NSW NATIONAL PARKS & WILDLIFE SERVICE

Trial Bay Visitor Precincts

Coast and Foreshore Protection Strategy

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Cover photo: Trial Bay Gaol, Arakoon National Park. Jessica Robertson/DPE

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Trial Bay, in Arakoon National Park, is a key site and landscape feature within the NPWS Coastal Reserve System. Often described as the 'jewel in the crown' of the Macleay Valley Coast, it is widely acknowledged as one of NSW premier coastal visitor destinations. It is equally important to the local community who use Trial Bay's beach, foreshore and surrounding natural environment, for a range of recreational activities.

Trial Bay's primary visitor precincts are situated at the north-west termination of the park and incorporate an approximately one-kilometre long section of semi-protected coastline. Longshore coastal processes, combined with major storms and climate change, are eroding sections of the precinct's beach and foreshore requiring their periodic closure due to public safety concerns and the need for coastal recovery activities.

The Trial Bay Visitor Precincts Coast and Foreshore Protection Strategy, provides a framework to address these and other impacts consistent with stakeholder expectations. The strategy is a living document, highlighting the need for adaptive coastal management facilitated through ongoing learning, open and transparent stakeholder communication and evidence-based decisions. Through this approach it contributes to:

- increased recognition of Trial Bay as a visitor destination of regional, state and national significance
- better alignment of NPWS, other NSW government agencies and Kempsey Shire Council coastal management and planning activities
- ongoing protection of Trial Bay's natural and cultural values, as identified and confirmed by stakeholders
- evidence-based, proportionate actions to address local coastal hazards and risks.

Apart from providing a strategic framework for managing Trial Bay's beach and foreshore, the strategy also outlines the specific actions to be taken by the NPWS and partner organisations over the next 5 years and beyond. In deriving these actions consideration was given to the:

- financial and general resource capability of the NPWS
- natural variability of coastal geomorphic processes and their role in beach and foreshore development
- influence of Laggers Point Breakwater on coastline configuration, wave action in the embayment and longshore sand transport/deposition
- impact of stormwater drainage on foreshore stability
- need to balance natural, cultural, recreational and socioeconomic values, as confirmed by stakeholders
- potential overlaps in jurisdictional responsibilities and property boundaries
- integration of Indigenous cultural values into precinct planning and management.

Decisions relating to these considerations were informed through targeted stakeholder engagement facilitated through one-on-one consultations with key knowledge holders, separate community and technical advisory groups, and the public exhibition of the draft strategy. This comprehensive engagement also supported the successful delivery of key project components including a coastal hazard and risk assessment, development of a site-

based coastal adaptation framework and multi-criteria analysis of proposed management actions.

Strategy implementation will be staged, with actions prioritised according to need (i.e. immediate or future), the risk/s of not taking action, and funding availability. The strategy also acknowledges that some capital works may need to be fully, or partially, funded through external grants, such as those available to local councils under the NSW Coastal and Estuaries Grant Program, or through partner agreements between the NPWS, other NSW government agencies and the Kempsey Shire Council.

Along with its local application, the Trial Bay Visitor Precincts Coast and Foreshore Protection Strategy provides a practical, technically robust and adaptable template for developing similar strategies across the NSW Coastal Reserve System. This provides the NPWS with the opportunity to pro-actively manage current and emerging coastal hotspots where beach recession, foreshore erosion, coastal vegetation loss and infrastructure damage are expected to increase in scale and severity over the next decade.

Photo 1 Trial Bay Campground. Nick Cubbin/DPE (2014)

1. Project background and drivers

The NSW coastal zone contains natural, cultural and socioeconomic values of regional, state and national significance. Close to half of the NSW coastline is within reserves managed by the NSW National Parks and Wildlife Service (NPWS) under the *National Parks and Wildlife Act 1974.*

Trial Bay, in Arakoon National Park, is a key site and landscape feature within the NPWS Coastal Reserve System that has been identified for increased management focus. Often described as the 'jewel in the crown' of the Macleay Valley Coast, it is widely regarded as one of NSW premier coastal holiday destinations attracting thousands of visitors each year. It is equally important to the local community who use its beach, foreshore and surrounding natural environments for a range of recreational activities.

Trial Bay Visitor Precincts (TBVP), at the north-west termination of Arakoon National Park, are key hubs for recreational activity. Incorporating an approximately one-kilometre long section of semi-protected coast, their low-energy offshore zone and relatively sheltered aspect make them preferred locations for swimming, snorkelling, wind surfing and other aquatic-based recreational activities. The precinct's spectacular coastal landscape, historic ruins and abundance of visitor facilities, also ensuring their popularity amongst picnickers and other recreationists.

Over the past decade, coastal geomorphic processes, together with major storms, climate change and visitor activity, have eroded areas of TBVP beach and foreshore. This has led to safety concerns around foreshore stability, fallen trees and the collapse of beach access tracks, while also reducing the viability of coastal ecosystems through the loss of endemic vegetation and changes to local hydrology. Of equal concern, it has required the periodic closure of TBVP beach and foreshore areas, potentially tarnishing Trial Bay's reputation as a year-long holiday destination.

To date, actions to mitigate coastal hazards in TBVP have been mostly reactive, event based, and undertaken in relative isolation from other coastal protection recovery works. While of short-term benefit, this places the natural, cultural and socioeconomic values of TBVP at risk, specifically, when considering projected increases in the scale, severity and frequency of major storm events due to climate change.

The Trial Bay Visitor Precincts Coast and Foreshore Protection Strategy (the strategy) has been developed to pro-actively respond to these and other issues impacting TBVP beach and foreshore areas. This strategic approach responds to stakeholder requests for proportionate, balanced and evidence-based management interventions; it also aligns with the requirement for sustainable coastal management, as discussed in the NSW Coastal Management Manual and mirrored by the conservation objectives of the *National Parks and Wildlife Act 1974.*

The strategy complements regional initiatives for increasing visitation to the Macleay Valley Coast, including the Macleay Coast Destination Project, which aims to modernise and improve visitor facilities at Arakoon National Park. The works and measures outlined in the strategy, such as foreshore stabilisation, beach access improvements and coastal landscape enhancement, are planned to support this development.

In developing the strategy, the NPWS carefully balanced the expectations of the local community with current and projected visitor requirements. Consideration was also given to ensuring all stakeholder values were identified, comprehensively discussed and assessed, and assigned appropriate actions. This inclusive approach, supported by technical information, enabled the identification of coastal protection measures that, as best possible,

reflect the shared values of stakeholder values and the coastal management objectives of the NPWS.

Photo 2 Trial Bay Gaol and surrounding visitor precincts. Robert Mulally/DPE (2019).

2. Project setting

Trial Bay is part of the Arakoon National Park, situated near the townships of Arakoon and South West Rocks on the NSW Mid North Coast. TBVP comprise 2 parcels of land containing historically significant infrastructure such as gaol ruins, memorials and graves; the precincts are also recognised for their significant natural values and spectacular coastal landscape, which are drawcards for visitors to the area.

TBVP foreshore and immediate surrounding area form a naturally changing landscape that has been extensively modified by development. Laggers Point Breakwater, a relic of Trial Bay's colonial history, is a dominant feature of TBVP's built landscape, and is attributed to inter-decadal realignment of the Trial Bay shoreline.

Beach development in TBVP is influenced by longshore sand transport, wave and tidal action, and the buffering effect of Laggers Point Breakwater. This has resulted in the current pattern of onshore sand accretion and erosion, which has required the periodic closure of the precinct's beaches to public access. Rock walls south of the breakwater may have also influenced shoreline development, though to less degree.

In 2013, a coastal hazard study of the Macleay Local Government Area by BMT WBM Consultants, concluded TBVP main (front) beach is generally accreting, with its southern and eastern boundaries eroding. While further modelling is required to support this finding, a general pattern of sand deposition and erosion has been observed by NPWS staff and local residents over many years.

In addition to its beach and foreshore TBVP incorporate Runaway Creek, an intermittently closed and open lake or lagoon (ICOLL). Water entering and leaving the ICOLL through tidal movement and wave action is causing localised scouring of the coastline and erosion of

nearby foreshore. More active management of this and other coastal sites within TBVP has been a focus of the strategy.

Figure 1 Trial Bay Visitor Precinct.

The over-arching purpose of the strategy is to outline appropriate, cost-effective and evidence-based actions for mitigating the impacts of major storms, climate change and human activity on TBVP beach and foreshore areas. The strategy achieves this by providing a strategic framework for identifying, analysing and responding to local coastal issues, and aligning these with the following key objectives:

- to seed, grow and maintain stakeholder support for proposed coastal protection measures
- to facilitate adaptive coastal management through continuous learning, sharing of knowledge and evidence-based decisions
- to ensure NPWS coastal planning and management actions align with other NSW government agencies and the Kempsey Shire Council
- to mitigate the adverse impacts of coastal geomorphic processes, major storm events, climate change, and human activity and development, on beach and foreshore stability
- to inform NPWS investment decisions so Trial Bay remains a key recreational and tourism hub for the local Macleay Valley community, region and state.

The strategy has also been developed to meet the objectives for managing NSW national parks, as specified in the *National Parks and Wildlife Act 1974* (NPW Act), and the general provisions of the *Coastal Management Act 2016* (CM Act).

3. Legislative and planning context

Trial Bay, incorporating surrounding foreshore lands and infrastructure, was first reserved for public recreation in 1946. It was subsequently gazetted as a state recreation area in 1974 before becoming part of the Arakoon National Park in 2010. Park management is governed by the following legislative and planning instruments:

3.1 National Parks and Wildlife Act 1974

The NPW Act is the principle guiding legislation for managing NSW national parks and reserves. Key objectives of the NPW Act are summarised as:

- the conservation of nature
- the conservation of object, places or features of cultural value within the landscape
- fostering public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation
- providing for the management of land reserved under the NPW Act.

3.2 Coastal Management Act 2016

The CM Act establishes the strategic framework for managing coastal issues in New South Wales. Key objectives of the CM Act are summarised as:

- protecting and enhancing natural coastal processes and values
- supporting recognition of the social and cultural values of the coastal zone and maintain public access, amenity, use and safety
- acknowledging Aboriginal peoples' spiritual, social, customary and economic use of the coastal zone
- recognising the coastal zone as a vital economic zone and to support sustainable coastal economies

- mitigating the current and future risks from coastal hazards, taking into account the effects of climate change.

The NPWS undertakes coastal planning and management consistent with the NSW Coastal Management Framework and its statutory land management responsibilities, as defined under the NPW Act.

3.3 State Environmental Planning Policy (Coastal Management) 2018

The Coastal Management State Environmental Planning Policy (CM SEPP) is a NSW coastal planning instrument that supports and facilitates the CM Act. The CM SEPP defines four coastal management areas:

- coastal wetlands and littoral rainforests area
- coastal vulnerability area
- coastal environment area
- coastal use area.

Except for the Coastal Vulnerability Area, each of these areas are managed to objectives aligning with those of the CM Act.

3.4 NSW Heritage Act 1977

The *NSW Heritage Act 1977* provides for the identification and registration of items of Local or State heritage significance, and seeks to protect and conserve these items through the operation and establishment of the Heritage Council of NSW. Key objectives of the Heritage Act are summarised as:

- to promote understanding and encourage conservation of the State's heritage
- to provide for the identification and registration of items of local and state heritage significance
- to assist owners with the conservation of items of local and state heritage significance.

3.5 Arakoon State Recreation Area Plan of Management 1987

Under the NPW Act, a plan of management or statement of interim management intent is required for all lands designated as a national park or reserve, state conservation area or similar protected area managed by the NPWS.

The 1987 Arakoon State Recreation Area Plan of Management is the current planning document for Arakoon National Park and includes provisions for its care, control and sustainable use. The NPWS is developing a new plan of management for the park that will include new and updated actions, including those outlined in the strategy.

Photo 3 Trial Bay Campground. Robert Mulally/DPE (2019).

4. Cultural and historic setting

Arakoon National Park has Indigenous connections and historic associations which have shaped its present character. A description of these connections and associations is provided in sections 4.1 and 4.2.

4.1 Indigenous cultural connections

TBVP comprise the traditional lands of the Dunghutti Language Group. Prior to European settlement, the Dunghutti lived and moved through the Macleay Valley chasing the seasonal supply of food. Key sources of food included the Macleay River, South West Rocks Creek, Saltwater Creek and the Pacific Ocean, which supplied an abundance of fish and crustaceans. Edible dune vegetation also sustained Aboriginal people and communities over much of the NSW coast.

The Dunghutti have an enduring spiritual and cultural connection to Arakoon National Park. Trial Bay and Smoky Cape are sites of spiritual significance, having intimate association with sacred beings, such as Ulitarra, an important figure in North Coast Aboriginal creation stories. Sites of spiritual significance to the Dunghutti are also located near Trial Bay Gaol and at South West Rocks.

The Dunghutti Language Group has a unique, evolving connection to the land and sea Country comprising Trial Bay and Arakoon National Park. The NPWS acknowledges and respects this connection, and is committed to working with the Dunghutti on the management of Arakoon National Park in line with its Indigenous cultural values.

4.2 Historic cultural associations

The area colloquially known as Trial Bay was first reserved for public recreation in 1946 and incorporates Trial Bay Gaol and surrounding visitor precincts.

In 1974, Trial Bay Reserve was re-gazetted as the Arakoon State Recreation Area (with subsequent additions of Gap Beach, parts of Front Beach and Saltwater Lagoon over the next decade). Between 1974 and 1998, the state recreation area was managed by a local community trust. The management of the state recreation area was then transferred entirely to the NPWS. In 2002 the reserve became a state conservation area, and in 2010 it was re-gazetted as Arakoon National Park.

Trial Bay Gaol and Laggers Point Breakwater

Trial Bay Gaol is located on the eastern edge of Trial Bay, adjacent to Laggers Point. The gaol was constructed in the 1870s and was occupied as a public works prison (from 1876) and later an internment camp during World War One (from 1915). Not long after the gaol was abandoned, holiday makers commenced taking advantage of the site. The site was also used by local Aboriginal people for camping and hosting visitors. Trial Bay has been a popular holiday destination since the 1940s although it wasn't until the 1950s that visitors and locals began to more frequently venture beyond the town's borders to Trial Bay Gaol and Arakoon. Today, the gaol ruins form a picturesque historic site overlooking Trial Bay and the Pacific Ocean.

Laggers Point Breakwater, constructed from boulders quarried from Trial Bay Headland, only attained 20% of its originally planned length due to repeated damage from storms. The construction of the breakwater is attributed to major sand deposition in the embayment and on Trial Bay Front Beach, negating its use for deep harbour.

In 2010, Trial Bay Gaol, Laggers Point Breakwater and surrounding environments were listed in the NSW State Heritage Register for their historic heritage value.

Photo 4 Laggers Point Breakwater. Andrew Baker/DPE (April 2021).

Camping and day use

TBVP incorporate over 100 campsites suitable for tents, caravans and camper trailers. Popular camper activities include swimming, fishing, snorkelling and bush-walking.

Over the past 20 years whale-watching from vantage points near Trial Bay Gaol has increased Trial Bay's popularity adding to its reputation as a visitor destination of regional, state and national significance.

Trial Bay Campground is one of only a few campgrounds on the NSW coast facing west, providing relatively uninterrupted views of the setting sun.

Beach and foreshore access

Access to TBVP beach and foreshore areas is via Trial Bay Gaol Road and Trial Bay Campground, and the access road at the coastal termination of Cardwell Street. The campground is periodically fronted by sandy beach and has several defined beach access points, including ramps stairs.

While mostly associated with the township of South West Rocks, the area known as Main Beach, adjacent to the South West Rocks Surf Life Saving Club, provides the west most access to TBVP beach and foreshore areas.

Boat access to Trial Bay is provided by the Trial Bay Boat Ramp located behind the Laggers Point Breakwater.

Runaway Creek

Runaway Creek (or lagoon) is a small ICOLL (Intermittently Closed and Open Lakes and Lagoons) fringing the boundaries of TBVP camping and day use areas. The entrance to the lagoon is mostly closed, with intermittent breakouts during major storms opening it to Trial Bay.

The geomorphology of the lagoon and surrounding beach area is influenced by wave action, longshore sand drift and tidal processes. In the absence of major storm and tidal events, beach development at the lagoon entrance limits inter-tidal flushing contributing to the temporary inundation of camping and day use areas.

5. Planning and policy alignment

The strategy aligns with, and supports, other planning documents of relevance to Arakoon National Park and Trial Bay including:

5.1 Arakoon National Park Plan of Management

A new plan of management (PoM) is under preparation for Arakoon National Park. This statutory document will identify management priorities and actions to meet NPWS responsibilities under the NPW Act. Actions outlined in the strategy will support the new plan of management, specifically, in protecting beach and foreshore areas in TBVP.

5.2 Macleay Valley Coast Destination Project

The NSW Government has provided the NPWS with approximately $6.7 million to help implement the ‘Macleay Coast Destination Project’. Specifically, the project aims to ‘improve the range and quality of experiences offered to visitors, boost the regional visitor economy and contribute to community wellbeing’.

New nature-based and Australian heritage experiences will be developed under the project, including within TBVP, as well as the upgrade and replacement of visitor infrastructure such as walking tracks, picnic shelters, access roads, amenities and campsites and general site beautification.

The strategy will support this work, outlining measures for stabilising the foreshore and improving beach access in TBVP.

5.3 Kempsey Shire Coastal Management Program

The CM Act requires councils to develop a coastal management program (CMP) for relevant areas of the coast. The Kempsey Shire Council (KSC) has recently commenced this process, which will be informed by the management principles, objectives and requirements of the NSW Coastal Management Manual.

While the KSC CMP will focus on areas of coastline and assets managed by the KSC, collaboration with other coastal resource managers including the NPWS, NSW Crown Lands, Department of Primary Industry (Fisheries) and local Aboriginal land councils is required to facilitate integrated coastal zone management.

The strategy has been developed in advance of the KSC CMP and outlines actions of local and site-specific application. The KCS CMP will support the strategy (and vice versa) and is expected to include complementary actions for protecting one of New South Wale's most significant coastal sites.

5.4 Kempsey Coastal Zone Management Plan

The Kempsey Coastal Zone Management Plan (CZMP) 2016 meets the principles and objectives for integrated coastal management, as outlined in the NSW Coastal Management Manual. Key objectives for the Kempsey CZMP are:

- preserving the natural and rugged character of the Kempsey Coastline
- recognising and accommodating natural coastal processes and hazards, including sea level rise in the management of the coastal zone
- protecting the natural attributes of beaches, dunes, and undeveloped headlands, permitting only minor development for essential public purpose
- managing and reducing the risks to existing development and values
- preparing to manage future risks to existing development and values
- providing safe access within the coastal zone to the community and visitors.

The Kempsey LGA Coastal Zone - Coastal Management Plan 2016, will replace the existing Kempsey Coastal Zone Management Plan on finalisation in 2023, providing long-term direction for integrated coastal management on the Macleay Valley Coast.

6. Key issues and considerations

The strategy includes practical, cost effective and evidence-based actions for protecting beach and foreshore areas in TBVP. Issues and considerations informing these actions include:

6.1 Natural variability of coastal processes

Natural beach development is through a combination of wave action, tidal movement and longshore sediment deposition. Major storm events also contribute to the accretion and erosion of coastal sediment, influencing the profile and width of many beaches.

Beach areas in TBVP are subject to these and other coastal influences, occurring at various spatial and temporal scales. This is attributed to periodic changes in beach width and shape, periodically limiting their public access due to safety concerns.

The natural variability of coastal processes is a key consideration when determining actions for mitigating coastal hazards. Reactionary management to natural variations can result in poor outcomes and as such, mitigating actions must be carefully balanced with temporary changes to shoreline configuration and beach development.

