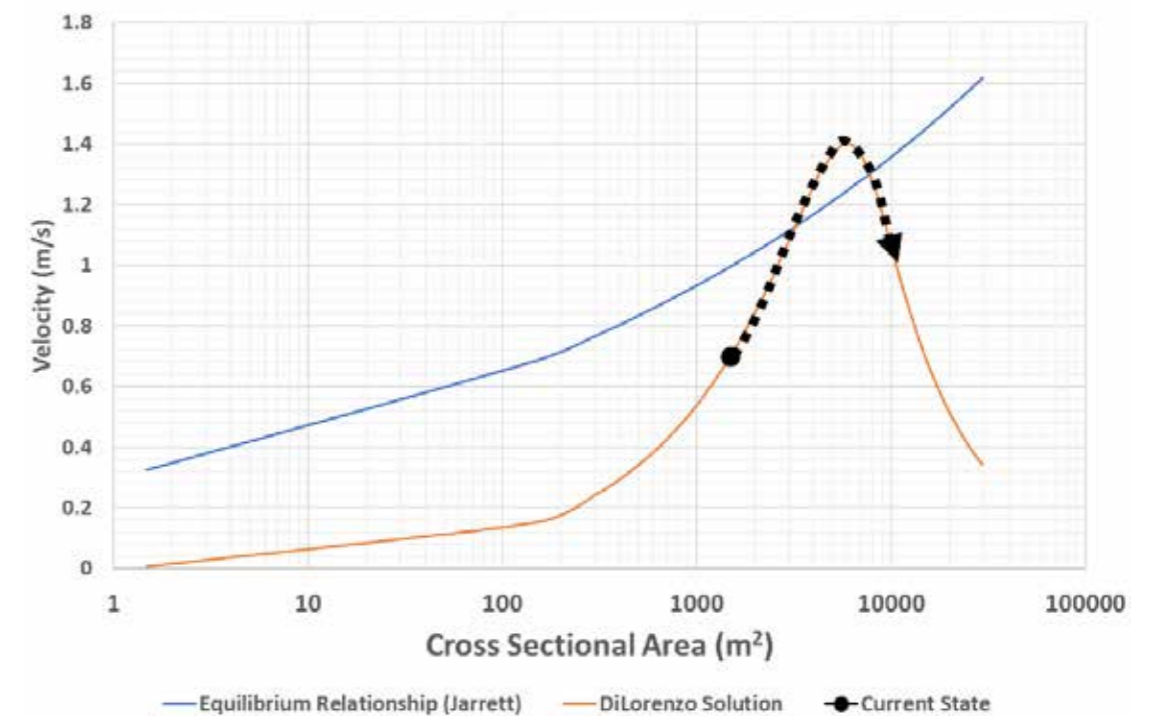


Figure 15: Escoffier diagram (using DLorenzo’s method and Jarrett’s relationship) for Swansea Channel (Source: Salients 2021)

Further information on the evolution of the channel is detailed in the [Pelican Foreshore Stabilisation project](#).

3.3 Coastal Zone Emergency Action Subplan

Council is required to develop a Coastal Zone Emergency Action Sub-Plan (CZEAS) under Clause 15(1) (e) of the CM Act. The CZEAS forms part of this CMP and is included in full as Appendix 5.

The purpose of a CZEAS is to identify and facilitate the implementation of appropriate emergency responses for coastal hazard related emergencies. The aims of the plan are to:

- protect human life and public safety
- minimise damage to property and assets
- minimise impacts on social, environmental and economic values
- not create additional hazards or risks

Clause 15(3) of the CM Act specifies:

A CZEAS is a plan that outlines the roles and responsibilities of all public authorities (including the local council) in response to emergencies immediately preceding or during periods of beach erosion, coastal inundation or cliff instability, where they occur through storm activity or an extreme or irregular event. For the purposes of this CZEAS, those roles and responsibilities include the carrying out of works for the protection of property affected or likely to be affected by beach erosion, coastal inundation or cliff instability.

A CZEAS must identify any requirements for how emergency coastal protection works, within the meaning of the State Environmental Planning Policy (Resilience and Hazards) 2021 (R&H SEPP), are to be carried out. Clause 19(4) of the R&H SEPP defines emergency coastal protection works to mean *'works comprising the placement of sand, or the placing of sandbags, for a period of not more than 90 days, on a beach, or a sand dune adjacent to a beach, to mitigate the effects of coastal hazards on land'*.

The CZEAS has been prepared to facilitate effective emergency responses by:

- defining a coastal emergency and triggers for emergency response actions
- identifying the locations that may be affected by beach erosion, coastal inundation or cliff instability that would constitute a coastal emergency
- outlining the roles and responsibilities of all public authorities (including Council) and coordinating their response to emergencies immediately preceding or during periods of beach erosion, coastal inundation and cliff instability

- identifying the locations and types of works that may be undertaken for the protection of property and assets
- outlining what actions are to be undertaken in the prevention, preparation, response and recovery phases of emergency management
- informing the public and potentially affected property owners about their responsibilities during a coastal emergency and what actions they are and are not permitted to undertake.

This plan does not include:

- matters dealt with in any plan made under the *State Emergency and Rescue Management Act 1989 (SERM Act)* in relation to the response to emergencies
- proposed actions or activities to be carried out by any public authority or relating to any land or other assets owned or managed by a public authority, unless the public authority has agreed to the inclusion of those proposed actions or activities in the program.

See Appendix 5 for further details.



SECTION 4 - OUR PLAN FOR A HEALTHY, RESILIENT COASTAL ZONE



4.1 Preparing the CMP

Council's approach to preparing the CMP is outlined below.

STAGE 1

Identify the scope of CMP

STAGE 2

Determine risks, vulnerabilities and opportunities

STAGE 3

Identify and evaluate options

STAGE 4

Prepare, exhibit, finalise, certify and adopt the CMP

STAGE 5

Implement, monitor, evaluate and report

Stage One

The scoping study prepared as part of Stage One of the CMP was completed in December 2020 and is provided in Appendix 2.

Stage Two

During Stage Two, a wave overtopping assessment for the coastline and a surf amenity assessment for Blacksmiths Beach were carried out. A State of the Estuary Report was also completed, and a water level analysis. Refer to section 4.3.

Recommendations and identified options from these studies have been considered and incorporated into the Implementation Plan.

Stage Three

Stage Three of the CMP involved the identification and evaluation of options. A detailed options evaluation process was undertaken with the assistance of Umwelt and is provided in Appendix 8.

This process was undertaken to fulfil the mandatory requirements of the Coastal Manual, being:

- MR6(iii) During preparation of a CMP, a council is to evaluate and select coastal management actions (to address the most important risks)

- MR8(v) A CMP must identify how the coastal management actions have been considered and evaluated, including without limitation, how the council has evaluated the coastal management actions in light of the functions and responsibilities of council under legislation other than the CM Act.

Options were identified by reviewing the implementation status of CZMP actions, addressing issues and gaps identified in Stages One and Two and through consultation with the community and relevant stakeholders.

An evaluation of these options was then carried out. The aim of the evaluation was to determine if strategic actions offer good value for money. Where an action was modified from a previous management response, the evaluation should show how the new option offered better value for money than the previous approach.

The existing management of the coastal zone of Lake Macquarie, including management responses for risks in the main body of the estuary, the channel and for the open coastline, is the 'base case' for this assessment.

Short benefit statements have been prepared for all actions to describe the technical benefits provided by the action. In addition to these technical evidence benefits, Council's community satisfaction survey results provide evidence that investment in projects that protect, restore and enhance the natural environment is highly regarded by the community.

Coastal zone management (lake, foreshore, coastline) is identified as a very important service, with high levels of satisfaction. This management protects one of the most valued reasons for living in Lake Macquarie.

By identifying environmental concerns as a priority over the next decade, the community has recognised there are significant challenges for the coastal zone and ongoing investment in the health of coastal systems and the benefits they provide for the community, is important and supported.

The outcome of this evaluation has resulted in 114 priority actions identified in the CMP. These actions make up the Implementation Plan included as section 4.4.

Stage Three also involved the preparation of a business plan, which was prepared by Umwelt to meet the following mandatory requirements.

- MR8(x) A CMP must include a business plan
- MR9(i) The business plan must identify all proposed management actions identified elsewhere in the CMP
- MR9(ii) The business plan included in the CMP must identify the full proposed capital, operational and maintenance costs and recommended timing of proposed coastal management actions.

The business plan is detailed in section 4.5 and Appendix 4.

Stage Four

Stage Four is to prepare, exhibit, finalise, certify and adopt the CMP and associated documentation.

Community and stakeholder engagement

A Community Engagement Plan was prepared for Stages 1-5 of the Lake Macquarie CMP. Refer to Appendix 3 for details on engagement activities.

The stakeholder groups involved in preparation of the CMP included Council's Coastal Zone Management Committee and an external stakeholder group, with membership from:

- Hunter Water Corporation
- DPI Fisheries
- Marine Infrastructure Delivery Office
- Environment Protection Authority
- City of Newcastle
- NSW National Parks and Wildlife Service
- Sustainable Neighbourhood Groups
- Hunter Surf Life Saving
- Central Coast Council
- Local Aboriginal Land Councils
- Aboriginal traditional owners groups
- Roads and Maritime Service
- Belmont Wetlands State Park
- Transport for NSW
- Local environmental advocacy groups
- Department of Planning, Industry and Environment
 - Biodiversity and Conservation Division
 - Science, Economics and Environment division
 - Crown Lands



Council's online Shape Lake Mac platform was used to deliver updates, documents and studies to the community, with online workshops and presentations provided at key milestones and contribution points during Stages 1-4.

Aboriginal community groups (Land Councils and traditional owner groups) were contacted individually, seeking their comments and contributions to the CMP.

During Stage Two, an online meeting was held with the external stakeholder group to share findings from the studies carried out during this stage, with recommendations from the studies informing the actions developed in Stage Three. At each meeting of the Coastal Zone Management Committee, an update on the CMP was provided.

During Stage Three (October 2021), a series of external stakeholder workshops were held online to review the draft CMP actions for each area of the coastal zone. These workshops resulted in the generation of 30-40 new actions for inclusion, and amendments and additions to many existing actions. Identifying partners to implement each action was a significant part of this engagement.