Photo 5 **Beach erosion within Trial Bay Visitor Precincts has resulted in vegetation loss and the periodic closure of beach access points. Andrew Baker/DPE (2021).**

6.2 Influence of Laggers Point Breakwater on shoreline configuration

The construction of Laggers Point Breakwater more than 100 years ago altered the shape of Trial Bay Headland, changing local wave direction and sediment dynamics in the embayment. Along with the periodic impacts of major storm events, these processes are attributed to Trial Bay's current shoreline configuration that has historically demonstrated a pattern of accretion and erosion.

Though unsubstantiated, wave attack over many years is thought to have reduced the length and stability of the breakwater, resulting in a mostly erosional trend (refer Figure 2). This indicates the shoreline configuration of Trial Bay is closely linked to the length and shape of Lagger's Point Breakwater; a longer breakwater resulting in the shoreline's seaward alignment, and shorter breakwater emulating the prevailing coastline.

A fuller understanding of the impacts of breakwater length on shoreline configuration is critical to the sustainable management of TBVP. This relationship is discussed in more detail in Appendix 5.

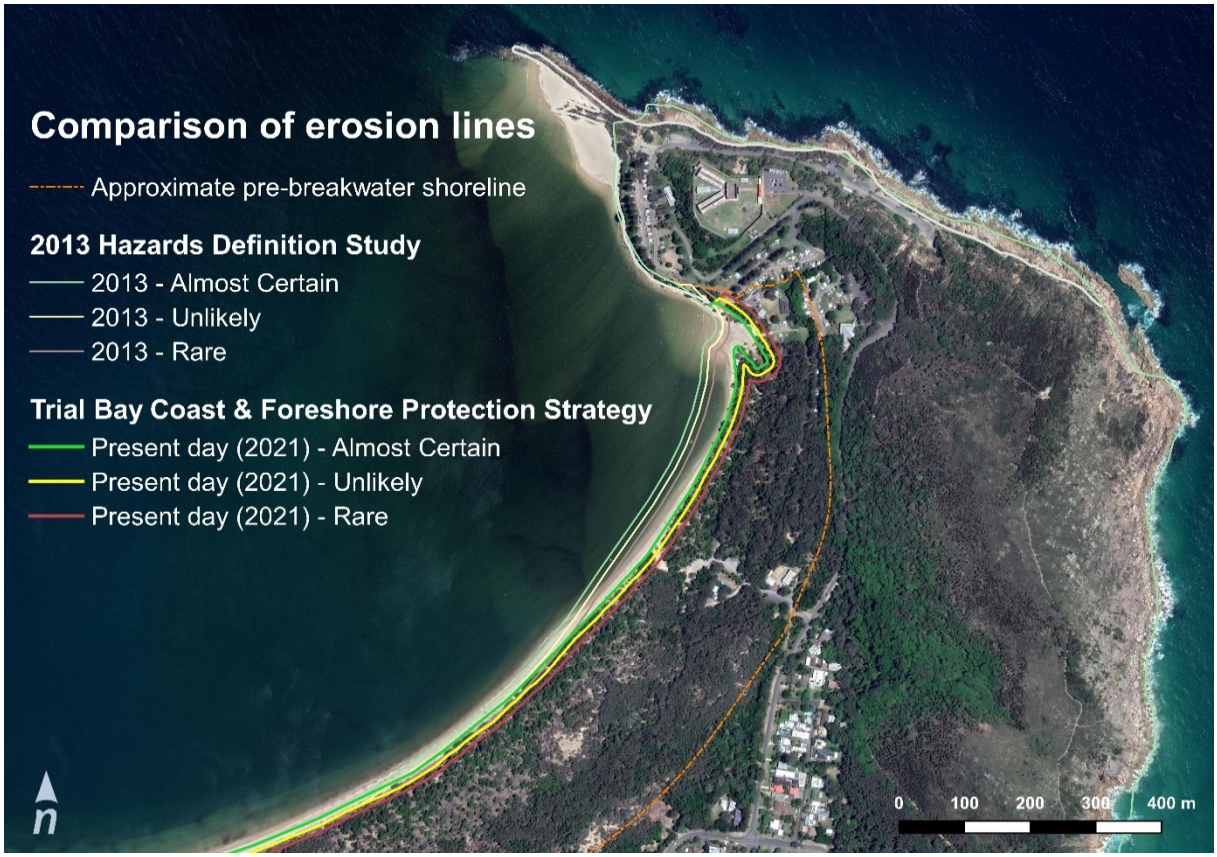


Figure 2 **Estimate of pre and post breakwater shoreline configuration using erosion line modelling. Alluvium Consulting (2021).**

6.3 Stormwater drainage and foreshore stability

Recent heavy rain has contributed to landslips in and adjacent to TBVP. These included a major slip near the eastern wall of Trial Bay Gaol which led to temporary closure of the access road to the seafront day use area. Stormwater runoff from Runaway Creek has also caused localised erosion of nearby foreshore areas threatening built assets.

NPWS recently commissioned a stormwater drainage study to identify opportunities for improving TBVP drainage system. Matters for design consideration include stormwater (incorporating groundwater) impacts on geo-stability, the hydrodynamic characteristics of Runaway Creek and associated catchment, the potential implications of redirecting overflow from Overshot Dam into the creek (or ICOLL), and public safety issues.

6.4 Assessing and prioritising values

TBVP incorporate natural, cultural and socioeconomic values of regional, state and national significance. While desirable, the presence of these values presents management challenges, including which values to prioritise, and on what basis.

The strategy considers these complexities and gives equal standing to each of the values identified and shared by stakeholders. Key aspects for planning consideration included:

Understanding the environmental setting

Beach and foreshore areas in TBVP are relatively sheltered environments distinguishing them from more exposed coastal sites where the impacts of wind, high-energy wave action

and aspect make them less desirable. For these reasons, Trial Bay is a preferred coastal location for thousands of people each year, providing year-long access for a wide range recreational activities.

TBVP's favourable environmental setting is enhanced by its spectacular coastal landscape and features which include:

- a dune system formed as the shoreline accreted on construction of the Laggers Point Breakwater and which contains endemic vegetation communities used by native animals
- runaway Creek, a relatively clean ICOLL providing habitat for adult and juvenile fish
- a low-energy surf zone, making it suitable for all ages to recreate and providing the living conditions for inter-tidal and macro-benthic fauna.

Photo 6 Stormwater runoff from Runaway Creek has caused erosion threatening built assets. Andrew Baker/DPE (2021).

Managing for sustainable visitor use

Trial Bay has been a popular destination for local recreationists and visitors for decades. This popularity is unlikely to wane with people's desire to connect with the natural environment expected to increase over time.

While tourism to coastal areas brings economic benefits, projected increases in annual visitation and associated impacts warrant strategic consideration. Poorly managed visitation can result in traffic congestion, over-crowding, a proliferation of rubbish, and land degradation; it can also lead to user conflict, in particular, between day-use visitors and campers, and adverse changes to the natural and cultural landscape.

Heavily patronised areas of TBVP, such as the foreshore and immediate surrounds and campground, are highly susceptible to visitor impacts. Similar concerns can be extended to sections of Trial Bay Front Beach where future changes in shoreline configuration may reduce the space available for recreational activities.

Resolving jurisdictional accountabilities

Resolution of land tenure, asset accountability and jurisdictional responsibilities is critical to the integrated and sustainable management of beach and foreshore areas in TBVP.

Currently, jurisdictional accountabilities and property boundaries are unclear and, in some cases, are demarcated by mean high water level (MHWL). For example, the NPWS has jurisdictional responsibility for Front Beach above the MHWL, whereas the intertidal zone is Crown Land managed by Kempsey Shire Council. This is contributing to management

complexities which are exacerbated by open public access to TBVP beach and foreshore areas.

Ownership of Laggers Point Breakwater and associated management accountabilities are key points of conjecture amongst local and state agencies. A recent property and boundary review by the NPWS has determined the breakwater is not within the gazetted boundaries of Arakoon National Park. A request to confirm this finding has been lodged with NSW Crown Lands with its determination pending.

Integrating cultural land management principles into precinct planning

The Dunghutti Language Group is the traditional owner of the land on which TBVP are located. The strategy acknowledges and respects the enduring connection of the Dunghutti and their descendants to the land and waters of Trial Bay, and outlines actions to facilitate their ongoing involvement in managing TBVP. This includes ongoing recognition of TBVP Indigenous cultural significance, the ongoing and authentic engagement of Dunghutti representatives in key planning decisions, and the employment of Aboriginal people in coastal resource management.

7. Key strategy components

Development of the strategy involved the following key components:

7.1 Comprehensive and inclusive stakeholder engagement

The actions outlined in the strategy were informed by stakeholders. This was facilitated through one-on-one conversations with key knowledge holders, structured meetings with separate community and technical advisory groups, and the public exhibition of the strategy.

This inclusive engagement process was integral to meeting local community aspirations and ensured the strategy considered the full range of issues, opportunities and management constraints of relevance to TBVP.

The ‘Trial Bay Visitor Precincts Coast and Foreshore Protection Strategy Community Reference Group’ (CRG) comprised representatives of key community groups including the South West Rocks Figtree Descendants Aboriginal Corporation, South West Rocks Aboriginal Corporation, South West Rocks Dune Care and the South West Rocks Surf Life Saving Club.

The ‘Trial Bay Visitor Precincts Coast and Foreshore Protection Strategy Technical Reference Group (TRG) comprised coastal specialists and representatives of the NPWS Hastings Macleay Area, Department of Planning, Industry and Environment (Fisheries and Biodiversity and Conservation divisions), Transport NSW and the Kempsey Shire Council.

Summaries from stakeholder engagement workshops are provided in Appendix 4.

Table 1 Summary of engagement activities

Stakeholder	Initial outreach	1st Stakeholder workshop	2nd Stakeholder workshop	Public exhibition of draft strategy	Final presentation to stakeholders
Community Reference Group	✓	✓	✓	✓	✓
Technical Reference Group	✓	✓	✓	✓	✓
Other identified stakeholders	✓			✓	✓

7.2 Coast and foreshore hazard assessment

A coastal hazard assessment was undertaken to determine areas of TBVP beach and foreshore where coastal protection and recovery works were required. Key elements of the assessment included reviewing known coast and foreshore hazards, and hazard lines, against newly captured data, and the re-analysis of local and regional coastal geomorphic processes. A copy of the TBVP Coastal Hazard Assessment is provided at Appendix 5.

Outcomes of the assessment were used to inform the design of proposed coastal hazard protection and recovery works; they also provided the NPWS with improved understanding of the impacts of climate change, major storm events, and natural variations in coastal processes on TBVP built and natural assets and related management considerations. Key findings of the assessment were:

- Shoreline recession, particularly Front Beach, has increased over the past decade with shoreline realignment of approximately 30 m recorded in the precinct's eastern-most corner. This pattern of recession indicative of the incremental loss of sand from the broader beach profile over many years.
- Based on recent observations and data analysis the coastal hazard extent, as identified in the Kempsey Coastal Processes and Hazard Definition Study (BMT, 2013), has potentially under-estimated the erosion risk to the eastern part of Trial Bay Front Beach by approximately 30 m. This supports the revision of coastal hazard lines in the eastern section of the TBVP shoreline, noting that changes to western coastal hazard lines are not required.
- Laggers Point Breakwater is the key control point for shoreline alignment in Trial Bay and, together with other factors, is responsible for accretion of approximately 200 m at its widest point. Ongoing degradation of the breakwater is likely to change current patterns of sand accretion and contribute to further recession of TBVP beach areas. Under worst-case scenario this may lead to the shoreline returning to its pre-breakwater alignment.
- Recent observed changes to shoreline alignment are attributed to a combination of factors including:
    - long-term climate variability and changes to local wave dynamic, potentially impact beach equilibrium and profile
    - changes in the volume of longshore sediment deposition near Laggers Point, which is thought to have reduced the overall amount of sand within the embayment
    - sand distribution on offshore banks leading to localised changes in wave action and coastal eddying
    - changes in the shape and size of Laggers Point Breakwater.

Figure 3 models the coastal processes shaping the Trial Bay shoreline.

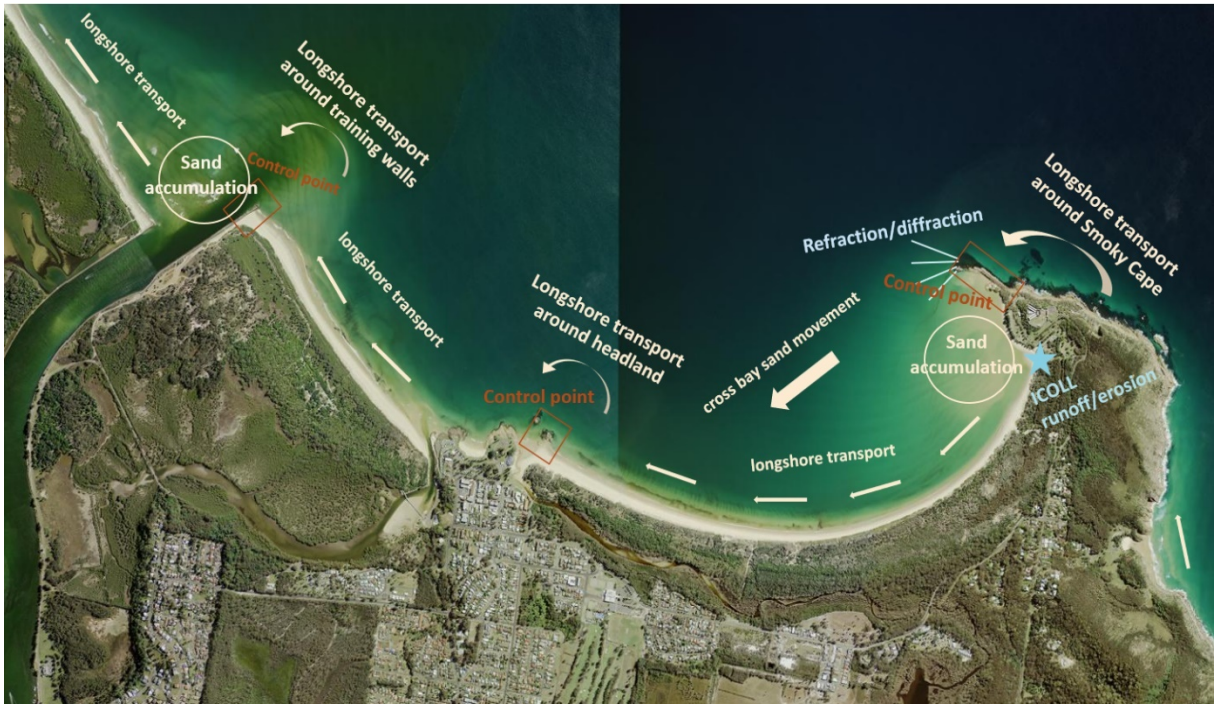


Figure 3 Conceptual model of Trial Bay coastal processes. Alluvium Consulting (2021).

7.3 Coastal hazard risk assessment

A coastal hazard risk assessment was completed to establish the comparative risk profile of built and natural coastal assets in TBVP (refer Appendix 6). Key elements of the assessment included:

- defining the appropriate risk assessment components
- identifying and assessing (likelihood versus consequence) coastal hazard risks
- mapping of built and natural assets at risk across the project area.

Assets considered in the assessment were sourced from the NPWS Assets Geo-database. Other data, such as vegetation community extent, was collected from publicly available datasets on the NSW SEED Data Portal.

For the purpose of the strategy, TBVP coast and foreshore (including immediate surrounding area) assets were broadly categorised under the following themes:

- visitor infrastructure
- services and utilities (e.g. roads, electricity)
- non built (environmental) assets including beaches, dunes, coastal vegetation etc.
- historic and indigenous

Following this action ‘at-risk coastal assets’ were identified for each theme, assessed for their hazard risk and assigned a level of consequence. Subsequently, the outcomes of these processes were used to establish a unique risk profile for each at risk coastal assets over the short, medium and long term. Key outcomes of the coastal hazard risk assessment were:

- identification of coastal hazard risks for key built and natural coastal assets in TBVP over multiple planning horizons
- determination of consequence risk profiles for identified built and natural coastal assets (see above)

- enhanced understanding of the evolving coastal hazard risk profile for different beach and foreshore areas in TBVP
- critical information to inform the design of proposed coastal hazard protection works in TBVP, and the likely consequence of not taking action.

Photo 7 Picnic shelter overlooking Trial Bay. Nick Cubbin/DPE (2014).

Table 2 Trial Bay Visitor Precincts risk consequence categories

	Community and lifestyle			Environment	Place and planning			
	Lifestyle	**Access**	**Public safety**	**Environmental values**	**Aboriginal cultural landscapes**	**NSW State Heritage**	**Property**	**Lifestyle**
Consequence	Considers elements of lifestyle such as community services, recreational and social activities, cultural connection, and day to day business activities.	Considers access for recreational activities such as beachgoing, swimming, boating and fishing, as well as access to areas used for cultural/ ceremonial sites.	Considers threats to human health and safety such as injury, disease, mental and physical wellbeing.	Considers elements such as ecological values, ecosystem services, and cultural and traditional uses. Factors considered include the scarcity and natural resilience of ecosystem types.	Specific consideration of Aboriginal cultural values and the ability to maintain and pass on traditional knowledge and practices to future generations.	Considers the threat of damage to assets and values associated with significant heritage value including those listed on local, regional, and State Heritage Registers.	Considers the threat of damage to built assets and any interdependencies such as access and ability to deliver critical services. Considers factors such as relocatability and replacement value.	Includes existing business and potential economic growth opportunities, especially for locally owned and operated enterprises.

	Community and lifestyle			Environment	Place and planning			
	Lifestyle	**Access**	**Public safety**	**Environmental values**	**Aboriginal cultural landscapes**	**NSW State Heritage**	**Property**	**Lifestyle**
Catastrophic	Widespread semi-permanent impact (~1year) to highly utilised community services, wellbeing, or culture of the community with no suitable alternatives.	Widespread and permanent impact on access to key sites and activities. Recovery unlikely.	Loss of lives and/or permanent disabilities.	Severe and widespread, permanent impact on multiple regionally or nationally significant environmental values of the region. Recovery unlikely.	Severe and widespread, permanent impact on multiple sites of cultural significance, including loss of land, connection to land, and ability to continue traditional practices. Recovery unlikely.	Severe and widespread, permanent impact on multiple sites of Heritage significance including loss of heritage materials and function. Recovery unlikely.	Widespread major damage or loss of property or infrastructure with total value >$500,000. Full recovery/repair may take many years.	Regional economic decline, widespread business failure and impacts on state economy.

	Community and lifestyle			Environment	Place and planning			
	Lifestyle	**Access**	**Public safety**	**Environmental values**	**Aboriginal cultural landscapes**	**NSW State Heritage**	**Property**	**Lifestyle**
Major	Major widespread long-term (~1 month) disruption to well-utilised services, wellbeing, or culture of the community with very few alternatives available.	Severe and semi-permanent impact on access to key sites and activities requiring significant works to restore access.	Widespread serious injuries/ illnesses.	Severe and widespread semi-permanent impact on one or more regionally or nationally significant environmental values of the region. Full recovery may take many years.	Severe and widespread semi-permanent impact on one or more sites of cultural significance, including loss of land, connection to land, and ability to continue traditional practices. Full recovery may take many years.	Severe and widespread semi-permanent impact on one or more sites of Heritage significance including loss of heritage materials and function Full recovery may take many years.	Major damage or loss of property or infrastructure with total value >$100,000. Full recovery/repair may take several years.	Lasting downturn of local economy with isolated business failures and major impacts on regional economy.
Moderate	Minor medium to long-term (~1 week) or major short-term disruption to moderately utilised services, wellbeing, or culture of the community with limited alternatives.	Medium impact on access to key sites and activities requiring some works to repair or restore access.	Isolated serious injuries/illnesses and/or multiple minor injuries/ illnesses.	Substantial impact on one or more locally significant environmental values of the region. Full recovery may take several years.	Substantial impact on one or more sites of local cultural significance. Full recovery may take several years.	Substantial impact on one or more sites of local Heritage significance including damage to heritage materials and function. Full recovery may take several years.	Moderate - major damage to property or infrastructure with total value >$50,000. Full recovery may take less than 1 year.	Significant impacts on local economy and minor impacts on regional economy.

	Community and lifestyle			Environment	Place and planning			
	Lifestyle	**Access**	**Public safety**	**Environmental values**	**Aboriginal cultural landscapes**	**NSW State Heritage**	**Property**	**Lifestyle**
Minor	Small to medium short-term disruption (~1 day) to moderately utilised services, wellbeing, finances, or culture of the community with some alternatives available, or more lengthy disruption of infrequently utilised services.	Small short-term disruption of access to key sites and activities which may require minor works to repair or restore access.	Minor and isolated injuries and illnesses.	Small, contained and reversible short-term impact on isolated ecosystem services and natural features of the region. Full recovery may take less than 1 year.	Small, contained and reversible short-term impact on sites of cultural significance. Full recovery may take less than 1 year.	Small, contained and reversible short-term impact on sites of cultural significance. Full recovery may take less than 1 year.	Minor damage to properties or infrastructure with total value >$25,000.	Individually significant but isolated impacts on local economy.
Insignificant	Very small short-term disruption (~1 hour) to services, wellbeing, finances, or culture of the community with numerous alternatives available.	Very little to no impact on access to key sites and activities.	Negligible injuries or illnesses.	Little to no environmental impact.	Little to no impact to sites of cultural significance.	Little to no impact to sites of cultural significance.	Minimal damage to properties or infrastructure with total value <$2,500.	Minor short-term impact on local economy.

7.4 Coastal adaptive management

Contemporary natural resource management is underpinned by an adaptive approach incorporating the need for flexibility and continuous improvement. In a coastal management context this approach has become increasingly important as managers strive to balance stakeholder expectations with an ever-changing coastal environment and finite resources.

A key principle of adaptive management is that some management options are only viable once a certain hazard threshold is triggered. Managers must therefore understand the evolving risk profile of the area/asset and effectively communicate this to stakeholders. After this, relevant parties are appropriately placed to establish and agree to a threshold which, once crossed, triggers a management response.

The NSW Coastal Management Manual advocates 'adaptive management' in coastal planning and management. Under the manual, planning for adaptive coastal management is typically undertaken using one or a combination of the following approaches:

- alert – stay informed of likely coastal impacts
- avoid future impact – reduce the future exposure of natural and built assets to coastal change
- planning for change – accept the dynamic nature of coastal landscapes and incorporate appropriate measures into planning and management
- active intervention – take action or measures to mitigate known impacts
- emergency response – initiate immediate action to address emergency situations.

The strategy incorporates elements of all approaches and aligns with relevant NSW planning legislation (refer Table 3). Importantly, it provides a decision-making framework for meeting stakeholder expectations, including maintaining Trial Bay as a key NSW site for passive beach and water-based recreation.

Photo 8 Eastern grey kangaroo, with sunset over Trial Bay. Nick Cubbin/DPE (2014).

7.4.1 Local application

Trial Bay is a relatively 'low-energy coastal system' making it well-suited to appropriately scaled, proportionate and environmentally sustainable coast and foreshore interventions. Commonly, these interventions are unsuitable for more open/exposed areas of the coast where their economic and practical viability are limited.

The strategy is based on the principle of 'no regret' where today's actions are compatible with future coastal adaptation scenarios. It also acknowledges that in some instances the need for action has been established and that active intervention over the short-term is required.

In cases where short-term intervention is not appropriate, the Alert (or monitor) approach has been recommended. This recognises that while the option to do nothing and 'let nature take its course' is not viable in the medium to long term, it may, however, be a suitable approach while the extent and variability of coastal change is further examined.

Table 3 Trial Bay Visitor Precincts coastal adaptation objectives

	Public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation is fostered.
	Habitat, ecosystems and services and biological diversity are conserved.
	Safe and easy access for a wide range of recreational activities is maintained and enhanced.
	Public day use areas including beaches, foreshores and surrounds are managed.
	Public safety risks to local recreation users and visitors are minimised.
	The State Heritage values of the precincts are maintained and protected.
	The economic viability of the precincts is maintained for NPWS and local community.
	First Nation's people's spiritual and customary use of the precincts is acknowledged and their ongoing access facilitated.
	Natural coastal processes and values, including natural landscape amenity are preserved.

7.4.2 TBVP adaptation zones

For the strategy, TBVP comprise 2 geographically-linked management areas defined by values, use, and exposure to coastal hazards. These are the Front Beach and Campground Foreshore (refer Figure 4). Both of these areas were assessed under different adaptation scenarios over multiple planning horizons. Careful assessment of the evolving risk profile for each area was also undertaken using information sourced from the Coastal Hazard Risk Assessment (Appendix 6). The recommended adaptation approach for each area is outlined in Table 4.

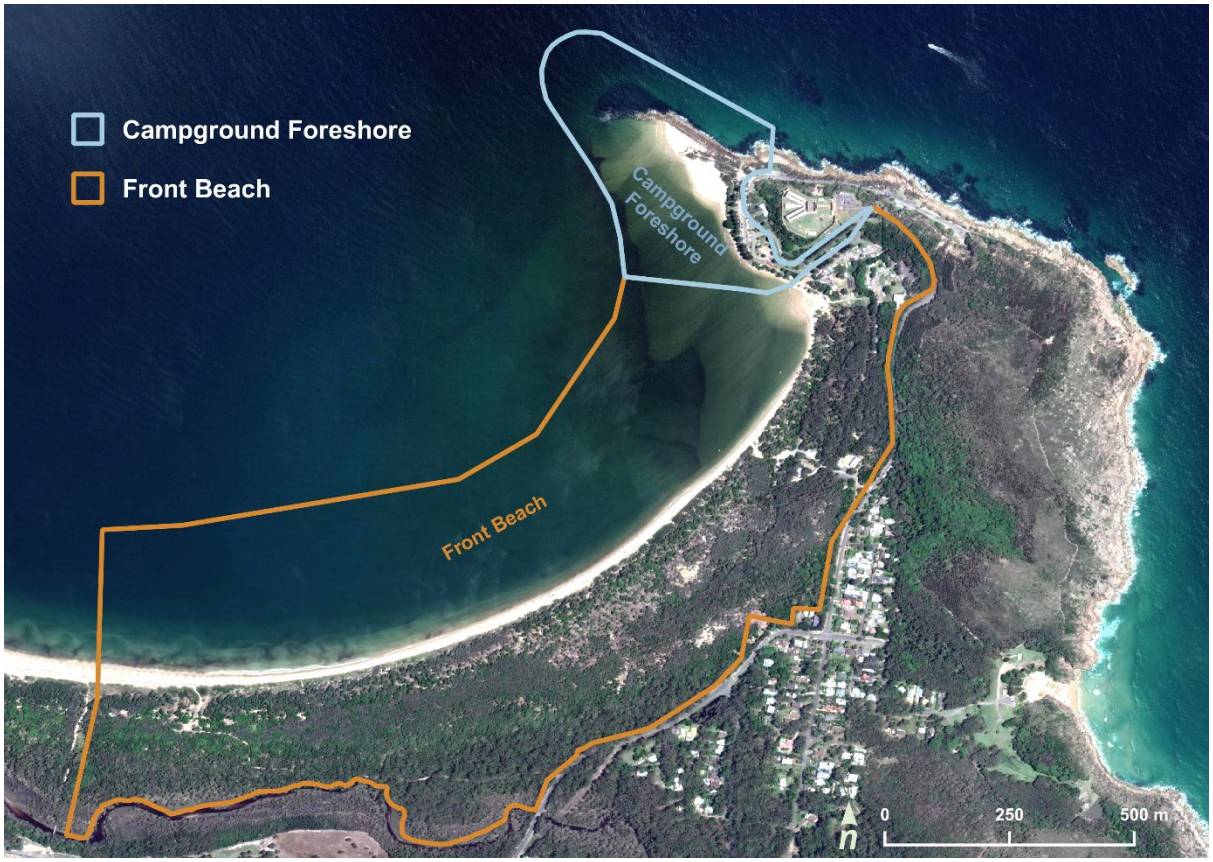


Figure 4 Trial Bay Visitor Precincts adaptation zones. Alluvium Consulting (2021).

Table 4 Trial Bay Visitor Precincts management areas – adaptation approach

	Present Day	2050	2100
Campground foreshore	**Alert: Active intervention** This section of the shoreline is relatively stable and low risk. However, the constructed rock seawall along the shore and multiple beach access points should be monitored and maintained. It is likely that the beach width will grow and shrink due to natural variability. Access points should be safe in all conditions. Installing non-relocatable assets and land uses requiring infrastructure and utilities services should be avoided. The existing campsites closest to the shoreline are currently protected by the seawall. An emergency response should be developed in case of severe wave overtopping, land slip, or other hazards threatening public safety.	**Alert: Active intervention – planning for change** Monitoring should be focused on the condition of the seawall and access points. Active intervention in the form of maintenance and repairs of the seawall is appropriate. Should the impact of coastal hazards reduce the effectiveness of the existing sea wall, this may trigger options for enhanced coastal protection works or relocating assets and changing land uses.	**Alert: Active intervention - planning for change** Monitoring should be focused on the condition of the seawall and access points. Active intervention in the form of maintenance and repairs of the seawall is appropriate. Should the impact of coastal hazards reduce the effectiveness of the existing sea wall, this may trigger options for enhanced coastal protection works or relocating assets and changing land uses.
Front Beach	**Alert: Active intervention** This section of the shoreline is exposed to coastal hazards including erosion of the beaches and dunes and inundation in Runaway Creek, however, there are few built assets at risk. The beach and dune system itself is considered an important asset and actions to enhance beach amenity are appropriate.	**Alert: Active intervention - planning for change** Increased erosion can be expected, potentially threatening built assets. A key consideration is the condition and effective length of the Lagger's Point Breakwater. If it continues to degrade, increased erosion and shoreline recession is likely. Continued active intervention or plans to relocate assets and transition the land use of some campground areas may become more appropriate.	**Alert; Active intervention - planning for change** Increased erosion can be expected, potentially threatening built assets. A key consideration is the condition and effective length of the Lagger's Point Breakwater. If it continues to degrade, increased erosion is likely. Continued active intervention or plans to relocate assets and transition the land use of some campground areas may become more appropriate.

7.5 Multi criteria analysis of proposed actions and measures

Multi-criteria analysis (MCA) is an accepted form of evaluation in which project/management components are assessed against multiple, pre-determined criteria such as cost, viability, social impact and environmental benefit. In contrast to other methods of analysis, this enables the pre-determined value of relevant components to be quantified, and findings used to support decisions.

For the strategy a high-level multi-criteria analysis was undertaken to establish the relative benefits of the different coastal adaptation options under consideration. The results of the MCA are summarised in Table 5.

'Strategic' and 'Implementation' criterion formed the basis of the MCA. Strategic Criterion aligns with identified adaptation objectives and was informed by NPWS management aims and the values identified and confirmed by stakeholders. Implementation Criterion relates to elements of implementation including cost, adaptability to different climate change scenarios, ease and likelihood of obtaining development approvals, and their effectiveness in reducing risk.

In addition to these processes, stakeholder feedback was used to test the suitability of proposed adaptation options. This included one-on-one and group engagement with key stakeholders, where the preliminary outcomes of the MCA were discussed and management preferences identified (refer Appendix 4).

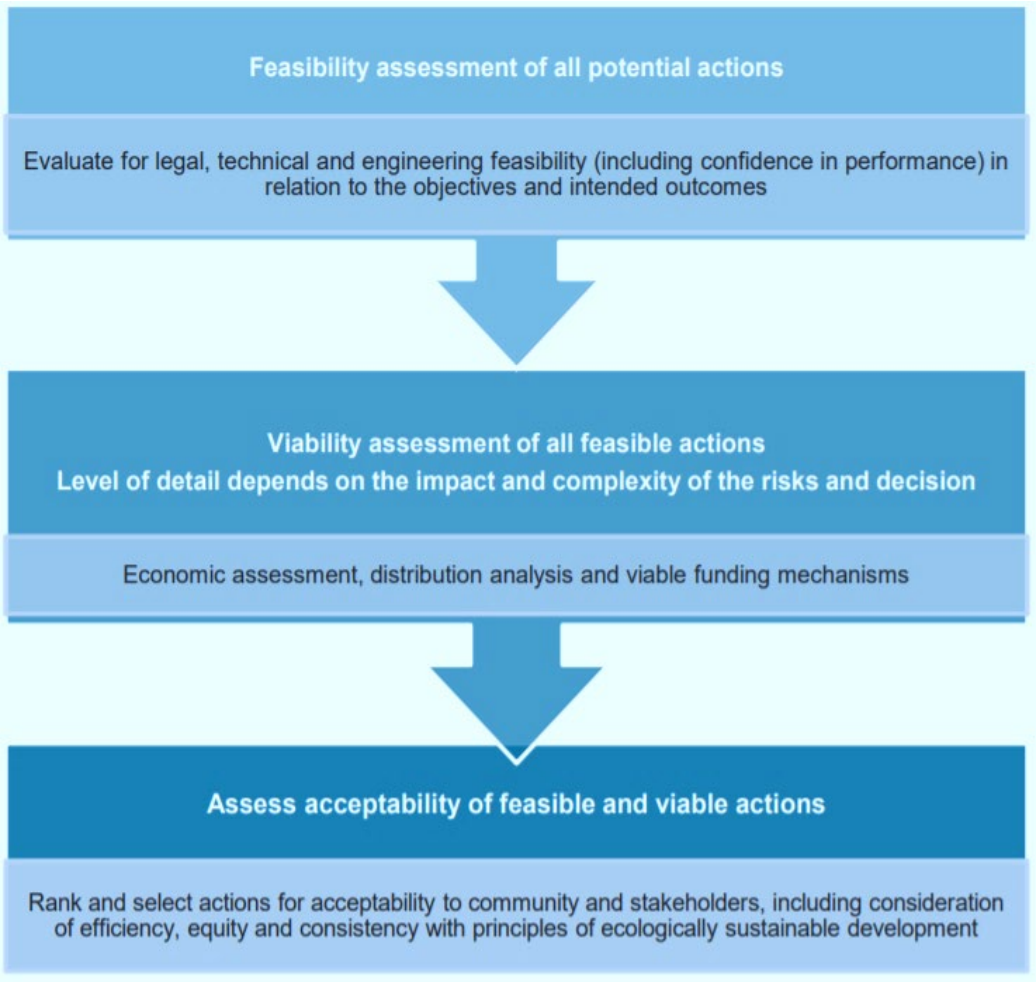


Figure 5 Screening of preliminary adaptation options. Alluvium Consulting (2021).

Table 5 Multi-criteria analysis of Trial Bay Visitor Precincts coastal adaptation options

Management preferences	Watch and wait (do nothing)	Dune management	Managing public access	Modify assets to increase resilience	Beach scraping	Beach nourishment	Extend/repair breakwater	Seawalls and revetments	Groynes	Offshore reefs	Sand bypassing and back passing systems	ICOLL entrance training	ICOLL berm management	Foreshore levees to prevent inundation	Improve/redesign stormwater drainage	Relocate assets and alter land use
Adaptation objectives																
Public enjoyment of nature and cultural heritage	N	M	M	M	E	E	E	E	E	M	E	E	E	E	E	M
Habitat and ecosystem conservation	E	E	E	M	E	E	E	M	M	M	M	M	E	N	E	E
Safe and easy access for recreational activities	N	E	E	E	E	E	E	M	E	E	E	E	E	M	E	E
Maximise day use areas including dry sandy beach	N	M	M	M	E	E	E	M	E	E	E	E	E	M	E	E
Public safety	N	E	E	E	E	E	E	M	M	M	E	E	E	E	E	E

Management preferences	Watch and wait (do nothing)	Dune management	Managing public access	Modify assets to increase resilience	Beach scraping	Beach nourishment	Extend/repair breakwater	Seawalls and revetments	Groynes	Offshore reefs	Sand bypassing and back passing systems	ICOLL entrance training	ICOLL berm management	Foreshore levees to prevent inundation	Improve/redesign stormwater drainage	Relocate assets and alter land use
Maintain NSW State Heritage values	M	E	E	E	E	E	M	E	M	M	M	M	E	E	E	E
Maintain economic viability of site	N	E	E	E	E	M	E	E	E	E	E	E	E	E	E	M
Aboriginal Peoples connection and access to Country is acknowledged and maintained	M	E	E	M	E	E	M	M	M	M	M	M	E	M	E	E
Preserve Coastal processes and values	E	E	E	M	M	E	M	N	N	M	E	M	E	N	E	E

Management preferences	Watch and wait (do nothing)	Dune management	Managing public access	Modify assets to increase resilience	Beach scraping	Beach nourishment	Extend/repair breakwater	Seawalls and revetments	Groynes	Offshore reefs	Sand bypassing and back passing systems	ICOLL entrance training	ICOLL berm management	Foreshore levees to prevent inundation	Improve/redesign stormwater drainage	Relocate assets and alter land use
Implementation criteria																
Cost	E	E	E	M	M	N	N	N	N	N	N	M	E	N	M	M
Climate adaptability	M	M	M	M	M	M	M	M	N	N	M	M	M	M	E	M
Ease of obtaining approval	E	E	E	E	E	M	M	N	N	N	N	M	M	N	E	M
Erosion	N	M	M	M	M	E	E	E	E	E	E	E	M	M	E	E
Inundation	N	M	M	E	M	M	M	M	E	M	M	E	E	E	E	E
Feasibility																
Campground foreshore	N	N/A	E	E	M	E	E	E	N	M	M	N/A	N/A	E	E	E
Front Beach area	N	E	E	M	E	E	E	M	M	M	E	E	E	E	E	E

N= Option does not achieve the objective/criteria

M= Option moderately achieves the objective/criteria

E= Option effectively achieves the objective/criteria

N/A= not applicable

8. Recommended actions and measures

The actions outlined in the strategy were informed by the coastal hazard assessment, coastal hazard risk assessment, stakeholder engagement and published research.

A total of 25 actions are recommended under the strategy. These actions are listed and described in the Strategy Implementation Schedule (Appendix 1), which also identifies lead and partner agencies, and the steps, risks, barriers and indicative costs for implementing individual actions.

Each of the 25 recommended actions have been assigned a priority of Low, Medium or High, reflecting their relative importance, potential benefit/s, ease of implementation and urgency. Actions are grouped under the following categories:

- planning and administrative initiatives
- operational initiatives
- monitoring and data capture initiatives
- further studies and specific management plans
- coastal protection structures
- sand management activities
- emergency response actions.

A map showing the indicative location of recommended actions is provided at Appendix 2. Concept designs and associated drawings were also developed for the following actions:

- buried foreshore revetment
- beach access
- Lagger's Point Breakwater (two iterations)
- beach scraping
- sand back-passing.

Concept designs and indicative costings are provided at Appendix 3.