Engagement with Council staff and elected representatives has occurred during preparation of the CMP. An internal interdepartmental working group was formed in Stage One of the CMP and this group has been involved with the risk assessment analysis and actions development and review.

Detailed discussions have occurred with other agencies identified as a lead or action partner to establish commitment and determine funding mechanisms.

The draft CMP was publicly exhibited from 29 November 2022 till 3 February 2023.

4.2 Principles for the Coastal Management Program

The following principles have been identified to assist in the formulation and evaluation of options and guide implementation.

Contribution to global sustainability

Council's Sustainability Policy commits us to making an equitable contribution to all aspects of sustainability (economic, environmental, social and sustainable governance) for the organisation and the city. It also commits us to demonstrate leadership by undertaking decision-making through the integrated framework of the United Nations Sustainable Development Goals.

Evidence based approach

Making informed decisions based on the best available evidence.

Focus on the causes

Determine the root cause of issues and make strategic decisions that address this cause rather than reactively addressing symptoms.

Build upon success of catchment management and soft engineering

For the past two decades, Council's approach to managing the estuary has been based on applying catchment management principles and soft engineering techniques. This approach has proven to be beneficial and is to be continually applied across the coastal zone.

Integrate coastal hazards and ecological health across the coastal zone

Where possible, management strategies should work to mitigate the impacts of coastal hazards and improve ecological health in an integrated manner.

Build on the success of local adaptation planning using a locally based, community co-design approach

Council's approach to climate change adaptation planning, based on embracing locally based community co-design principles, is well recognised as being highly successful, and should be applied to all aspects of coastal management, where feasible.

Build upon the success of community and volunteer engagement

Council has been successful in engaging and mobilising our community through programs such as Landcare and the Sustainable Neighbourhoods program. The benefits of community and volunteer engagement will be continually applied to coastal zone management.

Enhance Aboriginal involvement in coastal zone management

The Aboriginal and Torres Strait Islander community should be actively involved in decision making and management of the coastal zone.

Apply an adaptive approach

The dynamic nature and uncertainty involved in coastal environments and processes should be recognised, and adaptive strategies including monitoring, triggers and no-regrets actions developed to manage this uncertainty.

Embed climate change and circular economy principles

Consideration and incorporation of climate change and circular economy principles flow into decision making processes.

Recognise multiple benefits

The multiple benefits provided by coastal areas, including provision of essential ecosystem services, recreation, cultural, health, wellbeing and economic benefits, should be recognised when making decisions concerning management of the coastal zone.

Utilise the best available tools

Making use of the best available tools including technology, innovation, land acquisition, planning controls and economic analysis to manage the coastal zone, whilst recognising proven traditional approaches.

4.3 Stage Two studies

State of the Estuary Report

A State of the Estuary Report was compiled to summarise the findings of all relevant estuary research projects in Lake Macquarie, including analyses of trends in water quality in the lake, and recommendations for lake management.

Urban stormwater discharges from the fringing catchment and diffuse source runoff from the wider catchment are the largest ongoing threats to the ecological health of Lake Macquarie, and the benefits a healthy lake provides to the community.

The northern and western bay ends (e.g. Cockle Bay, Fennell Bay, Bonnells Bay, and Wyee Bay) are the most sensitive zones of the lake, with poor water quality (high nutrients and suspended sediments).

The central region of the lake is relatively resilient to nutrient enrichment due to the combination of relatively smaller catchment inputs, deep water and proximity to the ocean entrance.

This report also highlighted the need to recognise and respond to pressures placed on seagrass in the lake.

Wave overtopping assessment

The scoping study identified the need for an updated wave overtopping assessment for the Lake Macquarie coastline to fill current data gaps and to inform the development of management options during Stage Three.

Management options were assessed using a multi-criteria stakeholder analysis and key recommendations are as follows:

- Redhead Beach: continued monitoring of Nine Mile Beach will show whether the surf club relocation might need to be considered prior to the end of life of the surf lifesaving club.
- Belmont Wastewater Treatment Works/Pony Club site: medium-term option of fencing and formalising the access to the beach recommended. No immediate need to complete works.
- Blacksmiths residential area: issue of overtopping is not critically important, however is not to be ignored. Raising and formalising of low points in the dunes at Blacksmiths Beach to be considered in the first five years of the CMP.

Surfing amenity assessment

Blacksmiths Beach has a long surfing history and strong surfing culture. Swansea-Belmont Surf Life Saving Club was formed in 1927 and the Nine Mile

Beach Surfboard Club was formed in 1965. Long-term surfers at Blacksmiths Beach have reported a decline in surf quality, leading to the creation of the community group 'Bring Blacksmiths Back'. The need to assess the surfing amenity at Blacksmiths Beach was identified during Stage One of the CMP.

Short-term options

For improved alongshore access, steep dune scarps can be reprofiled to a nominal angle of 34° (range 25°-40°). Subject to ecological and botanical expertise, vegetation of the seaward portion of the dunes should consider low density species. Dune cross-section and planform designs would be required.

Medium-term options

The following medium-term studies and actions were identified to further understand or improve surfing amenity at Blacksmiths:

- Investigate the feasibility of an artificial sand bar placement for future dredging campaigns
- Smart cameras to assist with monitoring changes to beaches and capturing extreme weather events
- Trial of drone based bathymetry monitoring (to understand the movement of sand banks)
- Ongoing monitoring and analysis of changes to beach landforms

Long-term options

- Investigate feasibility of a sand transfer scheme
- Consider surfing amenity in any breakwater alterations, which could arise due to damage, repairs or upgrade, noting that it is presently unlikely that removal (partial or complete) of the breakwater would be acceptable to the broader community.

Pelican foreshore stabilisation project

Pelican foreshore contains some of NSW's most vulnerable assets at risk from coastal erosion. In 2016, erosion resulted in the sudden collapse of the Pelican Marina complex, including the marina buildings, a restaurant, a business and a residential apartment. Assets currently threatened by ongoing erosion include several essential emergency service facilities (NSW Coastal Patrol, NSW Maritime/ Fisheries, Northern NSW's Rescue Helicopter) and recreational assets (including Lake Macquarie Airport, foreshore reserves, boat ramps etc). If left unchecked, ongoing eastward erosion will eventually threaten residential housing.



Figure 16: Collapse of Pelican marina complex - February 2016 (Source: S Walpole)

The cause of this erosion (ongoing migration of Swansea Channel) is becoming better understood as the form of the channel continues to enlarge to achieve a stable state to match the configuration of the entrance breakwaters (estimated to be a five to eight-fold increase of the current channel cross sectional area).

The largely unprotected stretch of foreshore at Pelican will continue to claim assets unless foreshore protection works are effectively designed, costed and installed. The high vulnerability of the Pelican area to sea level rise means various adaptation pathways must be considered. The Pelican Foreshore Remediation Project is a key management action in the Local Adaptation Plan for Pelican, Blacksmiths, Swansea, Swansea Heads and Caves Beach.

Since the collapse of the marina complex, studies have been completed to further understand the issue, including the formulation of probable hazard lines for foreshore erosion in this area, and the

preparation of concept designs for protection works.

During conceptual design, Pelican foreshore was divided into four precincts to facilitate design and assessment, considering the uses and constraints of different lengths of foreshore. The precinct approach also provides for a staged approach to construction (based on a design philosophy of building stabilisation works between four 'fixed' points along the foreshore). Three separate options (schemes A, B and C) for each precinct were prepared, ranging from a 'minimalist approach' (scheme A) to a 'full protection approach' (scheme C).

Economic assessment of each of the options was undertaken through a cost benefit analysis that considered the probability of shoreline recession (based on the outcomes of the probabilistic hazard assessment). Detailed designs for recommended foreshore protection schemes have been prepared using the outcomes of the cost benefit assessment and multi-criteria analysis.

The recommended foreshore stabilisation options are identified in the table below.

Precinct	Location	Recommended option	Benefit cost ratio	Multi-criteria analysis ranking	Detailed design cost estimate (draft)
A	Naru Point to Lake Macquarie Airport excluding former Pelican Marina site	Scheme B Rock bag structure	1.09	1	\$4.6 million
B	Former Pelican Marina site Soldiers Road public wharf	Scheme B Spur dyke	0.10	1	\$2.1 million
C	Soldiers Road public wharf to Pelican boat ramp	Scheme B Rock bag structure	0.70	2	\$3.75 million
D	Pelican boat ramp to Entrance to Little Pelican	Scheme B Spur dyke	1.87	2	\$950,000

Table 10: Pelican foreshore stabilisation options

Benefit costs ratio >1 indicates that the benefits exceed the costs

The detailed design and associated cost estimates have been completed to a '90 per cent' stage based on bathymetric survey. Due to the rapidly changing nature of the channel, a revised survey and commensurate upgrade of the design alignments and volumes, along with cost estimates, will be required closer to construction.

There is a possibility that substantial savings of up to 50 per cent for some precincts could be realised if more testing is completed on the performance of rock bags to be used in some of the structures. This testing would aim to prove whether a 'flat placed' configuration could provide enough protection, instead of the more expensive and more stable 'stepped' configuration adopted in the present design.