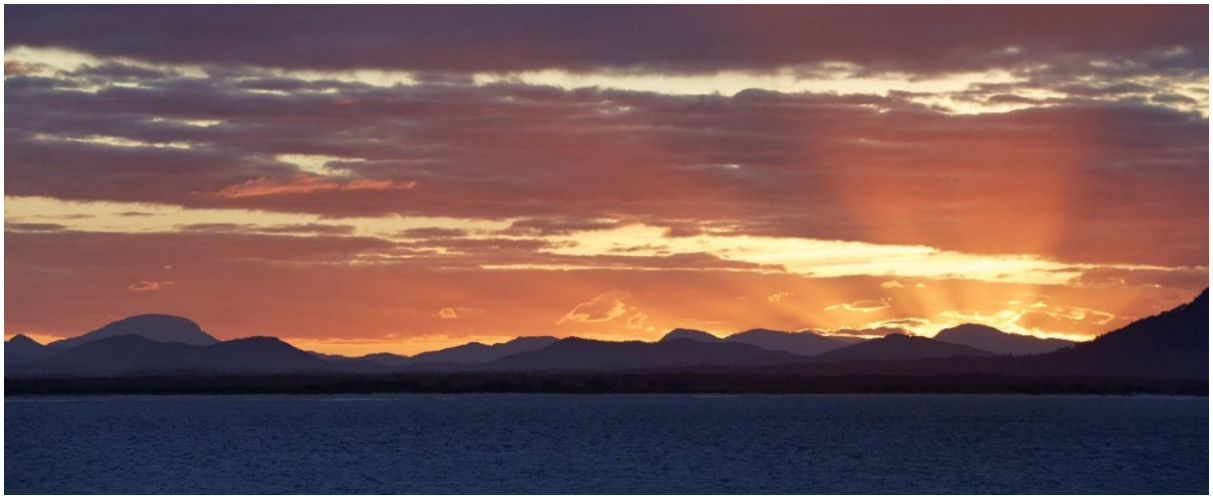


Photo 9 Sunset over Trial Bay. Nick Cubbin/DPE (2014).

9. Bibliography

BMT WBM (2013). *Kempsey Coastal Processes and Hazards Definition Study*. Repor prepared for Kempsey Shire Council.

BMT WBM (2015). *Kempsey Coastal Zone Management Study*. Report prepared for Kempsey Shire Council.

BMT WBM (2016). *Kempsey Coastal Zone Management Plan*. Report prepared for Kempsey Shire Council.

Davies, P. (2004). Trial Bay Gaol Conservation Management and Cultural Tourism Plan

Deloitte (2019). Understanding visitor regional dispersal in Australia

DLWC (2001). Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques. NSW Department of Land and Water Conservation. https://www.environment.nsw.gov.au/research-and-publications/publications-search/coastal-dune-management

DPIE (2019). NSW National Parks & Wildlife Service Tree risk management procedures. https://www.environment.nsw.gov.au/topics/parks-reserves-and-protected-areas/park-policies/tree-risk-management-policy

GHD (2020). Trial Bay Gaol Slope Risk Assessment

MacLachlan A., Defeo O., Jaramillo E. and Short, A.D (2012) Sandy beach conservation and recreation: Guidelines for optimising management strategies for multi-purpose use. *Journal of Ocean and Coastal Management* 71, 256-268.

NPWS (1987). Arakoon State Recreation Area Plan of Management

OEH (2018) NSW Coastal Management Manual. https://www.environment.nsw.gov.au/topics/water/coasts/coastal-management/manual

IPCC (2019). Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.* Intergovernmental Panel on Climate Change https://www.ipcc.ch/srocc/

SC Lennon & Associates (2019). Horizons 2030: Macleay Valley Economic Development and Tourism Strategy. Report prepared for Kempsey Shire Council.

SC Lennon & Associates, (2019). Macleay Valley Coast Destination Management Plan, 2019-2029. Report prepared for Kempsey Shire Council.

Short, A. D (2020). Australian Coastal Systems: Beaches, Barriers and Sediment Compartments. Springer International Publishing.

Appendix 1

Strategy implementation schedule

The implementation of all actions outlined in the Strategy Implementation Schedule will be at the sole discretion of the NSW National Parks and Wildlife Service and are subject to funding and resource availability.

Table 6 Strategy implementation schedule

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
Avoid future impact	1. Incorporate TBVP coastal hazard areas, including erosion buffers for 2050 and 2100, into new plan of management for Arakoon National Park, Trial Bay Master Plan and other relevant planning documents.	NPWS	TfNSW Kempsey Shire Council	Minimal. Undertaken in-house using existing NPWS resources.	Provide relevant project managers with maps highlighting TBVP coastal hazard areas.	Disagreement amongst stakeholders over accuracy of mapped TBVP coastal hazard areas. Development aspirations for TBVP override need to consider coastal hazards in infrastructure design and location.	Loss or damage of TBVP infrastructure due inappropriate siting and design.	High
	2. Regulate development in TBVP to limit non-essential visitor infrastructure and services in areas where coastal hazards present a high risk.	NPWS	N/A	Minimal. Undertaken in-house using existing NPWS resources.	Factor coastal hazard mapping and coastal hazard risk assessment into Trial Bay master planning.	Competing land use interests and limited space for development.	May lead to increased risk due to improperly located assets and land use zones.	High
Planning for change	3. Plan for the phased relocation of caravan and camping sites at high risk of coastal hazards to less vulnerable areas when enhanced coastal protection works are no longer effective. This action applies to a limited number of sites only. If a future recommendation to relocate a limited number of campsites is accepted, this should not significantly reduce the overall camping capacity of Trial Bay.	NPWS	N/A	Indeterminable. Costs subject to the number of camping sites approved for relocation and campground design (as determined by the master planning process).	Incorporate coastal hazard considerations into Trial Bay master planning, including the identification of sites at high risk of coastal hazards.	Criticism from stakeholders, specifically, long-standing users of campsites proposed for potential relocation. Competing interests for limited space. Reduced revenue from camping fees.	Current risks are manageable. However, projected increases in the severity and frequency of major storm events may result in public safety risks and the loss of inappropriately sites campgrounds due to foreshore collapse.	Medium
Alert (monitor)	4. Integrate the key findings of the strategy into the Kempsey Shire Council Coastal Management Program.	NPWS	Kempsey Shire Council Biodiversity and Conservation (DPE – EES)	Minimal. Undertaken in-house using existing NPWS resources.	Provide Kempsey Shire Council with a forward copy of the strategy for early consideration in relevant coastal management planning processes. Ensure NPWS representation on Kempsey Shire Council Natural Resources Consultative Committee. Develop a Memorandum of Understanding or similar partnership document with Kempsey Shire Council for accessing funding of coastal works under the Coastal and Estuaries Grants Program.	Disconnect between Kempsey Coastal Management Program and the strategy.	Integrated coastal management not realised.	High

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
	5. Establish 'Trial Bay Coast and Foreshore Partners Group' to identify, support and develop co-funding opportunities for implementing recommended actions (i.e. in the strategy).	NPWS	Biodiversity and Conservation (DPE - EES) Kempsey Shire Council TfNSW	Minimal. Undertaken in-house using existing NPWS resources.	Identify and confirm potential Partner Group members, and prepare terms of reference for its operation, as approved by NPWS. Identify current and emerging co-funding opportunities including commercial sponsorships.	Past differences in management approach and jurisdictional funding accountabilities reduce potential for tenure-blind approach to coastal management.	Missed opportunities to obtain funding for key coast and foreshore protection works.	High
Alert (monitor)	6. Raise awareness of local coastal processes and issues through targeted site interpretation.	NPWS	Kempsey Shire Council SWR Dune Care SWR Figtree Descendants Aboriginal Corporation SWR Aboriginal Corporation	$5,000 for signage and training of tour guides.	Design and install theme-based coastal signage at selected vantage points within TBVP, giving attention to the emerging pattern of shoreline accretion and erosion in Trial Bay. Incorporate key coastal management information and messages into current and future guided tours.	Limited staff to deliver park interpretation activities.	Limited community support for actions to address coastal hazards such the removal, relocation or redesign of built coastal assets, beach scaping and nourishment, and construction of sea walls.	High
	7. Implement measures to limit public use of informal access points to Front Beach.	NPWS		Approx. $5,000 for installation of semi-permanent fencing (i.e. 1-2 years) and strategic revegetation.	Confirm and document informal beach access points. Recognised beach access points at the time of strategy development are identified as: • steps near boat ramp • steps in campsite area • steps in day use area • ramp in picnic area • dune pathway near Fisherman's. Refer concept drawing (Appendix 3) for details on access types. Incorporate need for people to use formal beach access points in precinct signage (refer Action 6). Install visually appropriate, semi-permanent fencing on boundary of informal beach access points. Plant endemic coastal vegetation (including coastal wattle (*Acacia longifolia*), coastal sheoak (*Casuarina equisetifolia*) and *Pandanus* sp.) in areas protected by semi-permanent fencing (refer above) and where foreshore stability is compromised. Also links to actions 8,16, 17, 25 and 26.	Continued use of informal beach access points. Increase in number of informal beach access points due to temporary closure of previously designated beach access.	Ongoing risks to public safety Increased foreshore degradation, including the loss of endemic coastal vegetation, due to the incremental expansion of current informal beach access points. Increase in scale and severity of foreshore erosion.	High
	8. Develop and implement a foreshore monitoring program (including fixed point, photo monitoring) to assess the condition of the Trial Bay Foreshore over time and need for remedial action.	NPWS	N/A	Minimal. Action to be incorporated into relevant NPWS Work Program.	Incorporate requirement for bimonthly and post-storm foreshore monitoring into relevant NPWS operational plans and new plan of management for Arakoon National Park. Aspects for monitoring including evidence of foreshore slumping and erosion, damage to sea/rock walls, loss of vegetation and presence of new beach access points.	Should levels of observable foreshore damage pose a risk to public safety, an immediate management response will be required. Costs for implementing responses subject to the type and extent of foreshore damage.	Unaddressed damage can quickly worsen leading to a more severe problem.	High

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
	9. Investigate viability of implementing CoastSnap (or similar photo monitoring program) to assess shoreline change. www.coastsnap.com	NPWS	Kempsey Shire Council	$2300 per camera cradle (including signage) $1500 per annum CoastSnap operation	Undertake a comprehensive site inspection to identify potential photo monitoring locations. Confirm viability of sites with EES Science Division. Initiate discussions with EES-BCS Division, external providers and tertiary institutions on the possibility of utilising drones to monitor coastal change. Supported by Action 11.	Lack of suitable locations with line of sight. Damage to, or removal of, photo monitoring stations due to major storms events and vandalism.	Missed opportunity to engage public in strategic coastal management. Missed opportunity to obtain site-critical data to inform adaptive coastal management.	Medium
Alert (monitor)	10. Monitor the structural condition of Laggers Point Breakwater through scheduled drone surveys and photogrammetric analysis.	To be confirmed (subject to accountability of Laggers Point). Refer Key steps for implementation.	TfNSW Kempsey Shire Council NPWS	$3000 one-off purchase of drone. $500 per annum to maintain drone. $5000 per drone survey and production of photogrammetric data.	Source and collate relevant background information which confirms jurisdictional responsibility for Laggers Point Breakwater. Convene meeting with NSW Crown Lands, TfNSW and NPWS to discuss the above and proposed actions for monitoring the condition of the breakwater. Prepare and formalise a Memorandum of Understanding (MoU) between principle and partner agencies, which clearly defines the roles and responsibilities of all parties. Subject to negotiations between relevant parties and the proposed MoU, work with NSW Crown Lands to: • Confirm the current status of the breakwater. Use findings to establish a baseline for future comparative assessment. • Implement annual drone surveys to produce a photogrammetric record of the breakwater over time. • Consider swell parameters preceding data capture from DPE managed WaveRider Buoys (Crowdy Head & Coffs Harbour) to support future analysis. • Maintain data records to support Action 19 (repair/maintain breakwater). Aligns with Action 18.	Accountability for breakwater maintenance is not resolved. Insufficient staff to operate drone and general resource limitations (e.g. purchase of drones and software, sourcing, collation, analysis and storage of data). Drone malfunction or loss (i.e. due to crash).	Missed opportunity to inform future actions for maintaining the breakwater Ongoing deterioration of breakwater resulting in changes to shoreline configuration and increased wave action in areas currently used for passive water-based recreation.	Medium
	11. Enhance shoreline monitoring of TBVP through annual drone surveys. Convert data captured from drone surveys into photogrammetric record. Incorporate into NSW Beach Profile Database.	NPWS	Kempsey Shire Council UNSW Water Research Laboratory DPE (EES-BCS)	$5,000	Source, collate and analyse existing date on shoreline change. Use findings to determine optimum drone fly-over routes. Develop and implement shoreline monitoring program in accordance with the key steps for implementation (refer Action 10). Liaise with the UNSW to ensure integration of monitoring.	No or limited commitment by relevant agencies to improving the current shoreline monitoring program. Insufficient staff to operate drone and general resource limitations (e.g. purchase of drones and software, sourcing, collation, analysis and storage of data). Drone malfunction or loss (i.e. due to crash).	Missed opportunity to obtain site-critical data to inform future management actions.	Medium

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
	12. Determine the impacts of existing stormwater drainage systems on foreshore stability.	NPWS	Kempsey Shire Council	$20,000	Engage a hydro-engineer to prepare a Stormwater Drainage and Impact Abatement Plan for TBVPs (including attention to foreshore stability and beach protection). Use the findings of the plan to develop Runaway Creek Entrance Management Strategy (refer Action 14).	Nil. The preparation of a Stormwater Drainage and Impact Abatement Plan is a key component of the Trial Bay master planning process and is accepted by stakeholders as a critical and necessary action.	Continuance and/or increase in foreshore erosion due to deficiencies in stormwater drainage. Damage to visitor infrastructure and a reduction in campground capability due to localised flooding. Limited information to Runaway Creek Entrance Management Strategy.	High
Alert (monitor)	13. Model the impacts of maintaining or extending Laggers Point Breakwater on shoreline alignment.	To be confirmed. Refer Action 10 'Key steps for implementation'	Universities DPE (EES-BCS) NPWS	$40,000	Engage a coastal engineer to undertake advanced modelling to understand the impacts of different breakwater lengths on future shoreline configuration and development. Linked to Action 19.	Efficacy of modelling outcomes may be challenged due to insufficient data on sand transport and deposition from Smoky Cape.	Missed opportunity to obtain site-critical data to inform future management actions.	High
	14. Develop Runaway Creek Entrance Management Guidelines.	NPWS	DPE (EES-BCS) Kempsey Shire Council	Minimal. Developed in-house using existing resources. Use approach and methodologies outlined in existing ICOLL entrance management plans developed by Kempsey Shire Council.	Review approach, objectives and methodologies outlined in existing ICOLL entrance management plans developed by Kempsey Shire Council. Where appropriate, assimilate into Runaway Creek Entrance Management Guidelines. Convene meeting with identified stakeholders to confirm key areas for consideration. Establish NPWS Project Working Group. Commence preparation of the Guidelines giving consideration to: • past and project flood levels • berm height • triggers for entrance opening • water quality • public health and safety • local ecology and hydrology • NPWS resource limitations • stormwater drainage (Action 5) • relevant approvals and processes. Linked to Action 19.	Misalignment of proposed guidelines with Saltwater Lagoon management actions. Low level of take-up (i.e. of guidelines) due to competing priorities and resource constraints. Disruption to ICOLL ecology (including function and services) if artificial opening of entrance points, or entrance modulation, is ill-informed and/or poorly managed.	Ongoing erosion of TBVP foreshore exposing built and non-built assets to damage/harm. Reduced viability of aquatic fauna populations due to critical inter-tidal processes being impeded by sand accumulation. Potential for localised flooding of visitor camping and day-use areas due to projected rises in sea level.	High

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
	15. Develop a Trial Bay Coastal Zone Emergency Action Sub-plan, as recommended under the NSW Coastal Management Framework, to support and align with the Kempsey Shire Council Coastal Zone Emergency Sub-plan.	NPWS	Kempsey Shire Council SES NSW Police	Minimal Develop in-house using existing resources.	Engage NPWS Safety, Risk and Compliance Unit to prepare an emergency action sub-plan which outlines: • The origin and type of coastal emergencies. • The roles and responsibilities of public authorities, including NPWS, in responding to coastal emergencies. This including extreme erosion events, localised flooding and damage to infrastructure. • The triggers for emergency response. • How NPWS should respond to coastal emergencies including relevant on-ground actions. • Actions to be undertaken in the prevention, preparation response and recovery phases of a coastal emergency. • Its alignment with valley-wide coastal emergency plans prepared by Kempsey Shire Council.	Lack of intra and interagency coordination is responding to major coastal emergencies.	Potential risks to public health and safety. Ongoing damage to built and non-built coastal assets due to ill-informed response actions.	High
Active intervention	16. Develop and implement a Dune and Foreshore Revegetation Plan incorporating areas currently identified for revegetation. Note: Proposed foreshore revegetation requires assimilation with broader Trial Bay landscape master planning.	NPWS	SWR Dune Care SWR Figtree Descendants Aboriginal Corporation SWR Aboriginal Corporation	Approximately $2000 per annum. To cover costs for procuring, replacing and maintaining plants. Dune and Foreshore Plan developed in-house by NPWS in partnership with SWR Dune Care.	Establish Dune and Foreshore Revegetation Planning Group Confirm/re-confirm dune and foreshore areas for priority revegetation, noting the need to maintain full or partial vistas of Trial Bay. Review existing natural area revegetation plans including the NSW Coastal Dune Manual, to establish knowledge gaps, best practice revegetation techniques and key issues for consideration. Identify and map priority areas for revegetation (detailing species composition and density). Develop and implement plan using new and updated information. Assimilate plan into Trial Bay landscape master planning.	Lengthy timeline for dune vegetation to establish. Visitors accidently or maliciously damaging vegetation. Reliance on volunteer workforce to implement plan. Potential difficulties in sourcing a supply of native vegetation specimens.	Missed opportunity to involve public (including Aboriginal community) in local coastal management. Lack of coherence between strategy and Trial Bay master planning. Ongoing erosion and destabilisation of dunes and foreshore. NPWS reputational risk due to public perceptions of reactive versus planned dune and foreshore revegetation.	High
	17. Continue to manage fallen trees on Front Beach to: ○ reduce risks to public safety ○ reinstate viable beach areas ○ facilitate pedestrian passage ○ assist with dune stabilisation.	NPWS	n/a	Minimal. Undertaken in-house using existing resources.	Manage tree risk in accordance with NPWS Tree Risk Management Procedures (NPWS 2019). Where not significantly impeding pedestrians, use fallen trees for wind capture of sediment on dunes. Limit the removal of tree trunks and deep growing roots on foreshore.	Trade-offs between public safety and dune stability can lead to sub-optimal management outcomes. Can be combined with access management (Action 7) to reduce risk however, past experience show that visitors ignore signs restricting access.	If trees are removed, then it may expose the dune to increased erosion. If trees are left on beach, then it increases the risk for public safety.	High

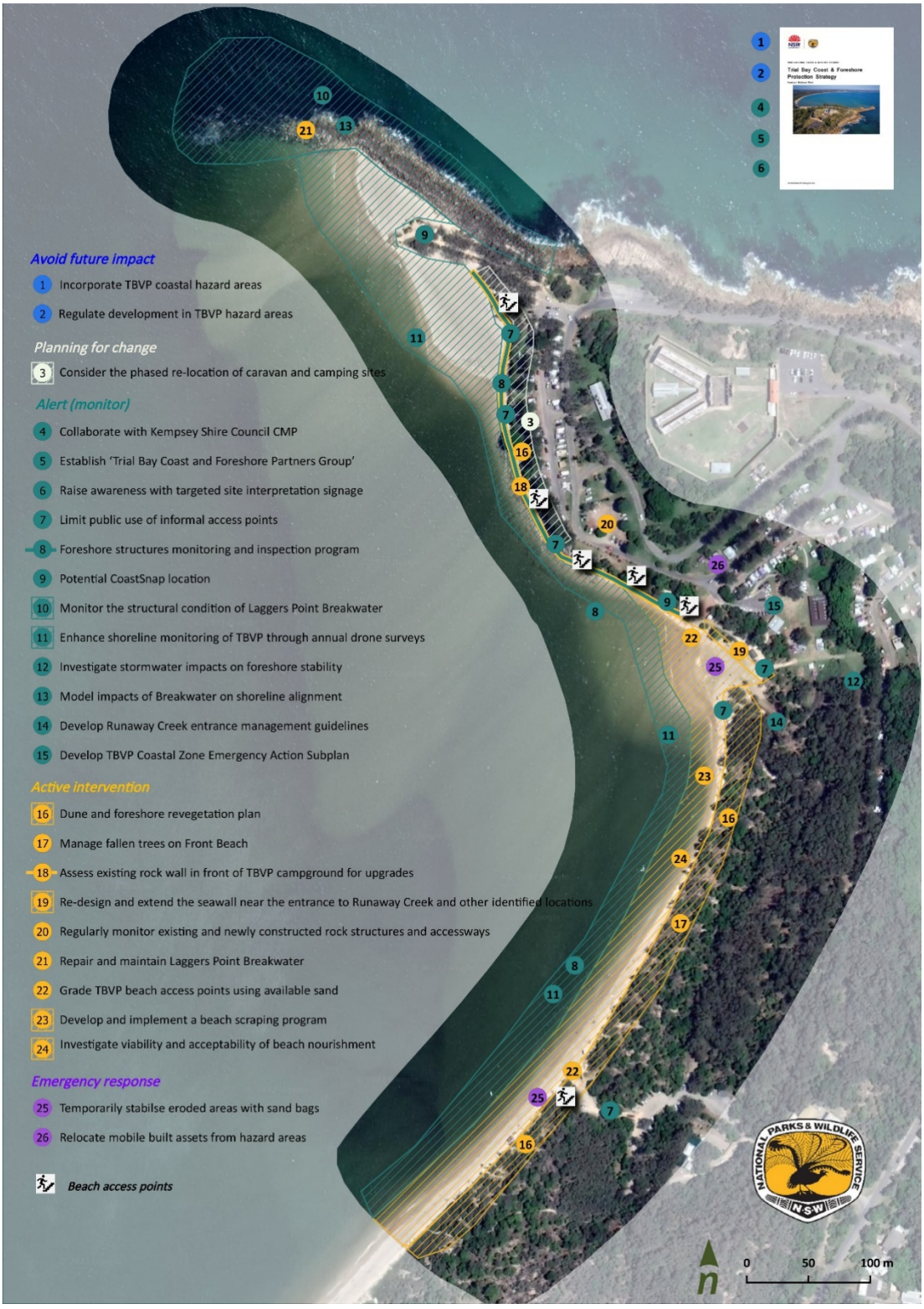
Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
	18. Assess existing rock wall in front of TBVP campground and identify areas for re-instatement or strengthening.	NPWS	DPE (EES-BCS) DPI (Fisheries) Kempsey Shire Council	$30,000 (including condition assessment and detailed designs for rock wall repair and re-construct)	Review historic photographic records and map/re-map areas of the TBVP foreshore where seawall enhancements are likely to be required. Undertake a detailed condition assessment and map/re-map areas of the TBVP foreshore where seawall re-instatement, strengthening or construction is required. Implement maintenance actions and replacement of existing displaced rocks to repair structure while maintaining the visual amenity. Prepare statement of requirements for coastal engineer to prepare detailed seawall design based on modelling outcomes for areas identified as requiring upgrade of structure.	Expensive coastal engineering option. Difficulty in obtaining approval from relevant NSW Government agencies for extensive construction works. Easier to implement maintenance of existing structure without need for full design and approvals process.	Seawall may be undermined and slump due to gradual degradation and impacts from large storm events. Note. This risk will be mitigated through the provision of appropriately designed seawalls based on current and projected hazard scenarios.	High

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
Active intervention	19. Redesign and extend the seawall near the entrance to Runaway Creek and other identified locations to better protect the visitor day-use and campsite areas from major storm events.	NPWS	DPE (EES-BCS) DPI (Fisheries) Kempsey Shire Council	$500,000 design and construct (dependant on length of works). $5,000 per annum maintenance. Refer cost estimates in Appendix 3.	Review historic photographic records and map/re-map areas of the TBVP foreshore where seawall enhancements are likely to be required (aligns with Action 18). Convene meeting with Kempsey Shire Council and other key stakeholders to discuss benefits of the proposed seawall enhancements to the long-term management of Runaway Creek. Use technical drawings/concepts (refer Appendix 3) and the outcomes of stakeholder consultation to inform detailed design. The latter giving priority to retaining the character and visual amenity of the existing natural landscape. Seek co-funding with KSC to implement seawall repair through Coastal and Estuaries Grants Program. Prepare statement of requirements for coastal engineer to prepare detailed seawall design. Use technical drawings/concepts included in Appendix 3 to inform detailed design (aligns with Action 18) Assimilate outcomes of detailed design into Runaway Creek Entrance Management Plan (refer Action 14) to ensure compatibility between proposed foreshore protection measures and the maintenance of the creek opening.	Expensive coastal engineering option. Seawall may be undermined and slump due to changes in the direction and velocity of flow from Runaway Creek. Note: This risk will be mitigated through the provision of appropriately designed seawalls based on current and projected hydrological modelling scenarios. Difficulty in obtaining approval from relevant NSW Government agencies.	Loss of built and non-built coastal assets due to the ongoing erosion of the foreshore. Increase in the number and duration of campground and visitor day use closures. Reduced level of visitor satisfaction due to negative impacts of foreshore erosion on recreational day use.	High
	20. Regularly monitor existing and newly constructed rock structures and accessways for signs of damage or failure	NPWS	N/A	Minimal. Undertaken in-house using existing NPWS resources.	Develop a condition assessment schedule (i.e. monthly, post storm inspections) Inspect rock wall and accessways for loose boulders, slumping, noticeable signs of damage. Incorporate condition assessment into operational plans.	Nil	Worsening of damage to seawalls. Increase in scale and extent of foreshore erosion.	Medium

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
Active intervention	21. Repair and maintain Laggers Point Breakwater	To be confirmed. Refer Action 10 'Key steps for implementation'	NPWS TfNSW (Maritime) Kempsey Shire Council NSW Heritage Council	High cost. Refer estimates in Appendix 3.	Source and collate relevant background information which confirms jurisdictional responsibility for Laggers Point Breakwater. Convene meeting with Crown Lands, TfNSW and NPWS to discuss the above and proposed actions for monitoring the condition of the breakwater. Prepare and formalise a Memorandum of Understanding between principle and partner agencies, which clearly defines the roles and responsibilities of all parties. Note. All of the above actions are duplicated in Action 10 Undertake a cost benefit analysis of proposed remedial works including their potential impact on the historic heritage value of the Breakwater. Use the outcomes of the cost benefit analysis and the technical drawings/concepts (Appendix 3) to develop a 'Laggers Point Breakwater Repair and Maintenance Program'. Investigate opportunities to obtain supplementary funding for implementing critical repairs.	Accountability for breakwater repair and maintenance is not resolved. Implications of the Breakwater's State Heritage Listing on proposed repair and maintenance actions and related approvals.	Continued degradation of the Breakwater will lead to the gradual realignment of the shoreline (i.e. up to 200m inland of its current widest point). Exacerbation of the rate and scale of Breakwater degradation due to sea level rise. Further decline in the structural integrity of the Breakwater. Ongoing recession of Trial Bay Front Beach and shoreline configuration due to increased wave action and changes to coastal geomorphic processes.	Medium
	22. As required, and where operationally viable, grade TBVP beach areas to ensure their safe and enjoyable use by the public and aesthetic appeal. All sand used in grading activities to be sourced on-site.	NPWS	N/A	$5000 per annum	Define and map areas of beach in TBVP where mechanical grading can be safely and efficiently undertaken. Develop standard operating procedures for undertaking beach grading based on the principles of least disturbance and ecological sustainability. Convene meeting with TfNSW (Maritime) and Kempsey Shire Council to discuss their potential pro rata contributions to grading operations. Determine the volume of sand required. Obtain quote (cost per hour) from a suitably qualified and licensed local operator to implement, as required beach grading. Engage grading operator.	No end to program due to ongoing displacement and erosion of sand. Not feasible at all locations due to on-site sand shortages, access and safety consideration, and high levels of sand mobility.	Accelerated deterioration of beach access points and areas. Ongoing requirement to restrict or temporarily close beach access points or areas. Public safety concerns due to poor of deficient beach accessways.	Medium
	23. Develop and implement a beach scraping program to support dune recovery in TBVP beach areas.	NPWS	NSW Crown Lands Kempsey Shire Council	Approximately $30,000 Refer cost estimates in Appendix 3.	Engage a coastal engineer to determine: • the preferred sand 'take zone' • the volume of sand available • target points for sand deposition • the desired beach and dune profile • patterns of sand transport and deposition. Use engineers report to develop a customised beach scraping program. This including the need to regulate offshore sand extraction to reduce impacts on benthic flora and fauna. Initiate fixed point photo monitoring of beach and dune profile. See concept design (Appendix 3).	Difficulty in obtaining approvals and coordinating with relevant authorities. Potentially requires a cost benefit analysis. Works are likely to be required in the long term with periodic sand replenishment. Stability of shoreline is dependent on the effective length of Lagger's Point Breakwater, so if it is allowed to degrade, then the efficacy of sand management decreases.	Ongoing deterioration of dune and heath ecosystems.	Medium

Adaptation approach	Management action	Primary responsibility	Supporting partners	Cost estimate	Key steps for implementation	Potential risks/barriers to implementation	Current and projected risks of not implementing	Priority
Active intervention	24. Undertake detailed investigations into the technical viability and community support for large-scale nourishment of Trial Bay Front Beach.	NPWS	NSW Crown lands DPE – EES Heritage Council Kempsey Shire Council	$100,000	Prepare a statement of requirements for detailed technical investigation into the viability of large-scale nourishment of Front Beach. Factors to be considered include: • the preferred sand 'take zone' • the volume of sand available • target points for sand deposition • the desired beach and dune profile • patterns of sand transport and deposition • subject to the outcomes of the technical investigation commence targeted discussions with stakeholders. Undertake cost benefit analysis. Notes: Refer concept design (Appendix 3) To consolidate beach scraping.	High cost of implementing beach nourishment Refer cost estimates in Appendix 3. Difficulty in obtaining environmental and other approvals. Lack of community consensus on requirement for large-scale beach nourishment. Insufficient supply of sand.	Issues of small beach width and associated impacts on beach amenity, public safety and asset exposure will continue. These risks will increase into the future and will be influenced by the effective length and condition of the Breakwater.	Low
Emergency response	25. Stabilise areas of TBVP foreshore where erosion has, or is projected to occur, through installation of temporary sandbags.	NPWS	N/A	$5000	Identify and map areas of the TBVP foreshore where temporary sand-bagging is required. Seek engineering advice on best practice 'sand-bagging technique'. Implement training program for NPWS local area staff. Prepare signage which explains the purpose of the sand-bagging including its use as a temporary, cost-effective coastal protection measure. Establish a fit-for-purpose sand-bagging station. Create a stockpile of sandbags (i.e. small, medium and large) for immediate and future use including in emergency situations. Incorporate use of sand-bagging into Trial Bay Coastal Zone Emergency Action Sub-plan (refer Action 15). Monitor effectiveness of sand-bagging and replace damaged sand bags as appropriate. Remove all sandbags prior to installation of permanent stabilisation/protective measure.	Displacement or damage of sand bags due to major storm events. Short working life of sand bags (i.e. 3-4 months). Lack of suitably qualified and experienced training providers.	Ongoing and accelerated erosion of TBVP foreshore leading to loss of, or damage to, built and non-built assets. Poor public perception of NPWS coastal management capability.	High
	26. Relocate mobile built assets from areas of the TBVP foreshore at high risk of coastal hazards.	NPWS	N/A	Minimal. Costs borne from existing NPWS operational budget.	Identify mobile built assets susceptible to damage from extreme storm events and suitable locations for their temporary storage. Based on the above, develop emergency response procedures defining the roles and accountabilities of relevant NPWS operational staff. Incorporate response actions into Trial Bay Coastal Zone Emergency Action Sub-plan (refer Action 15) Monitor weather forecasts for extreme storm events.	Nil	Potential loss of mobile built from extreme weather events.	High

Appendix 2: Locality map for recommended actions



Appendix 3: Concept designs for proposed coastal hazard protection works

Trial Bay Coast & Foreshore Protection Strategy

Info

Project number:

0420081

General comments:

This spreadsheet contains unit cost tables for the adaption options proposed for the Trial Bay Coast and Foreshore Protection Strategy project. It also provides calculations to determine aggregate costs with the entry of unit amounts.

The cost estimates provided are for comparative purposes only.
They should not be used for budgetary purposes.
If they are to be used for budgetary purposes a suitable percentage contingency should be applied.

0420081 - 0001	Foreshore buried rock revetment
0420081 - 0002	Breakwater repair
0420081 - 0003	Alternate breakwater options
0420081 - 0004	Beach scraping
0420081 - 0001	Sand backpassing

Additional information on various beach access options is provided after the engineering drawings.

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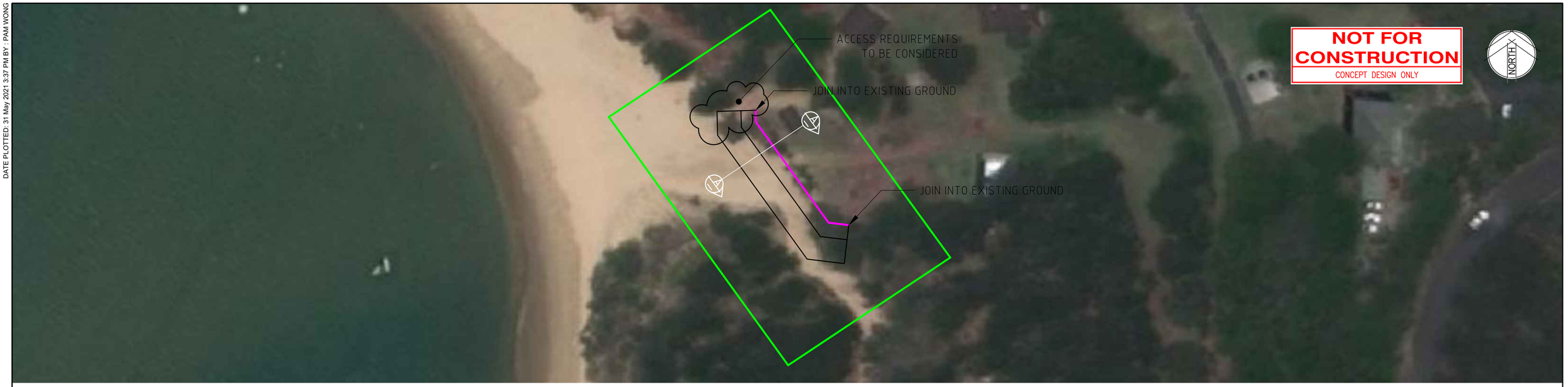
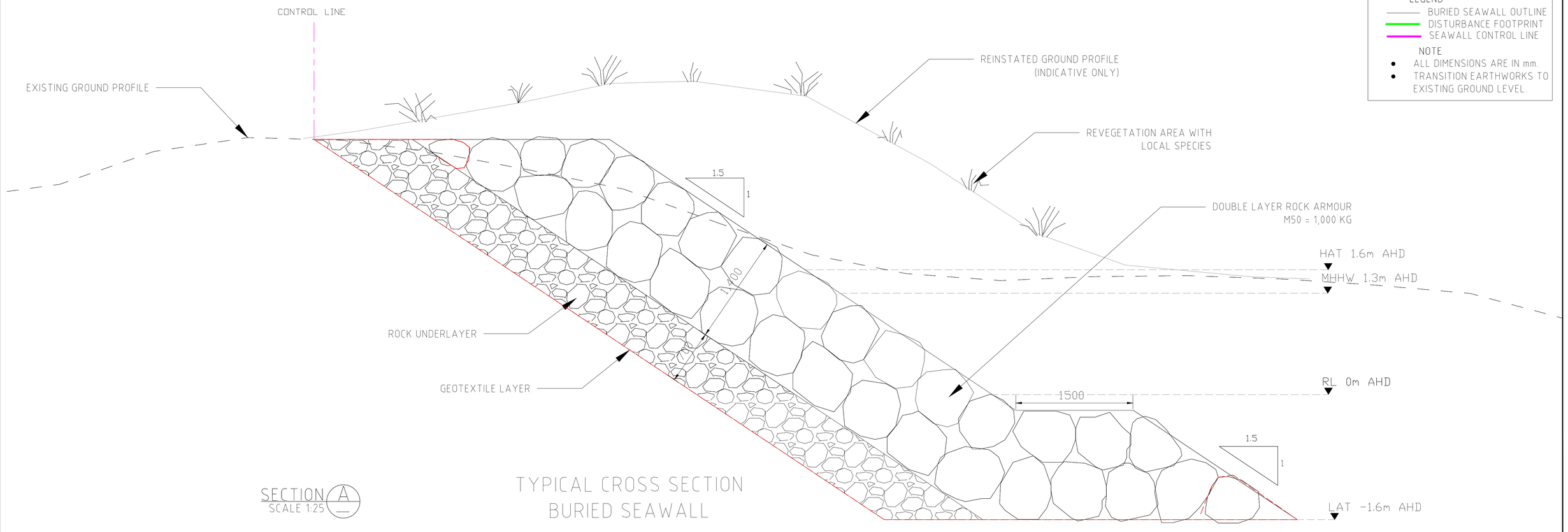


NOT FOR CONSTRUCTION
CONCEPT DESIGN ONLY

NORTH

LEGEND
- BURIED SEAWALL OUTLINE
- DISTURBANCE FOOTPRINT
- SEAWALL CONTROL LINE

NOTE
- ALL DIMENSIONS ARE IN mm.
- TRANSITION EARTHWORKS TO EXISTING GROUND LEVEL.