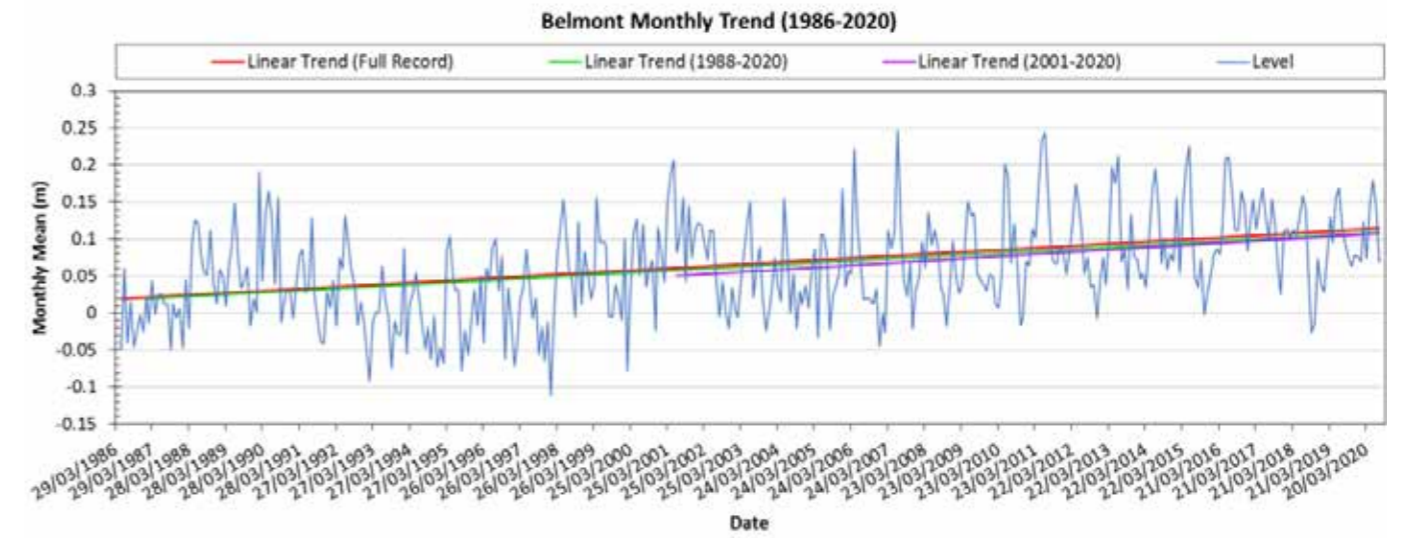


Figure 18: Trends on water levels at the Belmont gauge over varying time periods

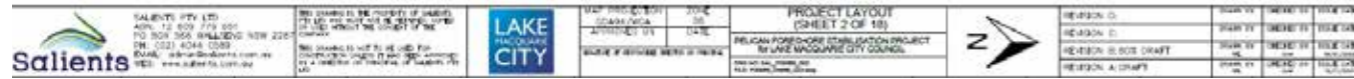


Figure 17: Proposed Pelican foreshore stabilisation works

Water level analysis

Council and the community are keen to understand how lake levels are changing over time to help inform our adaptation planning response. Council engaged Manly Hydraulics Laboratory (MHL) to update the previous analyses of water level trends and variability in Lake Macquarie using the last five years of data. This analysis covers water level trends in Lake Macquarie as compared to the open ocean, determination of a new mean high water (MHW) value for the Lake Macquarie foreshore, and analysis of key tidal harmonic constituents in relation to dredging of Swansea Channel (available at: [Water Level Analysis](#)).

The overall aim of the MHL study was to assist Council in understanding how lake levels are changing over time in order to effectively manage risks to coastal communities. From the results of this analysis, it can be concluded:

- ocean waters are rising between 2.0 and 3.5 mm/year. This was determined through water level trend analysis at Sydney (Middle Head) for the full period of record as well as last tidal epoch (2001-2020).
- water levels within Lake Macquarie are continuing to rise between 2.5 and 3.5 mm/yr. These results were calculated through water level trend analyses over different periods and multiple locations.

The rate of rise in water levels at Belmont was calculated to be 2.7 and 3.1 mm/year, based on the full period of record and 2001-2020 tidal epoch, respectively.

- the rate of lake water level rise in the lake is accelerating. This was determined by comparing water level trends across multiple time scales at Belmont and Marmong Point.
- with the data currently available, the levels in the lake have been observed to be increasing at a higher rate compared to the ocean. This difference is partly due to the lower tidal range within the lake compared to the ocean and has the potential to change over time depending on the bathymetry of the Swansea Channel. As more data becomes available, greater confidence can be placed on water level trends observed in Lake Macquarie.
- the overall tidal range and mean tidal range are increasing within the lake. This could be partly attributable to changes within Swansea Channel, however, there is not enough information to confirm this.

It is recommended that a review be conducted at five-year intervals as the lake system becomes more tidally dominated to monitor rising water levels and associated changes in lake behaviour.



4.4 Business Plan

4.4.1 Actions to be implemented by Council or by public authorities (Implementation Plan)

Component of management action included for certification under the CM Act Actions to be implemented by the council or by public authorities. All costs or funding sources are from various public funds (local, state and federal).

Part A – Coastline (37 actions)

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 1 - Increase understanding of coastal risks								
A1.1 Conduct further analysis of the interactions of lake sourced inundation, coastal recession and marine inundation from overtopping, to clarify likely constraints to land use and potential for retreat.	5-10	Council, DPE Science	Planning investigations (One-off)	Low 1d/m	\$0	\$0	\$10,000	13
A1.2 Encourage further research on the behaviour of dunes in pocket and long barrier coastal sediment compartments, as climate changes and sea level rises.	5-10	Council, Universities, DPE	Planning Investigations (Ongoing)	Low 1d/m	\$0	\$0	\$10,000	13
A1.3 Expand beach camera network and connect with the need to monitor coastal change (Redhead, Blacksmiths, Caves, Catherine Hill Bay beaches)	2-5	Council	Operations (One-off)	Low 1d/m	\$10,000	\$1,000 /yr	\$0	3, 13
A1.4 Continue to adopt use of technology (such as remote sensing) to support management of the coastline	2-5	Council	Operations (Ongoing)	Low 1d/m	\$10,000	TBC	\$0	9
Issue: 2 - Continue adaptive approach to managing coastal hazards where appropriate								
A2.1 Consider coastal hazards in future asset planning and determine trigger points for commencing detailed planning for protecting or relocating surf clubs	2-5	Council	Planning (One-off)	Med 1d/w	\$0	\$0	\$0	3, 9, 13
A2.2 Implement a resilience planning approach to managing coastal risk, aligned with the NSW government approach	1	Council	Planning (Ongoing)	High 5d/w	\$0	\$0	\$60,000 /yr	11, 13
A2.3 Hunter Water Corporation to consult with LMCC through detailed design, planning and assessment of the desalination plant proposed for Nine Mile Beach - Ensure that long term coastal hazards (erosion and wave overtopping) are addressed	1	HWC, Council	Planning (One-off)	High 5d/w	\$0	\$0	\$20,000	6, 13

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 3 Coastal dune stability is threatened by coastal erosion, disturbance, and unplanned access								
A3.1 Encourage community stewardship of natural areas through ongoing support of Landcare and increased awareness raising activities	2-5	Council, Landcare, Land Councils	Planning Operations Engagement (Ongoing)	Med 1d/w	\$0	\$0	Indicatively \$1.3 million/year	3, 14, 15
A3.2 Continue with community activity programs focusing on coastline protection and key environmental issues	1	Council	Planning Engagement (Ongoing)	Med 1d/w	\$0	\$0	\$10,000 /yr	11, 14, 15
A3.3 Maintain priority access to beaches, install fencing and matting on beach access ways to protect dune vegetation and habitats (priority locations are Blacksmiths, Caves and Redhead beaches). Include signage and other education material regarding domestic animals/4WD access	1	Council	Operations (Ongoing)	High 5d/w	\$0		\$0	3, 9, 13, 15
A3.4 Fence and formalise access to the beach at Belmont WWTW and Pony Club	2-5	Council	Operations (One-off)	Med 1d/w	\$250,000		\$0	3, 13, 15
A3.5 Develop and implement dune management plans for priority areas (Blacksmiths, Redhead, Nine Mile, Caves Beach and Catherine Hill Bay)	1	Council	Planning (One-off)	High 5d/w	\$50,000 / yr for implementation	\$0 see D3 for	20,000 per plan for development	3, 13, 15
A3.6 BWSP – review and improve permit issuing practices to manage vehicle numbers during peak periods and regulate waste dumping	1	BWSP, Council, DPE, Crown Lands	Operations Compliance (Ongoing)	Med 1d/w	\$0	\$0	Staff time only	3, 14, 15
A3.7 Assess vehicle use of other areas of Nine Mile Beach (outside the BWSP site) and which organisations have regulatory responsibilities	2-5	BWSP, Council, DPE, DPE-Crown Lands	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time only	3, 14, 15
A3.8 Raise and reinforce low points in the dunes (using on-site sand, or sand sources from dredging works) Locations include Nine Mile Beach, Caves Beach and Catherine Hill Bay Beach. Priority area is Nine Mile Beach (southern portions). Land owners/managers responsible for areas under their management	1	TfNSW Council, BWSP, DPE-Crown Lands, Hunter Water, Belmont Golf & Bowls	Operations (Ongoing)	Med 1d/w	\$50,000 per project	\$0	\$0	3, 13, 15