SECTION A
SCALE 1:25

TYPICAL CROSS SECTION
BURIED SEAWALL

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00	CONCEPT DESIGN	31/05/2021	PW

REVISIONS

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0 0.5 1.0 1.5 2.0 2.5m
SCALE: 1:25 @A1

	NAME	DATE
DESIGNED:	PAMELA WONG	31/05/2021
DRAWN:	PAMELA WONG	31/05/2021
CHECKED:	ADAM BROOK	31/05/2021
APPROVED:	ADAM BROOK	31/05/2021
RPEQ:		

Client:

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NSW NATIONAL PARKS AND WILDLIFE SERVICE

TRIAL BAY COAST & FORESHORE PROTECTION STRATEGY

OPTION 1 - FORESHORE BURIED ROCK REVETMENT

Drawing Number	Status	Scale	Rev.
0420081-0001	CONCEPT DESIGN	AS SHOWN	A

 ABN 76 151 119 792 A1

CAD File: C:\Users\pwong\OneDrive - Alluvium Consulting Australia\1_Project\Trial Bay\test2.dwg

Trial Bay Coast & Foreshore Protection Strategy

Option 1 - Buried seawall

Description:

Option 1 - foreshore buried rock revetment 40.3m

Detailed costing:

Item	Quantity	Quantity unit	Cost rate	Cost adjustment factor	Cost unit	Nominal Cost	Adjusted cost	Comment
Rocks for sea wall	846.3	m3	$ 120.00	1.05	$/m3	$ 101,556.00	$ 106,633.80	Cost of granite revetment (Revetment walls to foreshore embedded in mortar, average 450mm thick laid dry)
Sand backfilling (old material)	3022.5	m3	$ 15.00	1.05	$/m3	$ 45,337.50	$ 47,604.38	Using excavated sand as material
Trench Excavation (Sand)	1511.25	m3	$ 37.30	1.05	$/m3	$ 56,369.63	$ 59,188.11	Excavation 1m deep
Labour and minor items	n/a	n/a	7.50%	n/a	%	$ 15,244.73	$ 16,006.97	5-10% allowance as per Rawlinsons instructions (see Adjustments tab).
Approvals	1	n/a	$ 20,000.00	1.00	$	$ 20,000.00	$ 20,000.00	
TOTAL							**$ 249,433.25**	
Contingency			**30.00%**				**$ 324,263.23**	

DATE PLOTTED: 31 May 2021 3:18 PM BY : PAM WONG

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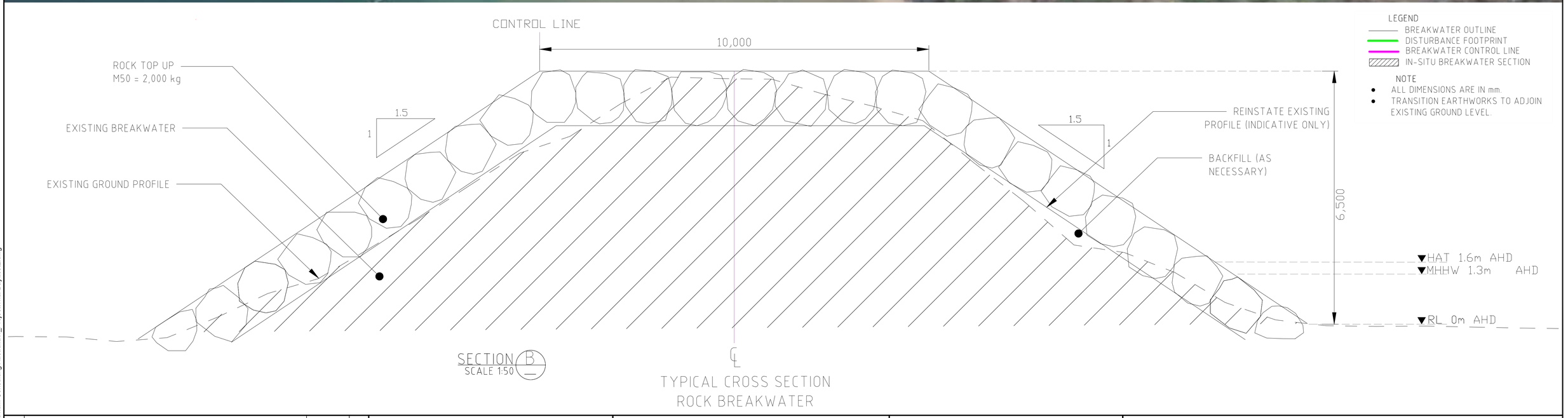
NORTH



SECTION B
SCALE 1:50

TYPICAL CROSS SECTION
ROCK BREAKWATER

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00	CONCEPT DESIGN	31/05/2021	PW

REVISIONS

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SCALE: 1:1000 @A1

0 1 2 3 4 5m
SCALE: 1:50 @A1

	NAME	DATE
DESIGNED:	PAMELA WONG	31/05/2021
DRAWN:	PAMELA WONG	31/05/2021
CHECKED:	ADAM BROOK	31/05/2021
APPROVED:	ADAM BROOK	31/05/2021
RPEQ:		

Client: NATIONAL PARKS & WILDLIFE SERVICE N.S.W.

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TRIAL BAY COAST & FORESHORE PROTECTION STRATEGY
OPTION 2 - BREAKWATER REPAIR

Drawing Number	Status	Scale	Rev.
0420081-0002	CONCEPT DESIGN	AS SHOWN	A

 ABN 76 151 119 792 A1

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Trial Bay Coast & Foreshore Protection Strategy

Option 2 - Breakwater repair

Description:

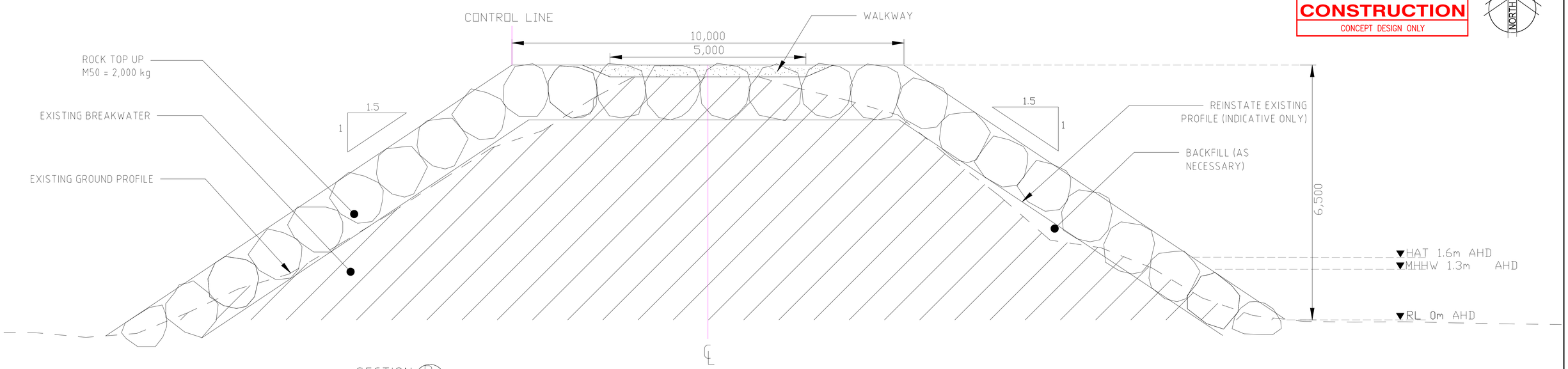
Repairing breakwater - 293m
- reinstate existing breakwater
- add single layer of rock - 2 tonne and 1.8m in diamater

Detailed costing:

Item	Quantity	Quantity unit	Cost rate	Cost adjustment factor	Cost unit	Nominal Cost	Adjusted cost	Comment
Rocks for sea wall	12306	m3	$ 120.00	1.05	$/m3	$ 1,476,720.00	$ 1,550,556.00	Cost of granite revetment (Revetment walls to foreshore embedded in mortar, average 450mm thick laid dry)
Rock backfilling (old material)	439.5	m3	$ 15.00	1.05	$/m3	$ 6,592.50	$ 6,922.13	Using excavated sand as material
Trench Excavation (Rock)	293	m3	$ 138.00	1.05	$/m3	$ 40,434.00	$ 42,455.70	Excavation 1m deep
Labour and minor items	n/a	n/a	7.50%	n/a	%	$ 114,280.99	$ 119,995.04	5-10% allowance as per Rawlinsons instructions (see Adjustments tab).
Approvals	1	n/a	$ 20,000.00	1.00	$	$ 20,000.00	$ 20,000.00	
TOTAL							**$ 1,739,928.86**	
Contingency			**30.00%**				**$ 2,261,907.52**	

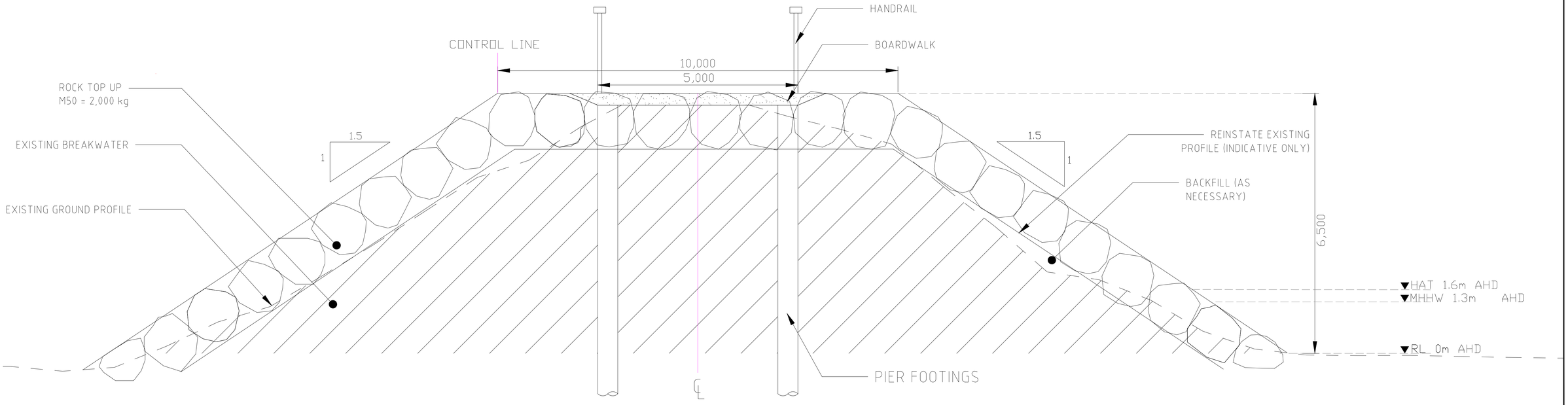
NOT FOR CONSTRUCTION
CONCEPT DESIGN ONLY

NORTH



SECTION B
SCALE 1:50

TYPICAL CROSS SECTION
ROCK BREAKWATER WITH WALKWAY



SECTION B
SCALE 1:50

TYPICAL CROSS SECTION
ROCK BREAKWATER WITH PIER

REV	DESCRIPTION	DATE	INTL
00	CONCEPT DESIGN	31/05/2021	PW

REVISIONS

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SCALE: 1:50 @A1

0 1 2 3 4 5m
SCALE: 1:50 @A1

	NAME	DATE
DESIGNED:	PAMELA WONG	31/05/2021
DRAWN:	PAMELA WONG	31/05/2021
CHECKED:	ADAM BROOK	31/05/2021
APPROVED:	ADAM BROOK	31/05/2021
RPEQ:		

Client: NATIONAL PARKS & WILDLIFE SERVICE NSW

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NSW NATIONAL PARKS AND WILDLIFE SERVICE

TRIAL BAY COAST & FORESHORE PROTECTION STRATEGY

OPTION 2 - ALTERNATE BREAKWATER OPTIONS

Drawing Number	Status	Scale	Rev.
0420081-0003	CONCEPT DESIGN	AS SHOWN	A

 ABN 76 151 119 792 A1

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Trial Bay Coast & Foreshore Protection Strategy

Option 2 Breakwater repair + walkway

Description:

Repairing breakwater - 293m
- reinstate existing breakwater
- add single layer of rock - 2 tonne and 1.8m in diamater
- walkway on top

Detailed costing:

Item	Quantity	Quantity unit	Cost rate	Cost adjustment factor	Cost unit	Nominal Cost	Adjusted cost	Comment
Rocks for sea wall	12306	m3	$ 120.00	1.05	$/m3	$ 1,476,720.00	$ 1,550,556.00	Cost of granite revetment (Revetment walls to foreshore embedded in mortar, average 450mm thick laid dry)
Sand backfilling (old material)	439.5	m3	$ 15.00	1.05	$/m3	$ 6,592.50	$ 6,922.13	Using excavated sand as material
Trench Excavation (Rock)	293	m3	$ 138.00	1.05	$/m3	$ 40,434.00	$ 42,455.70	Excavation 1m deep
Additional concrete volume	295	m3	$ 382.00	1.05	$/m3	$ 112,690.00	$ 118,324.50	For the walkway
Labour and minor items	n/a	n/a	7.50%	n/a	%	$ 122,732.74	$ 128,869.37	5-10% allowance as per Rawlinsons instructions (see Adjustments tab).
Approvals	1	n/a	$ 20,000.00	1.00	$	$ 20,000.00	$ 20,000.00	
TOTAL							**$ 1,867,127.70**	
Contingency			**30.00%**				**$ 2,427,266.01**	

Trial Bay Coast & Foreshore Protection Strategy

Option 2 - Breakwater repair + pier

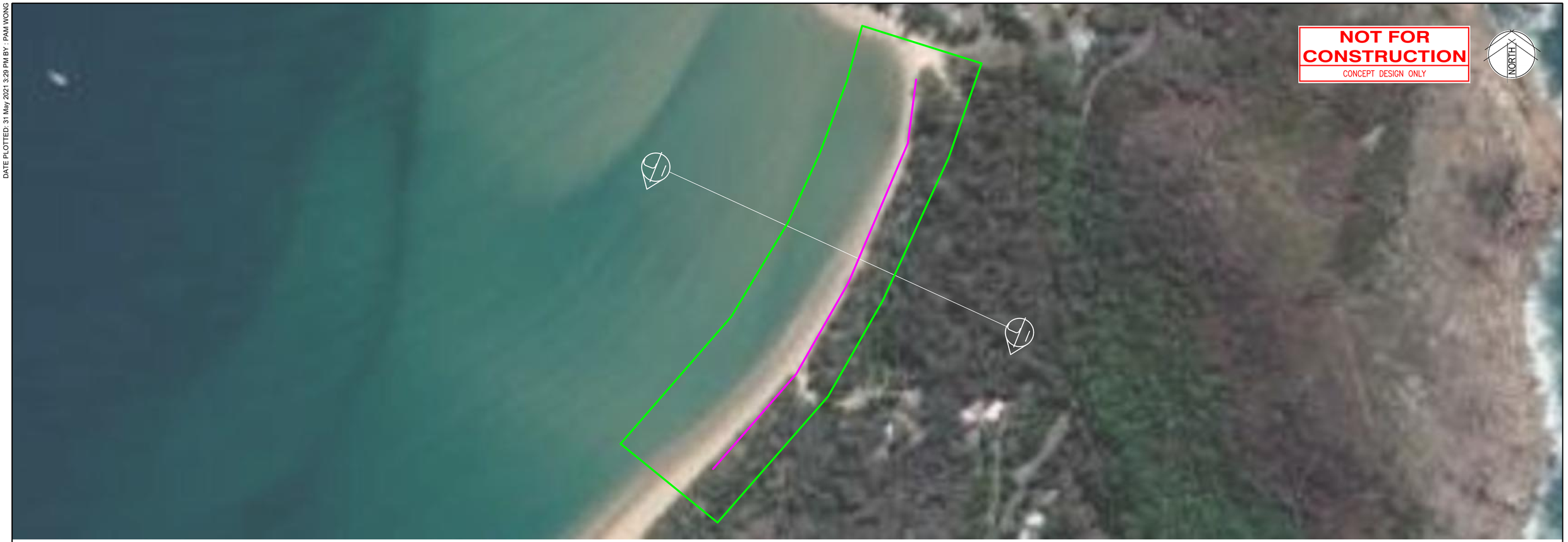
Description:

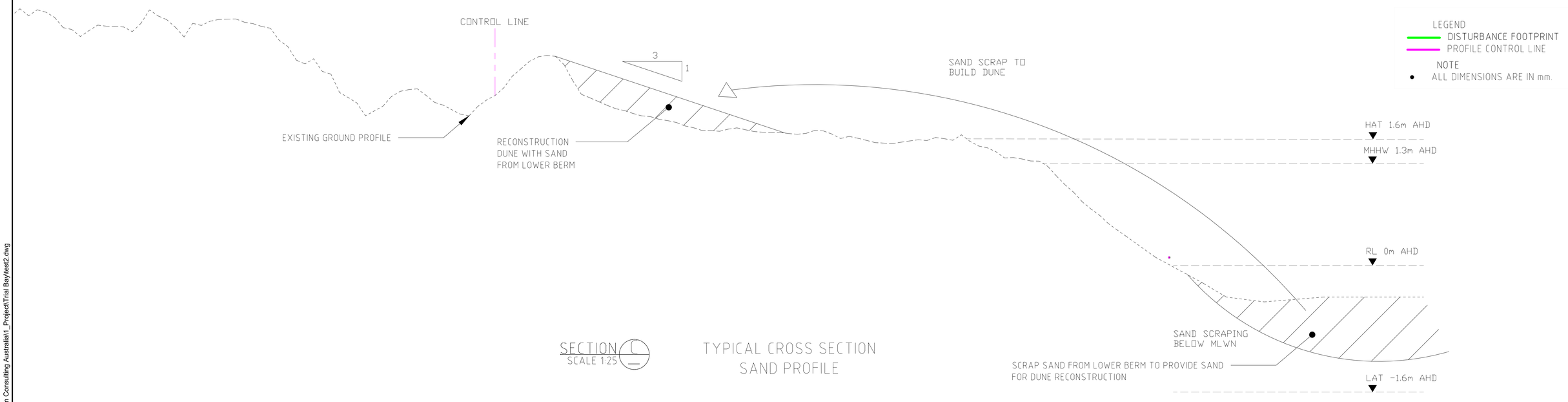
Repairing breakwater - 293m
- reinstate existing breakwater
- add single layer of rock - 2 tonne and 1.8m in diamater
- supported boardwalk/pier

Detailed costing:

Item	Quantity	Quantity unit	Cost rate	Cost adjustment factor	Cost unit	Nominal Cost	Adjusted cost	Comment
Rocks for sea wall	12306	m3	$ 120.00	1.05	$/m3	$ 1,476,720.00	$ 1,550,556.00	Cost of granite revetment (Revetment walls to foreshore embedded in mortar, average 450mm thick laid dry)
Sand backfilling (old material)	439.5	m3	$ 15.00	1.05	$/m3	$ 6,592.50	$ 6,922.13	Using excavated sand as material
Trench Excavation (Rock)	293	m3	$ 138.00	1.05	$/m3	$ 40,434.00	$ 42,455.70	Excavation 1m deep
Supported boardwalk/pier	295	m2	$ 3,000.00	1.05	$/m3	$ 885,000.00	$ 929,250.00	
Labour and minor items	n/a	n/a	7.50%	n/a	%	$ 180,655.99	$ 189,688.79	5-10% allowance as per Rawlinsons instructions (see Adjustments tab)., include geofabric
Approvals	1	n/a	$ 20,000.00	1.00	$	$ 20,000.00	$ 20,000.00	
TOTAL							**$ 2,738,872.61**	
Contingency			**30.00%**				**$ 3,560,534.40**	

DATE PLOTTED: 31 May 2021 3:29 PM BY : PAM WONG





SECTION C
SCALE 1:25

TYPICAL CROSS SECTION
SAND PROFILE

REV	DESCRIPTION	DATE	INTL
00	CONCEPT DESIGN	31/05/2021	PW

REVISIONS

0 100 200 300 400 500m
SCALE: 1:5000 @A1

0 0.5 1.0 1.5 2.0 2.5m
SCALE: 1:25 @A1

	NAME	DATE
DESIGNED:	PAMELA WONG	31/05/2021
DRAWN:	PAMELA WONG	31/05/2021
CHECKED:	ADAM BROOK	31/05/2021
APPROVED:	ADAM BROOK	31/05/2021
RPEQ:		

Client:

alluvium
www.alluvium.com.au

NSW NATIONAL PARKS AND WILDLIFE SERVICE

TRIAL BAY COAST & FORESHORE PROTECTION STRATEGY

OPTION 3 - SAND SCRAPING

Drawing Number	Status	Scale	Rev.
0420081-0004	CONCEPT DESIGN	AS SHOWN	A

 ABN 76 151 119 792 A1

CAD File: C:\Users\pwong\OneDrive - Alluvium Consulting Australia\1_Project\Trial Bay\tes2.dwg

Trial Bay Coast & Foreshore Protection Strategy

Option 3 - sand scraping

Description:	**Assumptions:**
Beach scraping - 462m - from lower beach to upper beach	There's sufficient sand from the lower beach section.