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
A3.9 Investigate the feasibility of a sand slug configuration placement for future dredging campaigns (southern corner of Blacksmiths beach). If feasible, undertake monitored trial(s) of configuration placement of sand slugs as sand becomes available.	2-5	Council, DPE Science	Planning Investigation (One-off)	Low 1d/m	\$0	\$0	\$50,000 for investigation	3, 13
A3.10 Investigate the development of a concept design and detailed design for a sand transfer scheme and consider surfing amenity in any breakwater alterations at Blacksmiths or Swansea Heads.	2-5	Council, DPE	Planning Investigation (One-off)	Low 1d/m	\$0	\$0	\$150,000 for assessment if detailed design is included	3, 14, 15
A3.11 Conduct beach management works to revegetate, reshape and increase dune volume/recovery after storms, and to control weeds. (Blacksmiths, Redhead, Nine Mile, Caves Beach and Catherine Hill Bay). <i>Land owners/managers responsible for areas under their management</i>	1	Council, BWSP, HWC, DPE-Crown Lands, Belmont Golf & Bowls, NPWS	Operations (Ongoing)	Med 1d/w	\$30,000 /year	\$0	\$0	13, 15
A3.12 Discuss the transfer or acquisition of private land (only when requested and/or supported by the landowner) along the coast with high values for public access, scenic and ecological quality into public tenure (including potential application to DPE under the Coastal Lands Protection Scheme). Priority locations include private owned land in the mid portion of Nine Mile beach, headland at Dudley, and land in the Catherine Hill Bay SLSC and sports precincts.	2-5	Council, DPE Planning	Planning Investigation (One-off)	Low 1d/m	\$0	\$0	Staff time only	11, 13
A3.13 Prepare creek management and water quality improvement plans for small coastal creeks and lagoons, used for recreational swimming/splashing. (Priority locations are First Creek, Third Creek and Catherine Hill Bay) <i>Land owners/managers responsible for areas under their management</i>	2-5	Council BWSP	Planning Operations (One-off)	Med 1d/w	\$0	\$0	\$20,000 per plan	6, 14
A3.14 Coordinate and implement monitoring and management efforts relating to recreational water quality on beaches and coastal creeks and lagoons (including links with state programs and ecological water quality monitoring)	1	Council, Hunter Water, NPWS	Planning Operations (Ongoing)	Med 1d/w	\$0	\$0	\$30,000 /yr analysis costs	6, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 4 - Habitat for migratory shorebirds is threatened by coastal processes and recreational use								
A4.1 Research the impacts of sea level rise on migratory shorebirds	5-10	DPE, Council, NPWS, Universities	Investigations (One-off)	Low 1d/m	\$0	\$0	\$5000-10,000	15
A4.2 Raise awareness of the importance of migratory shorebirds. Signage (about species and impacts of recreation) in key locations; investigate other awareness raising options	2-5	Council	Planning Engagement (Ongoing)	Low 1d/m	\$0	Nil	\$5,000 for design etc	15
A4.3 Protect little tern and pied oystercatcher nesting and feeding areas on beaches (Nine Mile Beach) and dunes, using fencing and vehicle access controls	1	Council, DPE, HBOC NPWS	Operations (Ongoing)	Med 1d/w	\$0	\$5000 /yr	\$0	15
A4.4 Control domestic animal access (eg, fencing) to sensitive habitat area for migratory shorebirds. Domestic dogs are the highest priority. Domestic dogs are the highest priority	1	Council, NPWS, LLS, DPE-Crown Lands	Operations Compliance (Ongoing)	Med 1d/w	\$0	\$0	Staff time only (Rangers)	3, 15
Issue: 5 - Recreational and conservation values of headlands and rock platforms are managed								
A5.1 Headland management: review PoMs considering opportunities for improved management (vegetation, cultural, tourism and headland stability) at Swansea Heads and other prominent headlands	2-5	Council, DPE-Crown Lands, NPWS (Involve LALCs)	Planning (One-off)	Med 1d/w	\$0	\$0	\$50,000 per POM	3, 11
A5.2 Identify and promote conservation status (Marine Protected area) for an intertidal area (Swansea Heads rock platform)	2-5	Council	Planning Investigations (One-off)	Med 1d/w	\$0	\$0	Staff time only	14, 15
A5.3 Investigate opportunities for awareness raising and enforcement activities to protect rock platform biodiversity <i>Land owners/managers responsible for areas under their management</i>	2-5	Council NPWS	Planning Compliance (Ongoing)	Low 1d/m	\$0	\$0	\$5000 for resource development	14, 15
A5.4 Continue with community activity programs focusing on coastline protection and key environmental issues	1	Council NPWS	Planning Engagement (Ongoing)	Med 1d/w	\$0	\$0	\$10,000 /yr	11, 13, 14, 15

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
A5.5 Assess hazards and risks and conduct a community awareness program about rock platform safety <i>Land owners/managers responsible for areas under their management</i>	2-5	Council NPWS, SLSC	Planning Engagement (One-off)	Low 1d/m	\$0	\$0	Staff time only	3, 13
A5.6 Review and upgrade the coastal walking path from Caves Beach to Catherine Hill Bay and further south to Munmorah SCA	2-5	Council NPWS	Investigation Planning Operations (One-off)	Med 1d/w	Not costed, but estimated as more than \$2 million	\$0	\$500,000 over 4 years for studies and design	3
A5.7 Investigate stormwater impacts on headlands and rock platforms (i.e. erosion issues, water quality and litter)	2-5	Council University	Investigation (One-off)	Med 1d/w	\$0	\$0	\$10,000 for monitoring over 4 years	6, 14
Issue: 6 - Manage (mitigate) risks to beach access and safety infrastructure								
A6.1 Investigate the refurbishment of the revetment and adding a wave return wall at Redhead surf club	2-5	Council	Operations (One-off)	Med 1d/w	\$850,000 capital cost	\$1000 /yr	\$20,000 for design	3, 9
A6.2 Investigate options to reduce coastal hazards to Redhead Surf Club and associated facilities	2-5	Council	Investigation Planning (One-off)	Med 1d/w	Note: estimated \$5,800,000 capital cost for surf club if relocation required.	\$0	\$30,000 (initial studies)	3, 9
Issue: 7 - Cultural management actions								
A7.1 Translate educational material (about coastal processes and hazards, habitats and protected species) into languages that reflect visitor profiles	5-10	Council	Engagement (One-off)	Low 1d/m	\$0	\$0	\$5000	3, 10
A7.2 Investigate pathways and feasibility for achieving co-management of Coastal Country	5-10	Council DPE-Crown Lands, NPWS, LALCs	Investigations Planning Staff time (Ongoing)	Med 1d/w	\$0	\$0	\$20,000 for assessing pathways	17
A7.3 Build awareness of cultural values and sensitivity for council construction staff (inductions and procedures for Council staff and contractors)	1	Council, LALCs	Operations (Ongoing)	Med 1d/w	\$0	\$0	\$10,000/yr for staff training	16, 17
A7.4 Include cultural awareness programs, developed with the Aboriginal community, in community activities in the coastal zone	1	Council, LALCs	Operations (Ongoing)	Low 1d/m	\$0	\$0	\$5000/yr	17

Part B – The Lake Macquarie estuary (37 actions)

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 1 - Hazard assessment and management are continually updated with new information to provide the best management processes and priorities								
B1.1 Identify and prioritise actively eroding creek bank sites on public land in the coastal zone	1	Council, LLS	Investigation Operations (Ongoing)	Med 1d/w	\$0	\$0	Staff time only	14, 15
B1.2 Conduct condition assessment of key sites impacted by lake foreshore erosion on public land	1	Council	Planning (Ongoing)	Med 1d/w	\$0	\$0	\$60,000 per year	6, 13
Issue: 2 - Ongoing Community engagement is needed to support a resilient community								
B2.1 Continue adaptation collaboration and planning with affected communities and expand locally-led climate resilience and adaptation programs	1	Council, Central Coast Council, DPE	Planning Engagement (Ongoing)	High 5d/w	\$0	\$0	\$40,000 plus staff time	13
Issue: 3 - Targeted studies and planning controls to be investigated								
B3.1 Review council's existing water cycle management development controls to improve water quality outcomes from new developments	1	Council, Central Coast Council, DPE	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time only	6, 11, 15
B3.2 Investigate hydrological characteristics and water quality of Muddy Lake and develop and implement a suitable management approach which may include Environmental Protection Works	2-5	Crown Lands, Council, DPE Science Origin Energy, Universities	Investigations (One-off)	Med 1d/w	\$0	\$0	\$100,000 Indicative cost for other research/studies.	14, 15
B3.3 Seek funding to implement the LT Creek Dredging Plan to address historic sediment deposits in the upper tidal reaches and improve aquatic ecosystem health	1 for securing funding 2-5 for implementation	Council	Planning (One-off)	Med 1d/w	\$0 for seeking funding \$1.63 million for implementation	\$0	Included in capital costs	14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 4 - Reduce urban stormwater impacts on lake water quality and estuary health								
B4.1 Monitor performance of Gross Pollutant Trap (GPT) type Stormwater Quality Improvement Devices (SQIDs) to inform the maintenance schedule, considering available sensors and other technology and modelling in the coastal zone	1	Council	Monitoring Planning Operations (Ongoing)	Low 1d/m	\$10,000	Nil	Staff time	6, 9, 14
B4.2 Minimise the use of machinery by adopting a bush regeneration approach to maintenance of vegetated SQIDs in the coastal zone	1	Council	Planning (One-off)	Low 1d/m	\$0	Council currently spends \$1.6/yr on SQID maintenance	Staff time	6, 9, 14
B4.3 Investigate and undertake retrofit upgrades to existing SQIDs within the coastal zone to improve asset performance, targeting catchments with high concentrations of nutrients and/or high sediment loads to sensitive parts of the lake	1	Council	Operations (Ongoing)	High 5d/w	SQID Asset Replacement \$125,000 New SQID (and retrofits) \$450,000 /yr	Continue current resourcing commitments	Design and approval included in capital budget	6, 9, 14
B4.4 Investigate, install and maintain SQIDs within the coastal zone to reduce sediment and nutrient load, maximising pollutant removal efficiencies and prioritising catchments	1	Council	Operations (Ongoing)	High 5d/w	SQID Asset Replacement \$125,000 New SQID (and retrofits) \$450,000 /yr	Continue current resourcing commitments	Design and approval included in capital budget	6, 9, 14
B4.5 Continue compliance and education programs for the construction industry and residential property owners to promote best practice stormwater management	1	Council	Operations (Ongoing)	High 5d/w	\$0	\$0	Predominantly staff time \$5,000/yr for development of educational resources	6, 9, 14
B4.6 Identify sediment and nutrient generation hotspots using spatially intensive, short term monitoring programs undertaken during a major rainfall event	1	Council DPE Science University, Central Coast Council	Investigations Planning Operations (One-off)	Low 1d/m	\$0	\$0	\$50,000 for data collection	6, 9, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
B4.7 Identify strategies to minimise erosion losses from unconsolidated road verges, building sites and other streetscape generation hotspots within the coastal zone	2-5	Council	Planning Operations (One-off)	Med 1d/w	\$0	\$0	10 sites at \$75,000 each over the life of the CMP	6, 9, 14
Issue: 5 - Monitor changes in seagrass/wetland response to estuary processes, water quality and lake use								
B5.1 Continue seagrass mapping and health monitoring, and investigate partnership opportunities with other organisations monitoring to improve the health and extent of seagrass	1	Council, DPI Fisheries, Central Coast Council	Monitoring Planning (One-off, but repeat every 5yrs)	High 5d/w	\$0	\$0	DPI whole of lake mapping indicatively \$150,000 (currently funded by MEMS). Targeted monitoring near boat ramps (20 sites, \$2,000 per site)	14
B5.2 Continue to monitor lake health, identifying areas for partnering with industry. Expand scope of monitoring to include microplastics	1	Council, DPE Origin Energy Delta, HWC	Monitoring Planning (Ongoing)	Low 1d/m	\$0	\$0	\$65,000 (investigate industry contribution)	14
B5.3 Continue wetland/saltmarsh rehabilitation program. Including investigation of removing potential barriers around wetland margins to facilitate migration of saltmarsh and other wetland species. (Refer to Appendix 8 – Environmental Protection Works in coastal wetlands and littoral rainforests for locations)	1	Council DPI Fisheries, DPE Science Landcare	Operations Planning (Ongoing)	Med 1d/w	\$30,000/yr (with matching grant funds). Also volunteer works by Landcare	Volunteer works by Landcare	Staff time	14, 15
Issue: 6 - Impact of stormwater and wastewater overflows on water quality for recreational use								
B6.1 Conduct monitoring of recreational swimming areas – monitoring bacterial counts to improve management of sewage and stormwater systems	1	Council, Central Coast Council	Monitoring Operations (One-off)	Med 1d/w	\$0	\$0	Sampling undertaken by Council staff (13 sites sampled weekly during swimming season). Cost of analysis is \$15,000 /yr	3, 6, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
B6.2 Implement recommendations from 'Effects based assessment of wastewater overflows in Lake Macquarie catchment' (Prepared for HWC by DPE) <i>Actions include: further investigation of pathogen profile and sources, implementing strategic improvement to sewerage network, and improved risk management systems</i>	2-5	HWC, Council	Monitoring Operations (One-off)	Med 1d/w	\$0	\$0	\$100,000 for studies. No current budget allocation.	3, 6, 14
Issue: 7 - Improve catchment riparian and wetland vegetation around Lake Macquarie to reduce nutrient loads, and improve habitat								
B7.1 Continue streambank, riparian corridor rehabilitation program within the coastal zone (including locations such as Stony Creek)	1	Council, DPE-Crown Lands	Operations (Ongoing)	Med 1d/w	\$200,000 /yr	\$20,000 /yr	Staff time	14, 15
B7.2 Support community stewardship of natural areas through ongoing support of Landcare and other environmental volunteer programs	1	Council, Central Coast Council, LLS, Landcare	Operations (Ongoing)	Med 1d/w	\$0	\$0	\$1,300,000 per year, note this is for the whole local council area, not just in the coastal zone or estuary context	14, 15, 17
Issue: 8 - Improve foreshore stability and ecological processes								
B8.1 Continue foreshore stabilisation program. Refer to Appendix 7 - Foreshore stabilisation works (Coastal Protection Works) prioritisation tool. <i>Land owners/managers responsible for areas under their management</i>	1	Council, Central Coast Council	Operations (Ongoing)	Med 1d/w	\$140,000 /yr	\$100,000 /yr	Staff time	14, 15
B8.2 Investigate and pilot an environmentally friendly seawall (retrofit an existing seawall structure). Refer to Appendix 7 - Foreshore stabilisation works (Coastal Protection Works) prioritisation tool.	2-5	Council, Central Coast Council, DPE	Operations (Ongoing)	Med 1d/w	\$20,000 - 50,000 for design, construction, monitor	\$0	Staff time	14, 15

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 9 - Catchment vegetation modification – riparian and wetland vegetation around Lake Macquarie is extensively modified or removed, affecting nutrient loads, and habitat								
B9.1 Manage new outbreaks of aquatic weeds and pests.	2-5	Council, DPE-Crown Lands, DPI, LLS	Operations (Ongoing)	Low 1d/m	Dependant on nature of new outbreak.	\$100,000 /yr	\$10,000 – 50,000/yr Dependant on nature of new outbreak.	14, 15
B9.2 Explore opportunities to establish (and implement if feasible) an aquatic weed and pests surveillance program	2-5	Council, DPI, LLS, DPE-Crown Lands, Universities	Investigations (Ongoing)	Med 1d/w	Potentially capital items required (vessel, UAV etc)	\$0	Staff time from relevant agencies	14, 15
B9.3 Evaluate opportunities local use of approved biocontrol applications for managing aquatic weeds and pests	1	Council, DPI, LLS, DPE-Crown Lands, Universities	Investigations (Ongoing)	Low 1d/m	\$0	\$0	Staff time only	14, 15
B9.4 Develop an awareness raising, education and safety risk management program for razor clams (particularly in enclosed swimming areas)	2-5	Council, Central Coast Council, DPI Fisheries	Planning Engagement (On-off)	Low 1d/m	\$0	\$0	\$5,000 for development of resources. Staff time	3, 14
Issue: 10 - Environmental issues associated with access to marine estate								
B10.1 Raise community awareness on the impact of boating on seagrass (focus on Posidonia)	2-5	Council, Central Coast Council, DPI Fisheries, TfNSW	Engagement (Ongoing)	L	\$0	\$0	\$5,000 for development of resources. Staff time	14
B10.2 Undertake a research trial "Environmentally Friendly Mooring" (EFM) Trial	1	TfNSW, DPI Fisheries	Investigations (One-off)	M	\$0	\$0	MEMS funded	3, 14
B10.3 Develop consumer "Guidelines" for the installation, use, and maintenance of Environmentally Friendly Moorings	2-5	TfNSW, DPI Fisheries	Engagement (One-off)	M	\$0	\$0	MEMS funded	3, 14
B10.4 Consider the outcome of the Environmentally Friendly Moorings trial in relevant plans of management	2-5	TfNSW, DPI Fisheries	Planning (One-off)	M	\$0	\$0	Staff time only	3, 14
B10.5 Use the Jetty Impact Assessment Tool when assessing new applications for jetty construction and in the redesign of existing public jetties to minimise impacts on adjacent seagrass beds.	1	Council, Central Coast Council, DPI Fisheries	Planning (Ongoing)	L	\$0	\$0	Staff time only	14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 11 - Protect migratory shorebird and marine species habitat around Lake Macquarie is impacted								
B11.1 Review factors influencing the population and breeding success of migratory shore bird species	2-5	DPE, NPWS, Council	Engagement (Ongoing)	Low 1d/m	\$0	\$0	TBC	15
B11.2 Raise awareness of bird species especially migratory birds and their vulnerability to disturbance. (Sooty and Pied Oyster Catchers, and other species)	2-5	Council, NPWS, DPE, Central Coast Council	Engagement (One-off)	Low 1d/m	\$0	\$0	TBC	15
B11.3 Raise awareness of marine mammals and other protected species within the lake, such as seals, turtles, dolphins. Include advice on natural behaviours and appropriate interactions with people	2-5	NPWS, Council, Central Coast Council, DPE	Engagement (One-off)	Low 1d/m	\$0	\$0	TBC	14, 15
Issue: 12 - Access to the recreational boating								
B12.1 Provide public boating access infrastructure (including improved access for persons with a disability). Work to provide equitable provision of boating facilities around the Lake	1	Council, TfNSW	Planning (Ongoing)	Med 1d/w	Dependant on facility.	Dependant on facility and provision included in maintenance programs	Staff time	3, 14
Issue: 13 - Foreshores and wetlands of Lake Macquarie are considered a passive recreation asset								
B13.1 Monitor community use of the lake and foreshores to provide up to date information on recreational use, demand and patterns – consider technology applications such as QR codes etc	2-5	Council, Central Coast Council	Monitoring (Ongoing)	Low 1d/m	TBC	TBC	TBC	3, 14
B13.2 Investigate enhancement of passive recreation access to wetlands and foreshores in other public land – link to future Tracks and Trails Strategy.	2-5	Council, NPWS, DPE-Crown Lands	Planning (On-off)	Med 1d/w	\$0	\$0	Staff time plus integration with Tracks and Trails Strategy	3, 14, 15

Part C – Channel (32 actions)

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 1 - The collaborative framework for management across multiple agencies needs to be clearer and stronger								
C1.1 Maintain the entrance breakwaters in accordance with asset management framework; considering sea level rise & climate change	1	TfNSW	Operations (Ongoing)	Low 1d/m	TBC	TBC	\$0	9, 13
C1.2 Conduct further investigations of sites or structures in the channel, assessed as high risk, and clarify responsibilities of agencies. <i>Land owners/managers responsible for assets under their management</i>	1	Council, TfNSW, DPE-Crown Lands, DPE	Investigations (One-off)	Med 1d/w	\$0	\$0 (maintenance addressed in C1)	Costs of site investigation will vary considerably depending on the nature of the site.	9, 13
C1.3 Develop interagency infrastructure design criteria for current and future coastal hazards <i>Land owners/managers responsible for assets under their management</i>	2-5	Council, TfNSW, DPE-Crown Lands	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time only	9, 13, 17
C1.4 Consider coastal hazards and risks in Asset Category Plans and when planning major public infrastructure	2-5	Council, TfNSW, DPE-Crown Lands, Hunter Water, Telstra, Ausgrid, NBN Co, Jemena	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time only	9, 13