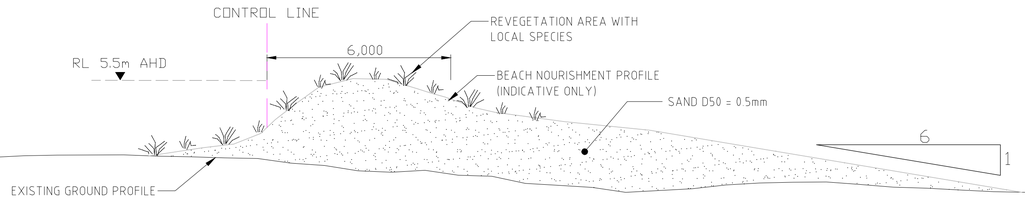
Detailed costing:

Item	Quantity	Quantity unit	Cost rate	Cost adjustment factor	Cost unit	Nominal Cost	Estimated cost	Comment
Sand management (scraping)	1155	m3	$5.00	1.05	$/m3	$5,775.00	$6,063.75	Sand scraping
Earthmoving equipment	2	day	$2,000.00			$4,000.00	$4,000.00	2 days to create the sand profile after moving sand
Labour and minor items	n/a	n/a	8%	n/a	%	$733.13	$754.78	5-10% allowance as per Rawlinsons instructions (see Adjustments tab).
Approvals	1	n/a	$10,000.00	1	$	$10,000.00	$10,000.00	
TOTAL							**$20,818.53**	
Contingency			**30.00%**				**$ 27,064.09**	

DATE PLOTTED: 31 May 2021 3:21 PM BY : PAM WONG

LEGEND
- DISTURBANCE FOOTPRINT
- SAND SOURCE AREA
- DEPOSITION AREA
- PROFILE CONTROL LINE

NOTE
- ALL DIMENSIONS ARE IN mm.



SECTION 1 SCALE 1:100

TYPICAL CROSS SECTION SAND PROFILE

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00	CONCEPT DESIGN	31/05/2021	PW

REVISIONS

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SCALE: 1:5000 @A1

0 2 4 6 8 10m
SCALE: 1:100 @A1

	NAME	DATE
DESIGNED:	PAMELA WONG	31/05/2021
DRAWN:	PAMELA WONG	31/05/2021
CHECKED:	ADAM BROOK	31/05/2021
APPROVED:	ADAM BROOK	31/05/2021
RPEQ:		

Client: NATIONAL PARKS & WILDLIFE SERVICE (NSW)

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NSW NATIONAL PARKS AND WILDLIFE SERVICE

TRIAL BAY COAST & FORESHORE PROTECTION STRATEGY

OPTION 4 - SAND BACKPASSING

Drawing Number	Status	Scale	Rev.
0420081-0005	CONCEPT DESIGN	AS SHOWN	A

 ABN 76 151 119 792 A1

CAD File: C:\Users\pwong\OneDrive - Alluvium Consulting Australia\1_Project\Trial Bay\tes\2.dwg

Trial Bay Coast & Foreshore Protection Strategy

Option 4 - Sand backpassing

Description:

Sand backpasing but costed as per nourishment.
- sand source from the west side

Detailed costing:

Item - Option 2	Quantity	Quantity unit	Cost rate	Cost adjustment factor	Cost unit	Nominal Cost	Estimated cost	Comment
Sand backpassing	18711	m3	$20.00	1.05	$/m3	$374,220.00	$392,931.00	Varied estimates outlined below.
Earthmoving equipment	2	day	$2,000.00			$4,000.00	$4,000.00	Assume once per year, for 5 working days each time
Labour and minor items	n/a	n/a	8%	n/a	%	$28,366.50	$29,769.83	5-10% allowance as per Rawlinsons instructions (see Adjustments tab).
Approvals	1	n/a	$40,000.00	1	$	$40,000.00	$40,000.00	Includes sand sampling and equipment
TOTAL							**$466,700.83**	
Contingency			**30.00%**				**$ 606,711.07**	

Beach access type	Example	Description	Suitability
Fences/barriers Low cost < $5,000 (subject to length)	 *Example: 9-Mile Beach, Forster*	Fences and other barriers such as bollards can protect dunes, wildlife habitats from pedestrians from forming new tracks in sensitive areas. Barriers are useful to delineate car parks. Signs may be used strategically to complement fences and barrier access control measures.	• Provide access over the foredune. • Gentle dune profile. • Low traffic areas. • Low-impact and low ongoing maintenance. • Maintain visual amenity.
Boardwalk and steps Medium to high cost $5,000 to $10,000+	 *Example: Tasmania*	Boardwalks are useful for controlling access and protecting highly sensitive or fragile areas. Discourage walkers from deviating around the steps and cause erosion. Steps are useful for providing access through foredunes or down steep coastal foreshores. Steps can be completely elevated timber structures, or a timber and gravel combination built into the contour of the land.	• Provide access over the foredune. • High-use areas • Suitable for steeper slopes. • Less susceptible to storm surges and general coastal processes • Suitable for a more protected area of the beach.
Sand ladders (board and chain) Medium to high cost $5,000 to $10,000+	 *Example: New Brighton Beach, Christchurch, New Zealand*	Sand ladders are flexible and can be adjusted to dune faces (e.g. on eroding beaches). Ladders are effective if erosion is caused mainly by walkers or wind rather than waves. Discourage walkers from deviating around the steps and cause erosion. Can be supplemented with fences.	• Provide access over the foredune. • Low traffic areas. • Gaps between rungs can become a trip hazard. • Adjustable to slope profile/steepness. • Cost-effective. • Highly dynamic coastal environments.

Beach access type	Example	Description	Suitability
Floating deck (recycled plastic) Medium to high cost $5,000 to $10,000+	 *Example: Blacksmiths Beach, Lake Macquarie (Enduroplank).*	Floating deck provides a flexible, durable surface suitable for walkers and disabled access. It is also suited to temporary use and subsequent removal (if required). Its flexibility allows it to conform closely to undulating dune surfaces, and it can be trimmed to suit corners and turns. Can be supplemented with fences.	• Provide access over the foredune. • High-use areas. • Adjustable to slope profile/steepness. • Cost-effective. • Low-impact and low ongoing maintenance. • Maintain visual amenity.
Track markers Low cost < $5,000 (subject to length)		Using rocks or bollards to denote a designated path provides a psychological barrier rather than a physical barrier to protect sensitive sites. This allows people to ‘stick to the track’, protecting the dunes without the need for fencing. Signs may be used strategically to complement fences and barrier access control measures.	• Provide access over the foredune. • Gentle dune profile. • Low traffic areas. • Low-impact and low ongoing maintenance. • Maintain visual amenity. • Able to restrict vehicle access.

Beach access type	Example	Description	Suitability
Beach matting (wheelchair access) Low cost < $5,000 (subject to length)	 *Example: Burleigh Heads, Gold Coast (Mobi-mat)*	Provide easy access for wheelchair users. The matting is flexible, durable, and suitable for walkers and disabled access. It is also suited to temporary use and subsequent removal (if required). Its	• Adjustable to slope profile/steepness. • Cost-effective. • Low-impact and low ongoing maintenance. • Inclusive for all users.
Concrete mats Medium to high cost $5,000 to $10,000+	 *Example: Clarkes Beach, Byron Bay (Concrete Mats)*	Concrete mats can be used to provide reasonably erosion-resistant track on low gradient accessways landward of the foredune. Sand is placed on top of the concrete mats, allowing for sand movement.	• Provide access over the foredune. • Allow vehicular traffic • High-use areas. • High capital cost. • Maintenance costs are high. • Flexible and adjustable to dune profile. • Maintain visual amenity.

Appendix 4: Description, proceedings and outcomes of stakeholder workshops

Trial Bay Visitor Precincts Coast and Foreshore Protection Strategy: Workshop 1

The NSW National Parks and Wildlife Service (NPWS) and Alluvium Consulting, facilitated two workshops on 9 February 2021 at the South West Rocks Country Club, South West Rocks, NSW.

Individual workshops were convened for the Technical Reference Group (TRG) and Community Reference Group (CRG). The objectives of the workshops were to:

- familiarise stakeholders with the project and project team
- confirm the purpose and objectives of the strategy
- clarify the role and functions of the TRG and CRG
- identify the values and issues of relevance to TBVP
- determine the likely consequences of damage to coastal assets and values
- understand the level of risk to assets and values.

Stakeholders were provided overviews of:

- the project plan and approach to developing the Trial Bay Coast and Foreshore Protection Strategy
- the regional and local coastal processes that shape the Trial Bay coastline, including a conceptual diagram summarising the physical coastal system.

Various group activities were facilitated, with different modes of engagement used for the TRG and CRG. Activities were designed to encourage active participation by stakeholders. Summaries of workshop outputs is provided below.

Key TRG activities included:

- discussion on the relationship between the strategy and Kempsey Shire Council Coastal Management Program
- asset and values mapping
- issues identification and assigning consequence ratings to confirmed coastal hazard risks.

Key CRG activities included:

- community historical timeline mapping
- assets and values mapping exercise.

Technical Reference Group Workshop 1

Meeting	Technical Reference Group Meeting
Project	Trial Bay Visitor Precincts – Coast and Foreshore Protection Strategy
Date & time	Tuesday 9 February 2021, 10:00 am – 1:00 pm
Venue	South West Rocks Country Club
Attendees	• **Sophia Meehan (Project Manager)** – Manager Landforms and Rehabilitation Unit, NPWS • **Shane Robinson** – Manager Hastings Macleay Area, NPWS • **Ben Stevenson** – Team Leader Rangers Hastings Macleay Area, NPWS • **Elizabeth Jude** – Ranger for Arakoon and Hat Head national parks, NPWS • **Luke Winters** – Field Supervisor, Arakoon and Hat Head national parks, NPWS • **Josh Chivers** – Senior Project Officer, Landforms and Rehabilitation Unit, NPWS • **Andrew Baker** – Project Officer, Landforms and Rehabilitation Unit, NPWS • **Lisa Walpole** – Project Director, Alluvium Consulting • **Michael Rosenthal** – Project Manager, Alluvium Consulting • **Marcello Sano** – Technical lead, Alluvium Consulting • **Phil Duncan** – Engagement specialist, Alluvium Consulting • **Ron Kemsley** – Senior Natural Resources Officer, Kempsey Shire Council • **Rod McDonough** – Manager Operations, Transport for NSW (Newcastle to Tweed Heads) • **John Schmidt** – Senior Coast & Estuary Officer, DPE • **Johnathan Yantsch** (online via Microsoft Teams) - Senior Fisheries Manager - Coastal Systems (North Coast) Aquatic Environment, DPI Fisheries

Photo 10 Technical Reference Group workshop 1

Discussion on integration with Coastal Management Programs

A discussion regarding the integration of the Trial Bay Coast and Foreshore Protection Strategy with the Kempsey Shire Council Coastal Management Program (CMP) under the NSW coastal management framework was conducted with the Technical Reference Group, which includes representatives from the relevant Council and state government departments.

Key discussion points included:

- Kempsey Shire Council has completed multiple CMP Stage 1 scoping studies, including for Saltwater Creek Lagoon and other large ICOLLs, as well as for the open coast of Kempsey Shire Council (KSC) LGA. The plan is for there to be one comprehensive CMP for the entire LGA.
- Development of the Trial Bay Coast and Foreshore Strategy will align with the Coastal Management Manual and, therefore, will facilitate smooth integration into the CMP.
- The final form of coordination between NPWS and KSC concerning implementing recommended actions from the CMP is not clear.
- NPWS acknowledges the benefits of including the study area within the scope of the KSC CMP; however, it is noted that CMP finalisation will likely take time, and there is a need for action before the expected CMP completion date.
- Council needs to be the lead applicant for funding from the NSW Coasts and Estuaries Grant Program. Still, other agencies (i.e., NPWS) can be co-applicants, thereby facilitating access to the 2 to 1 funding from the grants program.
- NPWS aims to increase the agency's coastal management capacity in line with the NSW coastal management framework. The goal is for NPWS coastal management to be totally complementary with the CMP process, acknowledging the unique constraints and mandates of NPWS under the NPW Act.
- Developing the Trial Bay Coast and Foreshore Protection Strategy provides an opportunity to work out a model for integrating NPWS coastal management projects with Council CMPs.

Photo 11 Technical Reference Group workshop 1

Assets and values mapping

The objective of this exercise was to use a large map of the study area to spur discussion about certain assets and values associated with specific areas of the Visitor's Precinct. Stakeholders were split into small groups and asked to write important assets, values, and uses onto sticky notes, which were then placed onto the map, creating a spatial illustration of the assets and values of the study area. The study area was divided into three areas: the northern rocky shoreline, the campground foreshore, and the front beach area. Results from the exercise are summarised in the table on the following page.

Figure 6 Assets and values mapping exercise areas

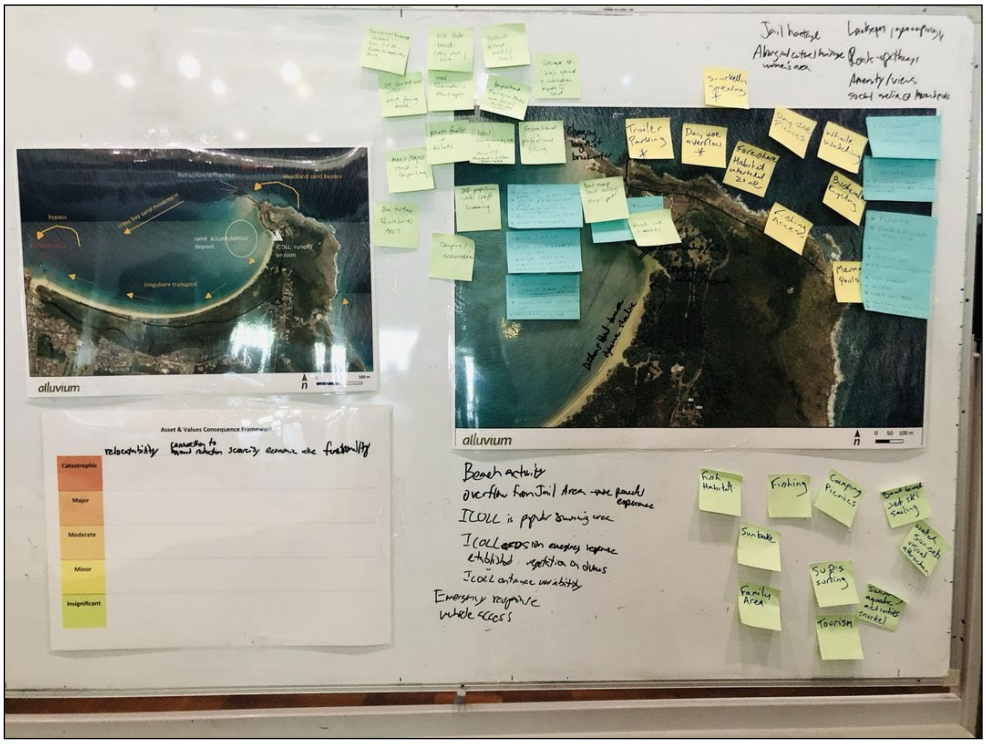


Photo 12 Assets and values map with post-it notes from stakeholders

Table 7 Summary of results from asset and values mapping exercise

Northern rocky shoreline	Campground foreshore	Front Beach area
• Fishing access • Day use overflow • Foreshore habitat and intertidal zone • Picnics • Whale-watching, turtles, and dolphins • Cycling and bushwalks • Parking • Snorkelling and spearfishing • Social/amenity • Rock fishing • Swimming • Photography/Instagram • Landscape and geomorph, viewscapes • Gaol heritage • Aboriginal cultural heritage – stone artefact found near Mermaid pools • Cultural resources and spiritual connections • Habitat, vegetation, terrestrial • Rock platforms • 'Looking out' • Place to be • BBQs/toilet block • Safety and waves • Trailer parking	• Camping • Shallow, calm waters • Access to beach and foreshore • Windsurfing • Safe anchorage and access for boats • Habitat, marine, and terrestrial wildlife • Mainstream cultural – a sense of calm and belonging and relaxation • Conflict of values if reduced space • Beach use • North-east protected • Boat ramp and boat access • Recreational and professional fishing • Local community use and tourism demand and visitor experience (different expectations – mix in a small space) • Picnic facilities and toilets at the top of the embankment • Kayaking, sailboards, catamaran (BYO, need to get to shore) • Access/egress, car parking • Local character, sunsets over water (being able to look to the west) • Aboriginal cultural values – a safe place for children • Drainage off high ground with coastal high tide storm surge • Historic heritage • Sea turtles and shorebirds • Kid-safe beach • Future – commercial businesses? Cultural tours, kayak hire, etc. • Cruise ship proposal – • Sailing and surf lifesaving events • Remnant wharf (also safety risk)	• Beach and water activity • Overflow area • ICOLL corner is the most popular swimming spot, deep pool • Loss of established Banksia (residential properties hard up against them) • ICOLL entrance used to be further down the beach • More secluded/peaceful • Dynamic environment (John commented, not a bad thing necessarily, normally moves back and forth, cycles) • Photos with Arakoon house on seafront • Processes to respond to the dynamic environment • Risk and benefit – multi-tenure benefit (Council, NPWS, commercial fishing) • ICOLL entrance – very dynamic

Considerations for assigning consequence ratings to inform the risk assessment

The objective of this exercise was to determine what elements should be considered when assigning a consequence rating to assets and values to complete a coastal hazard risk assessment to help inform the Trial Bay Coast and Foreshore Protection Strategy.

This exercise was initiated with an explanation of the process for performing a coastal hazard risk assessment by considering the likelihood and consequence of exposure to a hazard and applying the formula, Risk = Likelihood x Consequence, and referring to the risk matrix to be used in the risk assessment. Stakeholders were split into small groups and asked to discuss how to best assign a consequence rating to assets and values considering the context of the study area and perspectives from multiple stakeholders.

Key considerations provided from the group discussion include:

- triple bottom line approach; social, economic, environmental
- Traditional Owner and Aboriginal Cultural values
- ability/inability to relocate an asset or land use
- scarcity of an asset in a local and regional context
- contribution of the asset to coastal hazard reduction
- character and use of the asset in relation to key values and activities associated with the site.

Community Reference Group Workshop 1

Meeting	Community Reference Group Meeting
Project	Trial Bay Visitor Precincts - Coast and Foreshore Protection Strategy
Date & time	Tuesday 9 February 2021, 2:00 pm – 5:00 pm
Venue	South West Rocks Country Club
Attendees	• **Sophia Meehan (Project Manager)** – Manager Landforms and Rehabilitation, NPWS • **Shane Robinson** – Manager Hastings Macleay Area, NPWS • **Ben Stevenson** – Team Leader Rangers Hastings Macleay Area, NPWS • **Josh Chivers** – Senior Project Officer, Landforms and Rehabilitation Unit, NPWS • **Andrew Baker** – Project Officer, Landforms and Rehabilitation Unit, NPWS • **Lisa Walpole** – Project Director, Alluvium Consulting • **Michael Rosenthal** – Project Manager, Alluvium Consulting • **Marcello Sano** – Technical lead, Alluvium Consulting • **Phil Duncan** – Engagement specialist, Alluvium Consulting • **Edward Moran** – South West Rocks Aboriginal Corporation • **Zona Moran** – Dunghutti Elder, South West Rocks Aboriginal Corporation • **Maxine Dickson** – South West Rocks Aboriginal Corporation • **Nancy Pattinson** – South West Rocks Figtree Descendants Aboriginal Corporation • **Ben Carroll** – South West Rocks Figtree Descendants Aboriginal Corporation • **Cheryl Blair** – Dunghutti Elder, South West Rocks Figtree Descendants Aboriginal Corporation • **Ian Burnett** – President SWR Dune Care • **Caroline Adams** – SWR Dune Care • **Max Ingram** – resident of 41 years, former Regional Director, Soil Conservation, ex SRA Trust member • **Jim Crisp** – local resident, on the last of the Trusts with the SRA 1998, interested community member • **Terry Flannagan** – Local resident • **Rod McDonough** – RMS, President Surf Club • **John Schmidt** – DPE, local resident • **Marilyn Breen** – Economic Development & Tourism, Kempsey Shire Council

Photo 13 Community reference group workshop 1

Welcome to Country

Representatives from the Dunghutti People, Aunty Cheryl Blair, Nancy Pattinson, and Ben Carroll welcomed the workshop participants to their Country. The Welcome was delivered in Dunghutti language, along with the sounds of a Yidaki. Along with the Welcome, the workshop group was informed of the Dunghutti name for Trial Bay and the Smoky Cape headland, Wuumung.