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
C1.5 Commence feasibility and planning (and construct or retrofit when funds available) to upgrade coastal protection works by public land holders, in accordance with the R&H SEPP; incorporate environmentally friendly designs for all seawalls or revetments. Priority location is Belmont Street, Swansea. Other locations include revetments at Blacksmiths, Swansea Head and Swansea. <i>Land owners/managers responsible for assets under their management</i> Refer to Appendix 7 - Foreshore stabilisation works (Coastal Protection Works) prioritisation tool.	1	Council, TfNSW, DPE-Crown Lands	Operations Planning (Ongoing)	Med 1d/w	Will vary depending on site	\$100,000 /year	Staff time only	9, 13, 14
C1.6 Investigate expanding the pilot tidal gates project to other sites (Swansea urban areas, Black Neds Bay, Blacksmiths behind northern revetment)	1	Council	Investigations Operations (Ongoing)	Med 1d/w	Capital \$80,000 cost of current pilot	\$10,000 /yr	Staff time only	9, 11, 13
C1.7 Support LAP actions implementation relating to future inundation and/or pilots on public land	1	Council, DPE-Crown Lands	Planning Operations (Ongoing)	Low 1d/m	Integrate into future drainage projects. Costs depending on project	Unknown - dependent on site and design	Design costs dependent on site conditions and scope	9, 11, 13
Issue: 2 - Address erosion along the Pelican foreshore								
C2.1 Confirm details on funding provision and management responsibilities for implementation of Pelican foreshore stabilisation works (informed by cost benefit analysis and distribution analysis)	1	Council, DPE-Crown Lands, Lake Macquarie Airport, TfNSW, Marine Rescue	Planning (One-off)	M	\$0	\$0	Staff time only	9, 11, 12, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
C2.2 Stabilise Pelican foreshore – Precinct A (using scheme B approach identified in the Pelican Foreshore Design Project). (Coastal Protection Works) <i>* Detailed funding arrangements and responsibilities to be confirmed in action C2.1</i>	1 for securing funding 2-5 for implementation (dependent on funding)	Council, DPE-Crown Lands, Lake Macquarie Airport (TBC in action C2.1)	Operations Planning (One-off)	H	Estimated as \$4,670,000	See F6	Approval costs included in capital cost.	9, 11, 13, 14
C2.3 Stabilise Pelican foreshore – Precinct B (using Scheme B approach identified in Pelican Foreshore Design Project). (Coastal Protection Works) <i>* Detailed funding arrangements and responsibilities to be confirmed in action C2.1</i>	1 for securing funding 2-5 for implementation (dependent on funding)	Council, DPE-Crown Lands, Lake Macquarie Airport (TBC in action C2.1)	Operations Planning (One-off)	H	Estimated as \$2,100,000	See F6	Approval costs included in capital cost.	9, 11, 13, 14
C2.4 Stabilise Pelican Foreshore Precinct C (using Scheme B approach identified in Pelican Foreshore Design Project). (Coastal Protection Works) <i>* Detailed funding arrangements and responsibilities to be confirmed in action C2.1</i>	1 for securing funding 2-5 for implementation (dependent on funding)	Council, DPE-Crown Lands (TBC in action C2.1)	Operations Planning (One-off)	H	Estimated as \$3,750,000	See F6	Approval costs included in capital cost.	9, 11, 13, 14
C2.5 Stabilise Pelican Foreshore Precinct D (using Scheme B approach identified in Pelican Foreshore Design Project). (Coastal Protection Works) <i>* Detailed funding arrangements and responsibilities to be confirmed in action C2.1</i>	1 for securing funding 2-5 for implementation (dependent on funding)	Council, DPE-Crown Lands (TBC in action C2.1)	Planning Staff Time Capital (One-off)	H	Estimated as \$950,000	See F6	Approval costs included in capital cost.	9, 11, 13, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
C2.6 Monitor the Pelican foreshore – foreshore position, bathymetry and stability <i>** Land owners/ managers responsible for monitoring assets under their control</i>	1	DPE- Crown Lands, TfNSW Council, DPE- Science	Monitoring (Ongoing)	M	\$0	\$0	Include in routine TfNSW channel bathymetry (supplement with DPE surveys for non-navigable areas)	9, 11, 13, 14
C2.7 Implement interim stabilisation works until funding for major works is secured. (Coastal Protection Works) <i>* Detailed funding arrangements and responsibilities to be confirmed in action C2.1</i>	1	Council, DPE- Crown Lands, Lake Macquarie Airport, Marine Rescue	Operations (Ongoing)	M	\$0	\$50,000/yr	Staff time only	9, 11, 13, 14
C2.8 Investigate the condition and options for future management of the existing geofabric sandbag coastal protection works located in Pelican Foreshore Precinct B.	1	DPE- Crown Lands, TfNSW, Council	Planning	M	\$0	\$0	\$50-60,000	9, 11, 13, 14
C2.9 Monitor and manage the geofabric sandbag foreshore coastal protection works located in Pelican Foreshore Precinct B.	1	DPE- Crown Lands, TfNSW, Council	Operations	M	TBC subject to outcomes of C2.8	\$5- 10,000/ year	Approval costs included in capital cost.	9, 11, 13, 14
C2.10 implement outcomes from C2.8 and C2.8. This may include works to maintain, replace or construct coastal protection works at the location of existing geofabric sandbag coastal protection works. <i>* Detailed funding arrangements and responsibilities to be confirmed in action C2.1</i>	1	Lead to be determined, DPE- Crown Lands, TfNSW, Council	Operations	M	TBC subject to the outcomes of C2.8 and C2.9.	TBC subject to the outcomes of C2.8 and C2.9.	TBC subject to the outcomes of C2.8 and C2.9.	9, 11, 13, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 3 - Private property is threatened by tidal inundation								
C3.1 Implement priority actions of the Eastlakes LAPs; explore resilience planning	1	Council, Hunter Water	Planning Operations (Ongoing)	Med 1d/w	Costs vary dependant on actions – refer to LAP and associated CBA	Costs vary dependant on actions – refer to LAP and associated CBA	Costs vary dependant on actions – refer to LAP and associated CBA	9, 11, 13
Issue: 4 - Navigability of Swansea channel needs to be balanced with environmental and resilience impacts								
C4.1 Implement dredging and sand placement in accordance with the Sustainable Framework for Navigation in Swansea Channel (SFNSC). Small episodes of navigation dredging may be required at Black Neds Bay (sand to be used to provide build dune resilience)	1	TfNSW	Operations (Ongoing)	Med 1d/w	\$0	Indicatively \$500,000 per campaign	Staff time	3, 14
C4.2 Conduct regular hydro-survey of Swansea Channel in accordance with SFNSC	1	TfNSW	Planning (One-off)	Low 1d/m	\$0	\$0	\$50,000 per year (quarterly hydro-surveys)	3, 14
C4.3 Update the SFNSC to include channel evolution and impact of dredging on the natural environment.	2-5	TfNSW, Council	Planning (One-off)	Med 1d/w	\$0	\$0	\$100,000 to review and update the SFNSC	3, 14
C4.4 Utilise dredged sand for nourishment at priority locations and in accordance with dune management plans and foreshore areas along the channel. <i>Land owners/managers responsible for areas under their management</i>	1	DPE- Crown Lands, TfNSW, Council	Planning Operations (Ongoing)	Med 1d/w	\$0	\$0	\$50,000 per episode for sand shaping	
C4.5 Investigate the feasibility of a west channel diversion to reconfigure and train the navigation channel via the Airforce Channel, to address scour, navigation and maintenance issues	5-10	Council, TfNSW, DPE- Crown Lands, NSW Fisheries, DPE Science	Investigations (One-off)	High 5d/w	\$0	\$0	Capital works to realign the channel will require major coastal engineering studies and modelling \$250,000	9, 13, 14

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 5 - Swansea channel is a major recreation and tourism asset								
C5.1 Support actions to enhance recreation activation along Swansea Channel, as identified in the Lake Activation Strategy	1	Council	Planning (Ongoing)	Med 1d/w	Dependent on project	Dependent on project	See LAS proposed indicative budgets	3, 9
Issue: 6 - Estuary wetlands are vulnerable to sea level rise and climate change								
C6.1 Research best practice approach for enabling landward movement of saltmarsh in the estuary	2-5	Council, DPI Fisheries, DPE Science, Universities	Investigations (One-off)	Low 1d/m	\$0	\$0	TBA	9, 13, 14, 15
C6.2 Undertake pilot projects for re-establishing estuarine wetland communities such as saltmarsh and seagrass, which will be affected by higher lake levels. (Refer to Appendix 8 – Environmental Protection Works in coastal wetlands and littoral rainforests for locations).	2-5	Council	Investigations Operations (One-off)	Med 1d/w	\$0	\$0	\$30,000 per project	9, 13, 14, 15
C6.3 Monitor wetlands to evaluate the performance of protection activities and/or pilot projects for re-establishing estuarine wetland communities	5-10	Council	Monitoring (One-off)	Low 1d/m	\$0	\$0	\$10,000 per monitoring project	13, 14, 15
C6.4 Conduct wetland rehabilitation works. (Refer to Appendix 8 – Environmental Protection Works in coastal wetlands and littoral rainforests for locations).	1	Council, Landcare Bahtabah LALC	Operations (Ongoing)	Med 1d/w	\$0	\$0	\$30,000/yr wetland rehab program (citywide)	14, 15
C6.5 Work with existing or establish a formal Landcare program to undertake rehabilitation in priority channel locations	2-5	Council, (Landcare)	Operations (Ongoing)	Med 1d/w	\$0	\$0	Included in \$1.3 million annual Landcare allocation for the whole Lake Macquarie LGA	15
C6.6 Protect roosting, feeding and nesting habitat for migratory shorebirds. Strategies include sand placement and fencing	2-5	Council, DPE-Crown Lands, TfNSW NPWS	Operations (Ongoing)	Low 1d/m	\$0	\$0	\$10,000 /yr	15

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 7 - Strengthen evidence of tidal inundation patterns and levels								
C7.1 Monitor frequency, depth and spatial extent of storm inundation, tidal inundation and lake flooding events. Monitor and analyse data from tidal gauges to assess local trends in sea and lake levels.	1	Council, DPE Science	Monitoring Investigations (Ongoing)	Low 1d/m	\$0	Operation and maintenance of tidal gauges funded by DPE	Operation and maintenance of tidal gauges funded by DPE	9, 13
Issue: 8 - Clarity about land tenure is needed to enable effective management								
C8.1 Formalise ownership arrangements and responsibilities for public assets in Swansea Channel.	1	Council, DPE-Crown Lands, TfNSW	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time	17

Part D – Whole-of-coast governance actions (8 actions)

Issue: 1 - Governance arrangements for coordinated management need to be strengthened								
D1.1 Establish and implement an interdepartmental coastal management working group to support CMP implementation	1	Council, Multiple public authorities	Planning (Ongoing)	Low 1d/m	\$0	\$0	Staff time	17
D1.2 Maintain close liaison with State and Commonwealth agencies about Lake Macquarie issues and initiatives, drive innovative management, planning, monitoring and reporting processes	1	All Coordination by Council	Planning Engagement (Ongoing)	Low 1d/m	\$0	\$0	Staff time	17
D1.3 Conduct an annual review of CMP action status	1	Council	Planning (Ongoing)	Low 1d/m	\$0	\$0	Staff time	16
Issue: 2 - Council updates the community on coastal and lake management performance and share knowledge								
D2.1 Continue the Lake Macquarie environmental attitudes survey (every 4 years)	2-5	Council	Monitoring (One-off projects undertaken every 4 yrs)	Med 1d/w	\$0	\$0	\$20,000 Staff time	11
D2.2 Share the findings of coastal management (including research) projects more widely with the community	1	Council, Universities	Engagement (Ongoing)	Low 1d/m	\$0	\$0	Staff time	17

Management Action	Timing (years until commencement)	Responsibility (Lead) (Supporting Partner)	Type of action (One-off or ongoing)	Staff Resource Required	Indicative capital cost	Indicative maintenance cost	Indicative operational Costs (excluding staff time)	SDG (Sustainable Development Goal)
Issue: 3 - Providing more secure funding for coastal zone management into the future								
D3.1 Implement 'Actions to enhance the security of coastal zone management funding' as per Business Plan	2-5	Council	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time	16
D3.2 Increase understanding of the economic value of qualitative actions and services to aid in future viability analysis. (eg. ecosystem services of wetlands, wellbeing benefits)	2-5	Council	Planning (One-off)	Med 1d/w	\$0	\$0	Staff time	3, 9, 11, 14, 15, 16
Issue: 4 - Enhancing cultural involvement in coastal zone management								
D4.1 Collaborate with Aboriginal groups (including traditional owners and land councils) when planning works in, or developing plans for, the coastal zone	1	All	Engagement Planning (Ongoing)	Med 1d/w	\$0	\$0	Staff time only	17

Note: Where management actions are proposed on Crown land (including Crown waterways), authorisations and approvals may need to be obtained under the Crown Land Management Act 2016. With respect to works and activities that are proposed in the CMP, if they are to occur on Crown land and Council is the appointed Crown land manager, and the proposed works are consistent with the reserve purpose and a Plan of Management, then in most circumstances no other form of authorisation under the CLM Act will be required.

Management actions undertaken on Crown land will also need to consider Aboriginal Land Claims lodged under the Aboriginal Land Rights Act 1983. All activities relating to the use of Crown land must be consistent with the Commonwealth Native Title Act 1993 (NT Act).

4.4.2 Detailed Business Plan overview

A detailed Business Plan to support the CMP has been prepared by Umwelt, and is provided as Appendix 4.

Summary

The Business Plan shows how the CMP provides value to the community and the environment.

The CMP is a strategic program of actions to maintain and enhance the health and resilience of the natural systems of the city's coastal zone, while also recognising the strengthening social, cultural and economic value of the coastal zone to the people of Lake Macquarie.

Lake Macquarie is a city of more than 210,000 people. Investing in a healthy coastal environment within a major regional city and within easy reach of other large population centres sets up very significant social and economic values, based on the essential link between protecting healthy coastal systems and community lifestyle and wellbeing.

The community supports Council's approach to managing the lake, foreshores and the coast. Results of Council's community satisfaction surveys in 2020 and 2021 demonstrate very high community value placed on the natural landscape of the coastal zone and provide clear evidence of this nexus between a healthy coast and community wellbeing.

The value of implementing the CMP draws on 10 lines of evidence. The benefits accrue to the local environment, the local community and to the State of NSW, consistent with the objects of the CM Act.

The benefits and assurance of the certainty of benefits are linked to:

- **A demonstrated track record** of enhancing community lifestyle values by protecting and restoring natural systems, including restoring estuary water quality through effective catchment management
- **Value for the community.** A healthy lake underpins recreational amenity for diverse water-based activities and events, and enables economic development opportunities. Council explored this relationship in its 2021 Lake Activation Strategy
- **Value for the people of NSW.** The Lake Macquarie CMP is strongly aligned with NSW government priorities and rationale for protecting and restoring a healthy coastal zone. This includes land tenure and land use planning controls which support ongoing risk avoidance for development in the coastal zone

- **Community commitment and involvement.** One of the most expensive budget items supports Landcare projects which engage community volunteers to protect the health of lake side ecological communities. The CMP also fosters value through collaborative engagement with the people who live and work in the city, supporting an evidence-based, deliberative approach to complex coastal and land use planning issues where there is a high level of uncertainty and different perspectives.
- **Public investment in public land and for public benefit.** Almost the entire open coastline and 100km of 174km of lake foreshore are in public land management. Public benefits dominate the outcomes of CMP implementation.
- **Efficient use of Council resources,** targeted to real priorities for a coastal city with high lifestyle values and expectation of Council's environmental performance.
- **The CMP addresses high risks affecting the coastal zone as a priority** and provides an efficient pathway for mitigating risks to values
- **A program based and adaptive approach.** Right investment at the right time, across a spectrum of baseline data collection, technical and socioeconomic investigations, communications, detailed planning, on-ground works to protect coastal processes and to strengthen safe and sustainable public access and the monitoring and reporting that delivers accountability. Adaptive planning that recognises ongoing coastal change and is linked to thresholds of impact. Council has tested a range of natural defences for coastal hazards, on the lake foreshore and coastal dunes, and is continuing to develop natural options for estuarine creek banks.
- **Flexible and innovative longer-term funding mechanisms** are available to extend current resources. This includes investment inputs from public authorities when an action is their responsibility. Costs will be met by the right organisation. It may also include direct community contributions via reintroducing a version of the coastal environmental management levy, to offset the direct benefits to Lake Macquarie residents.
- **The value of partnerships.** Achieving more together.



These natural system, social and economic benefits are clear but qualitative. There is currently limited quantitative data which would enable dollar values to be placed on these benefits in a meaningful way. The CMP includes an action to work with the NSW Government to strengthen quantitative valuation of the environmental and community benefits of effective coastal management programs.

The capital, maintenance and operational (including staff resources) costs of implementing the Lake Macquarie CMP have been estimated over the one-year, four-year and 10-year time frames of Council's Integrated Planning and Reporting (IP&R) framework.

Twenty five per cent of the actions identified in the Implementation Plan will be the direct responsibility of Council, and a further group of actions will be led by Council but involve partnership with a public authority.

Approximately 75 per cent of the actions included in the CMP are non-capital items. Three significant capital items are staged protection works on the Redhead surf club building, asset upgrades and replacement of stormwater treatment devices (SQIDs), which are a key element of water quality management for the city's urban area, and coastal protection works to stabilise the Pelican foreshore alongside Swansea Channel. A separate cost benefit analysis was prepared for these engineering works in 2021.

Only 25 per cent of actions are associated with ongoing maintenance costs. Two key maintenance costs are supporting the function and efficiency of the network of SQIDs around the lake, and the cost of maintenance dredging to enable safe navigation of deep keel and larger cruising vessels through Swansea Channel.

Council's operational expenditure for coastal zone management is estimated to be around \$3-4 million a year for the next four-year period, i.e. the period of the current Implementation Strategy under IP&R. This figure includes staffing and delivery of projects such as lake health monitoring, dune and wetland rehabilitation works, community engagement activities, planning activities and research. Approximately 55 per cent of the actions in the CMP are ongoing actions where a continuing management commitment is required.

While the indicative cost of most operational activities is low to moderate (generally less than \$20,000 a year for individual actions) or is primarily staff time, a key implementation strategy for the CMP, with a high annual budget, is Council's support for Landcare. Council has allocated \$1.3 million a year to support Landcare activities across the city. This budget is for an integrated program across the entire city, not just within the coastal zone.

Other significant operational commitments include ongoing lake water quality/estuary health monitoring, including mapping and monitoring of sea grass (currently funded by the Marine Estate Management Strategy). This will be enhanced to provide good data about specific potential impact areas, such as around boat ramps, jetties and popular foreshore reserves. The CMP includes the update of some lake management framework documents such as the mooring management plan and the sustainable navigation dredging framework for Swansea Channel. These are key to balancing the natural and recreational values of the estuary.

Overall, the cost of Council staff to provide the services identified in the CMP, over the full life of the program is a significant part of the cost of sustainable management of the coastal zone and of the city's environment. Individually, more than 80 per cent of the actions in the CMP are anticipated to require low or moderate staff resource commitments, with staff being involved in investigations, communication, monitoring, stakeholder engagement, data analysis and project management.

Individual projects within the CMP that require more intensive staff resources include resilience and adaptive management planning for high-risk communities and the staff costs involved in maintaining beach accessways, dune protection and lake foreshore facilities.

Council's resourcing commitment is consistent with its responsibility for managing a large and complex coastal lake, multiple beaches and headlands, and the dynamic environment of Swansea Channel. All parts of the city's coastal zone are highly valued by the community, and there are high community expectations for effective management of the city's natural assets. Council's reputation for effective coastal management is linked to investment in resources for strong project management, adaptation, collaboration, communication and transparency.

Actions to enhance the security of coastal zone management funding

The following actions have been identified as potential means of increasing the availability and security of funding for Council's coastal zone management activities into the future.

- Investigate the introduction of Special Rate Variation to provide additional income for coastal zone management activities
- Investigate the introduction of a Stormwater Charge
- Continue to seek grant funds where appropriate
- Advocate for the Coast and Estuary Program funding (and other relevant funding programs) to be modified so grant guidelines provide for program level funding over longer terms, rather than short-term project level funding
- Where appropriate, include relevant coastal zone management actions in the review of Developer Contribution Plans to increase access to developer contribution funding
- Investigate a Coastal Protection Service Charge for funding of the maintenance of specific large-scale foreshore projects, particularly those in Swansea Channel
- Advocate for an expanded Coastal Protection Charge to fund new coastal and foreshore protection works (not just maintenance)
- Investigate and advocate for Crown Reserve Model to be utilised for lake and boating related programs
- Apply 'beneficiary pays' principles for foreshore and coastal protection projects that have a private benefit
- Continue to investigate emerging opportunities for additional income

4.5 Monitoring, evaluation and reporting program

The Lake Macquarie CMP is a program of on-ground works, monitoring, research and planning and engagement initiatives that targets the threats to the ecological and socio-economic values of the coastal zone. The CMP also includes actions directly aimed at improving recreational opportunities for the public, and targets coastal hazards within the coastal zone areas: coastline, estuary and Swansea Channel.

The Lake Macquarie CMP contains priority actions set out within the three coastal zone areas aimed at addressing the key threats to the coastal zone. Many of the actions are targeted towards improving ecological health, as this is the key to supporting the recreational, cultural and economic values of the coastal zone. Funding will be required for many of the actions, and will be vital for the success of the CMP.

There are action triggers relating to coastal hazards along the coastline (Table 8) and within the Local Adaptation Plan area (Table 7 and Figure 7) and the Coastal Zone Emergency Action Subplan (Appendix 5).

This subplan details locations vulnerable to beach erosion, coastal inundation and cliff instability hazards along the open coastline, and details actions during four phases of the emergency management cycle: prevention, preparation, response and recovery.

The Coastal Zone Emergency Action Subplan is to be reviewed within five years of adoption. Earlier review may be required:

- Following a coastal emergency and critical review of the CZEAS, as outlined in final action in recovery phase of the emergency management cycle (Figure 12 of appendix 5)
- After a review of the local, regional or State EMPLANS or relevant sub-plans that identify changes impacting the CZEAS
- If new/updated scientific hazard information becomes available



Annual review and reporting

Council currently implements a large number of environmental and sustainability initiatives reported in the annual Sustainability Report (previously known as the State of the Environment Report). This report describes progress on implementation of the various environmental and sustainability strategies and plans delivered by Council, including coastal zone management, and details the trends and conditions of key environmental condition indicators and progress towards meeting Council's adopted sustainability targets. This report also details Council's contribution to meeting relevant United Nations Sustainable Development Goals.

To ensure strong links with the local government integrated planning and reporting framework, key information from the Sustainability Report are incorporated into Council's Annual Report, adopted and published in accordance with provisions of the Local Government Act 1993.

The status of CMP implementation will be monitored and evaluated annually, and reported on by integrating into the existing reporting systems described above.

Five-year review

A review will be conducted after five years to measure the performance of the CMP managing and reducing threats to the ecological, social and economic values of the coastal zone area.

The main mechanism for determining whether the CMP has been successful is to re-evaluate the threats through a repeat of the threat assessment process.

10-year review

The Lake Macquarie CMP, and the need for additional supporting studies, will be reviewed every 10 years.

Internal monitoring and evaluation

An internal Coastal Management Working Group is recommended (Implementation Plan Action D1.1). This working group is to carry out a review of action status every quarter, aligning with other organisational quarterly reporting.

Results from the working group review are to be reported to the Coastal Zone Management Committee.

External review

An annual workshop in partnership with DPE, other agencies and community members will be conducted to review the implementation status of the CMP, identifying any barriers or challenges. Outcomes from this workshop are to be reported to the Coastal Zone Management Committee.

NSW Government and the NSW Coastal Council have a role to play in auditing CMPs. Details of this auditing framework are being developed.

Actions from the CMP Implementation Plan will be incorporated into Lake Macquarie City's Delivery Program and Operational Plans.

Council delivers an Annual Report to document progress with implementing Council's Delivery Program and Operational Plan activities over each financial year.

Business Plan and Finance review

The Implementation Plan and Business Plan reflects the expected cost of the CMP over the coming financial year and details the resourcing and financing arrangements to meet these costs. It also demonstrates the contribution from successful grant funding applications for specific actions, and the additional contribution required from Council.

The plan provides an avenue for bringing delayed actions into play. Through the Business Plan, the financial, resourcing or timing requirements for delayed actions can be modified, and forecasts adjusted to account for implementation of these actions over the coming or a future financial year. The Business Plan will be a key document for tracking success in grant funding applications and part or full contributions from Council. It is this financial success that will guarantee the implementation of the CMP.

As implementation of the CMP progresses, relevant sections of Council's business plans will be updated annually to reflect the budget for the CMP for each upcoming year, allowing relevant actions to be fed into the implementation process, and accounting for external grant funding awarded to implement CMP actions.

SECTION 5 - REFERENCES AND LINKS



Reference List

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Links to supporting studies

CZMP [CZMP](#)

Coastline Hazard and Risk Assessment - [Coastline Hazard and Risk Assessment](#)

Local Adaptation Plans (LAPs) [Marks Point & Belmont South LAP](#)

[Swansea and surrounds LAP](#)

Lake Activation Strategy [Lake Activation Strategy](#)

Surf amenity assessment [Blacksmiths surf amenity assessment](#)

State of Estuary State of the Estuary Report

Wave Overtopping [Wave Overtopping Assessment](#)

Water level analysis [Water Level Analysis](#)

Pelican Foreshore [Pelican Foreshore Stabilisation Project](#)

GLOSSARY

Accretion: Growth of coastal shorelines by steady addition of sediments.

Adaptation: Adjustments in natural or human systems in response to climate stimuli or their effects, which moderate harm or exploit beneficial opportunities.

Adaptive capacity: Ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities or to cope with the consequences.

Average Recurrence Interval (ARI) and Annual Exceedance Probability (AEP): Both terms are a measure of the rarity of a rainfall event, but can also be used to refer to the rarity of a storm event. The ARI is the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. The AEP is the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

Bathymetry: Refers to the depth of the ocean. A bathymetric chart will show the depths to the sea floor (and therefore the shape of the sea floor) at different locations.

Biodiversity: The numbers and relative abundances of different genes, species and ecological communities in a particular area.

Bluff or cliff: Coastal cliffs (especially steep and precipitous cliffs), steep rock and weathered rock slopes, headlands, hardened and cemented sand coastal slopes.

Breakwater(s): A constructed structure built offshore to protect coastal areas such as harbours from offshore waves.

Climate change: The long-term change (decades or longer) in pattern of weather, and related changes in oceans, sea level, land surfaces and ice sheets.

Climate projection: A projection of future climate based on simulation by climate models.

Coast: Generally used, with 'coastline', to refer to the actual shoreline where the sea meets the land.

Coastal hazard zone: The shoreline and hinterland areas determined to be at risk from coastal erosion or inundation. The zone is divided up as the Zone of Wave Impact and Slope Adjustment and Zone of Reduced Foundation Capacity for a given time period.

Coastal inundation: Flooding that occurs when waves overtop the frontal dune system, so that on or landward of low dunes is inundated by sea water. Some of these areas can also be flooded by rising lake waters. High lake water levels are influenced by catchment rainfall, accommodation capacity on local floodplains and the size/capacity of the lake entrance.

Coastal risk area: Any coastal area subject to coastal erosion, inundation or geotechnical hazard that has potential to negatively impact people or property. Coastal risk areas are generally identified in NSW for immediate, 2050 and 2100 planning periods.

Coastal zone: Extends from the continental shelf to as far inland as coastal processes (tides, wind-blown coast dunes) dominate. The NSW Coastal Policy defines this as including three nautical miles seaward of the mainland, one kilometre landward of the open coast high water mark, one kilometre around the shores of all bays, estuaries, lakes and lagoons and all tidal waters upstream to the limit of mangroves.

GLOSSARY

Coastal geomorphology: The physical structures, processes and patterns associated with the coast, including landforms, soil and geology and the factors that influence them.

Dredging: An underwater excavation activity intended to remove sediments and debris. Often used to keep navigable pathways within waterways.

East coast lows: Intense low-pressure systems that usually occur several times each year off the east coast of Australia. Severe east coast lows generate extreme water levels and high waves which drive coastal erosion.

Ecosystem services: Ecological processes or functions having monetary or non-monetary value to individuals or society at large.

Entrance management: Includes artificial opening of entrances, managing the configuration, height or location of the beach to enable entrance opening at a level lower than the natural range.

Erosion: The removal of land by natural forces such as waves, tidal currents and/or littoral currents.

Estuary: The section of a river affected by tidal activity where fresh water from the river mixes with salt water from the ocean.

Foreshore: The section of the shore between the low and high tidal limits.

Geomorphology: A branch of physical geography encompassing the formation of the earth's surface, distribution of land, water and other elements.

Native title: Native title or native title rights and interests means the communal, group or individual rights and interests of Aboriginal or Torres Strait Islander people in relation to land or waters, where the rights and interests are possessed under the traditional laws and customs observed by the Aboriginal or Torres Strait Islander people, and the Aboriginal or Torres Strait Islander people, by those laws and customs, have a connection with the land or waters; and the rights and interests are recognised by the Native Title Act 1993.

Ocean waves: Waves occurring in the ocean that have been generated from wind blowing over the ocean surface over long distances (known as the fetch of a wave, length of the fetch area is measured in the direction of the wind). Swell or incident waves on the coast typically have a wave period of eight to 10 seconds, with large storm waves having periods of 12 seconds or greater.

Riparian vegetation: Vegetation located along the banks of a body of water, usually rivers.

Scour: Localised loss of soil, often present around a foundation element.

Sea level rise: A long-term increase in mean sea level, usually associated with climate change and increase in temperature in particular.

Sedimentation: The settling of particles (e.g. sand or mud) out of the water column onto the bed of a water body.

Shoaling: The deformation of incident waves on the lower shoreface that starts when the water depth becomes less than about half of the wavelength, causing the waves to become steeper.

Tidal currents: Currents caused by the incoming (flood) or outgoing (ebb) tide. Tidal currents are typically the main current within estuaries, particularly in the entrance area where tidal currents transport marine sediments (sand).

Tide: The alternate rising and falling of the sea, usually twice in each day at a particular place, due to the attraction of the moon and sun.

Wetland: Areas of land that are partly saturated by water, including marshes and swamps.

Abbreviations

CMP	Coastal Management Program
CZEAS	Coastal Zone Emergency Action Sub-plan
DPE	Department of Planning and Environment
DCP	Development Control Plan
HWC	Hunter Water Corporation
IPCC	Intergovernmental Panel for Climate Change
IP&R	Integrated Planning and Reporting
LAP	Local Adaptation Plan
LEP	Local Environmental Plan
LGA	Local Government Area
LLS	NSW Local Land Services
LSPS	Local Strategic Planning Statement
MEMS	The Marine Estate Management Strategy
NPWS	National Parks and Wildlife Service
PHA	Probabilistic Hazard and Damages Assessment
SEPP	State Environmental Planning Policy
SQID	Stormwater Quality Improvement Device
SLR	Sea Level Rise
TfNSW	Transport for New South Wales
TARA	Threat and Risk Assessment Final Report (Marine Estate Management Authority)