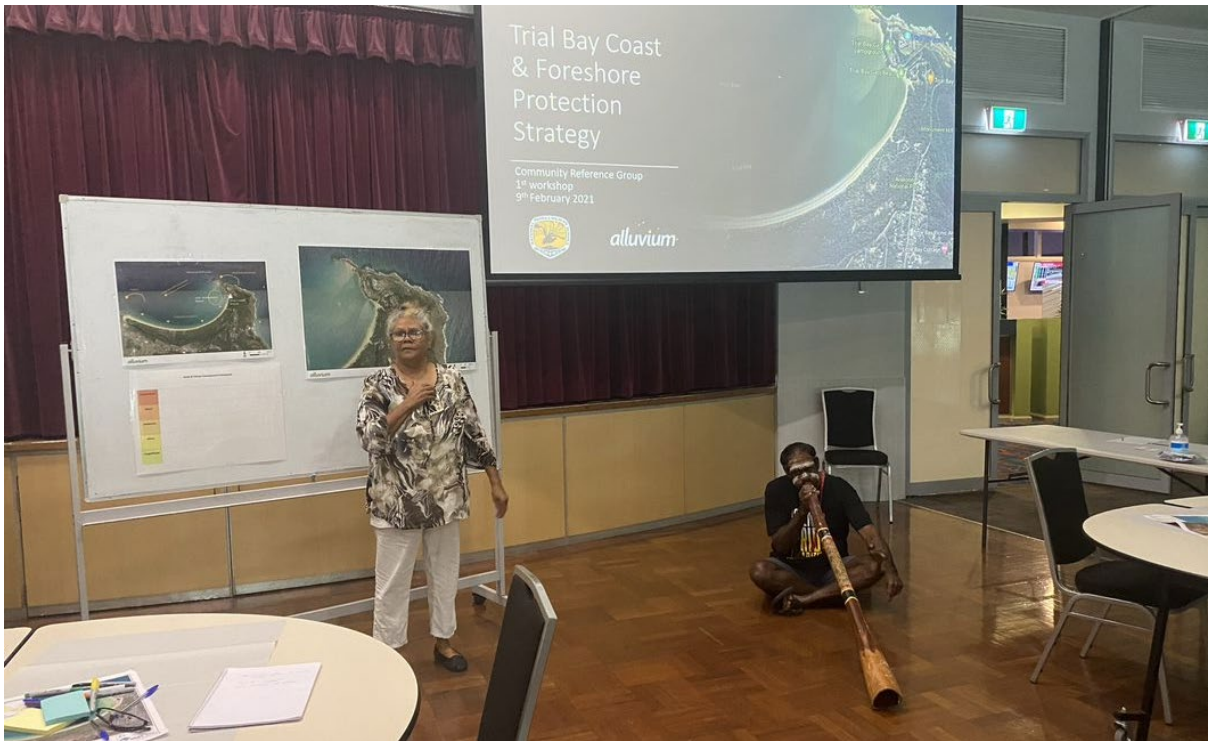


Photo 14 Aunty Cheryl Blair and Ben Carroll welcoming workshop participants to Country

Community historical timeline mapping

The objective of this exercise was to tap into the wealth of local knowledge and experience of the workshop participants to gain a better understanding of the historical evolution of Trial Bay and the surrounding areas. Participants were grouped by table, with each table asked to draw a timeline focusing on important events concerning the headland, Trial Bay Gaol, Laggers Point Breakwater. Information was gathered about the Traditional Owner Dunghutti occupation of the headland and surrounding areas, the early days of settlement, the construction of the gaol and breakwater, the use of the area once the gaol was decommissioned, the role of the area as an internment camp during World War I, and the recent history of the area as a public space, campground, and recreational area.

Table 8 Summary of the Trial Bay community historical timeline

Aboriginal history pre-settlement	Wuumung – the name of the area before South West Rocks Traditional campsites and middens The protected bay was a safe place for families Traditional hunting and gathering of native tucker and medicinal plants Spiritual connection to Country 1770 – The first ship past Smoky Cape, many fires were visible indicating the presence of the Dunghutti People 1816 – *Trial* (ship) wrecked in the bay, perhaps first European contact
Gaol and breakwater construction	1877 – Construction of the gaol begins (initial works completed circa 1890) 1887 – Arakoon House was built, coastline came up to Arakoon House, a beach front property. 1889 – Breakwater construction started, granite from nearby quarry provided construction materials. 1892 – 30m of breakwater lost due to storms 1893 – 36m of breakwater lost due to storms 1897 – 30m of breakwater lost due to storms 1903 – Breakwater construction ceased (303m completed) 1903 – End of official use of the gaol for prisoners
World War I	1915 – 550 German interns during war July 1918 – German internment ceased 1920s – Between wars, valuable iron and woodwork were stripped from the gaol and auctioned. A general trend of sand accretion causing the shoreline to grow seaward. Residents noted that it became further to carry sailboats to the beach.
Early Public Recreation Reserve	1946 – Site declared a Reserve for Public Recreation 1949 and 1951 – Key flood event in Kempsey Aboriginal peoples from up and down the coast used the gaol as somewhere to stay through to the 1950s.
Transfers of management	1963 – Large Macleay River flood event 1965 – Establishment of Trial Bay Gaol Trust to manage ruins 1970 – Key storms/shipwrecks (Jan 1972?) 1972 – Aboriginal Land Trust 1974 – Arakoon State Recreation Area Trust established, and campground established 1987 – NPWS takes over management of ruins and area 2010 – Trial Bay Gaol, Breakwater, and environs listed on the State Heritage Register

Recent storms and damage	2009 – Large storm event, widespread erosion June 2016 – East coast low – breakwall sustained significant damage (as did lots of others up and down the coast) December 2020 – 400mm+ rain, landslip behind the gaol, ICOLL/Runaway Creek rushing out

Assets and values mapping

Similar to the Technical Reference Group workshop activity, the objective of this exercise was to use a large map of the study area to spur discussion about certain assets and values associated with specific areas of the Visitor's Precinct. Stakeholders were split into small groups and asked to write important assets, values, and uses onto sticky notes, which were then placed onto the map, creating a spatial illustration of the assets and values of the study area.

One of the groups comprised representatives from two Aboriginal Corporations (SWRAC and SWR Figtree Descendants AC) who jointly discussed sites, values and uses that carry important significance to the local Aboriginal community. The other groups reflected on the area as a whole and provided notes explaining the local importance of the study area.

A list of sites, values, and uses associated with the study area is provided below:

Notes from the group comprising representatives from two local Aboriginal Corporations:

- **Keeping our culture alive** – This note was provided by one of the Elders who mentioned that the area is important to protect as it would enable the Dunghutti culture to survive.
- **Pandanus People** – The Pandanus plant is a culturally significant species connected to the cultural identity of the Dunghutti People.
- **Camping ground** – The headland was used as a camping ground pre-settlement and after the gaol was used as an internment camp. Local Aboriginal people and travellers would camp in the area. This use was disrupted once the area became a Reserve for Public Recreation.
- **Mermaid Pools, women's business** – This area is a popular tourist attraction that traditionally provided safety and protection to Dunghutti women and is a designated site for women's business.
- **Corroboree 2019** – A Corroboree was held within the study area. This was a chance for the Aboriginal community to gather and celebrate their culture.

Notes from other groups comprising long-term residents, community leaders, and Council staff:

- shallow, safe family beach
- flora and fauna
- dune vegetation
- access for adventure sports, including sailing and diving
- location for arts and cultural events
- importance of cultural events and tourism for local businesses
- recreation and hospitality
- a place for views and interacting with nature
- views west to the mountains and up the coast
- heritage tourism, value of the gaol and other ruins

- boat access
- walking trails
- Caldwell street beach access
- Landcare nursery near depot
- blue bottle protected area
- passive watercraft area, paddling
- recreational fishing
- safe cycling area.

Trial Bay Coast and Foreshore Protection Strategy – Workshop 2

The NSW National Parks and Wildlife Service (NPWS), along with Alluvium Consulting, facilitated a second series of two workshops on 27 April 2021 at the South West Rocks Country Club in South West Rocks, NSW. Like the first workshop series, separate workshops were held for the 2 reference groups (the TRG and the CRG). Key NPWS and Alluvium Consulting staff who comprise the membership of the Project Control Group (PCG) were present at both workshops. The workshops comprised the second of the 2 planned workshop series.

The objectives of the second workshops were to:

1. understand how Trial Bay has changed since the recent flood events
2. review the work to date, including the exposure and risk assessment
3. discuss the adaptation framework, objectives, and responses
4. screen the adaptation options
5. identify project risks, challenges, and possible solutions.

Stakeholders were provided with:

- a brief overview of the coastal processes and hazards assessment key findings
- an overview of the exposure and risk assessment process and results, including the erosion risk maps for present-day and 2100
- a summary of the proposed adaptation objectives for the site
- an overview of the NSW coastal adaptation framework, adaptive management thresholds, and triggers
- a summary of 16 adaptation options relevant to the site.

The CRG was additionally provided an introduction to coastal management approaches to adaptation/protection.

Several group activities were facilitated, with different approaches used for the TRG and CRG workshops, respectively. Like the first series of workshops, these activities were designed to encourage participation by stakeholders. A summary of outputs from each workshop are provided below.

The group activities from the TRG workshop included:

1. discussion and ranking of adaptation objectives exercise
2. facilitated discussion of the adaptation framework, the triggers for accelerated action, and the risks and barriers to implementation at Trial Bay
3. scoring of adaptation options exercise.

The group activities from the CRG workshop included:

1. discussion and ranking of adaptation objectives exercise
2. scoring of adaptation options exercise.

Technical Reference Group Workshop 2

Meeting	Technical Reference Group Meeting 2
Project	Trial Bay Visitor Precincts - Coast and Foreshore Protection Strategy
Date & time	Tuesday 27 April 2021, 10:00 am – 1:00 pm
Venue	South West Rocks Country Club
Attendees	• **Sophia Meehan (Project Manager)** – Manager Landforms and Rehabilitation Unit, NPWS • **Shane Robinson** – Manager Hastings Macleay Area, NPWS • **Ben Stevenson** – Team Leader Rangers Hastings Macleay Area, NPWS • **Elizabeth Jude** – Ranger for Arakoon and Hat Head national parks, NPWS • **Josh Chivers** – Senior Project Officer, Landforms and Rehabilitation Unit, NPWS • **Andrew Baker** – Project Officer, Landforms and Rehabilitation Unit, NPWS • **Lisa Walpole** – Project Director, Alluvium Consulting • **Michael Rosenthal** – Project Manager, Alluvium Consulting • **Marcello Sano** – Technical lead, Alluvium Consulting • **Lyndsay Charlton** – Project support, Alluvium Consulting • **Ron Kemsley** – Senior Natural Resources Officer, Kempsey Shire Council • **Megan Jones** – Kempsey Shire Council • **Rod McDonough** – Manager Operations, Transport for NSW (Newcastle to Tweed Heads) • **John Schmidt** – Senior Coast & Estuary Officer, DPE • **Annette Comerford** – Department of Planning, Industry and Environment – Fisheries

Table 9 Technical Reference Group workshop 2

Discussion on and ranking of adaptation objectives

A discussion regarding the adaptation objectives provided thus far was conducted with the Technical Reference Group (TRG), which includes representatives from the relevant council and state government departments.

TRG members were also asked to rank the 5 most important objectives as they apply to the Trial Bay Visitor's Precinct. Key discussion points included:

- the Visitor's Precinct is already a highly modified environment, so several stakeholders from NPWS do not view habitat and ecosystem conservation as a top objective
- there is confusion regarding the difference between the objectives of 'public safety' and 'safe and easy access for recreational activities.' NPWS suggests tweaking the wording to make the distinction clear.

Results from the ranking exercise are presented in the Figure below:

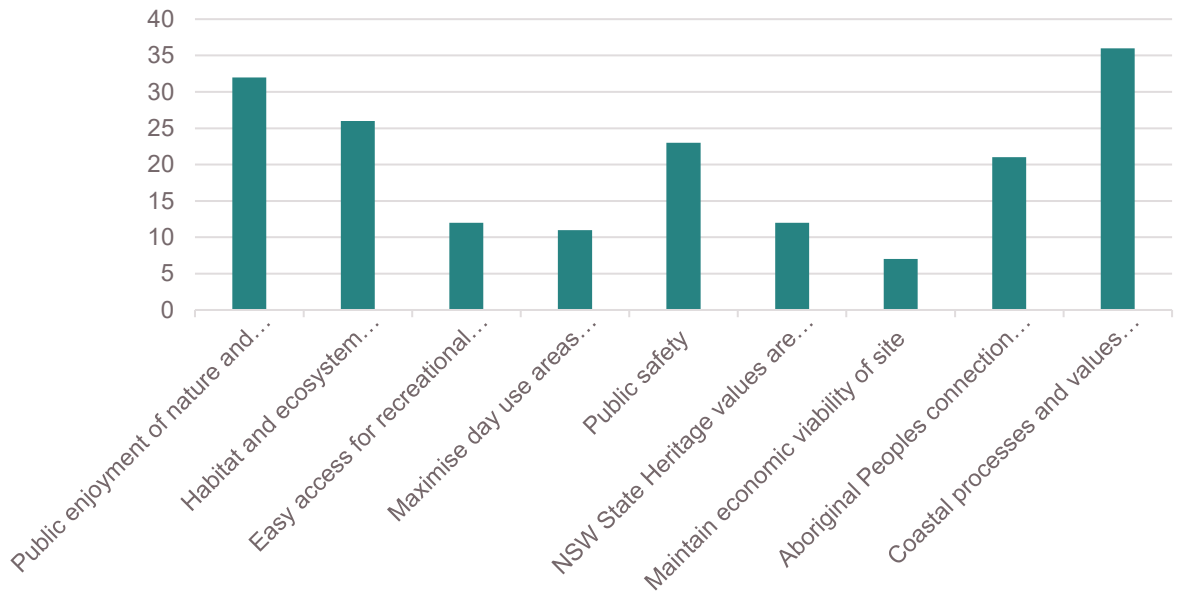


Figure 7 The Technical Reference Group members ranking the 5 most important objectives for the Trial Bay Visitor's Precinct.

Note: a higher score means the objective performed better in the ranking exercise.

Facilitated discussion on coastal adaptation

This discussion's objective was to understand what TRG members would like to see in the Coast and Foreshore Protection Strategy regarding coastal adaptation at Trial Bay, identify the appropriate triggers for accelerated action and determine the risks and barriers to implementation.

Scoring of adaptation options

Workshop participants were briefed on the 16 adaptation options applicable to the site (see following page). They were presented with a matrix comparing the 16 options against the adaptation objectives and asked to give each option a score from 1-5 on how well it achieves each objective (1 being very detrimental to the objective, 2 being somewhat detrimental, 3 being neutral, 4 being somewhat beneficial, and 5 being very beneficial).

Key discussion points included:

The option to watch and review is very unpopular amongst TRG members.

The option for sand bypassing and a back passing system is considered too expensive and visually intrusive for the site.

Dune management option would require more sand being added to the beach and presents a risk for Trial Bay, given that we cannot guarantee the sand won't just erode again.

There is not much scope for groynes; however, there could be temporary pilot sandbags placed at strategic locations.

Participants view relocating assets and altering land use as a medium-term solution, not something short-term (unless it is an emergency response). However, NPWS notes that this will certainly influence their thinking in the shorter-term and when thinking about other plans.

	Adaptation objectives																	
	Public enjoyment of nature and cultural heritage		Habitat and ecosystem conservation		Safe and easy access for recreational activities		Maximise day use areas including dry sandy beach		Public safety		NSW State Heritage values are maintained		Maintain economic viability of site		Aboriginal Peoples connection and access to Country is acknowledged and maintained		Coastal processes and values are preserved	
	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses
Watch and wait (do nothing)	1.3	6	3.0	6	1.8	6	1.3	6	1.2	5	1.7	6	1.7	6	2.4	5	2.3	6
Dune management	4.7	6	4.4	5	3.8	5	3.8	5	3.8	4	3.5	4	3.8	5	4.5	4	3.6	5
Managing public access	4.4	5	3.5	4	4.8	5	4.4	5	4.3	4	3.8	4	4.2	5	3.5	4	3.0	5
Modify assets to increase resilience	4.6	5	3.3	4	4.0	4	4.2	5	4.5	4	4.5	4	4.4	5	3.5	4	3.0	4
Beach scraping	4.8	4	3.0	4	4.3	4	4.0	4	3.3	4	2.7	3	4.5	4	3.3	4	2.4	5
Beach nourishment	4.3	6	2.8	5	4.0	4	4.5	4	3.8	4	3.8	4	4.8	4	3.5	4	2.4	5
Extend/repair breakwater	4.5	8	3.3	8	3.9	7	4.3	9	4.4	8	4.1	9	4.3	8	3.1	7	3.0	7
Seawalls and revetments	4.0	7	2.8	6	4.3	6	3.6	5	4.4	5	4.2	5	4.5	6	3.0	5	2.8	6
Groynes	2.2	5	2.3	4	2.3	4	2.3	4	2.5	4	1.7	3	2.3	4	2.3	4	2.3	4
Offshore reefs	3.0	4	3.2	5	2.7	3	3.0	3	2.0	3	3.0	4	3.3	4	2.3	3	2.0	4
Sand bypassing and back passing systems	2.4	5	2.0	4	2.8	4	3.0	4	2.5	4	2.0	3	3.0	4	2.3	4	2.0	5
ICOLL entrance training	2.8	5	2.6	5	3.0	4	3.0	4	3.0	4	3.0	5	3.0	4	2.8	4	1.8	5
ICOLL berm management	3.3	6	3.0	5	3.3	4	3.3	4	3.0	4	3.7	3	3.3	4	3.5	4	2.6	5
Foreshore levees to prevent inundation	3.8	4	2.8	4	3.0	4	3.3	4	3.5	4	3.3	3	4.0	5	2.8	4	2.8	4
Improve/redesign stormwater drainage	3.8	4	3.0	4	3.8	5	3.3	4	3.5	4	3.6	5	3.0	4	2.8	4	2.5	4
Relocate assets and alter land use	3.3	6	3.5	6	3.0	5	2.4	5	4.0	5	2.8	4	3.2	6	3.2	5	3.8	5

Figure 8 Results from the scoring exercise

	Implementation criteria															
	Cost		Adaptabiliy to future climates		Ease of obtaining approval		Effectiveness in minimising risk				Feasibility for implementing at each study area location					
							Erosion		Inundation		Northern rocky shoreline		Campground foreshore		Front Beach area	
	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses
Watch and wait (do nothing)	5.0	3	1.3	3	5.0	3	1.0	3	1.0	3	5.0	3	5.0	3	4.7	3
Dune management	3.0	2	3.3	3	3.7	3	4.0	3	2.7	3	1.0	1	3.0	2	4.7	3
Managing public access	2.5	2	2.7	3	3.7	3	3.3	3	2.0	3	4.0	1	4.3	3	4.3	3
Modify assets to increase resilience	2.5	2	3.0	3	3.7	3	3.0	3	2.3	3	4.0	1	4.3	3	4.3	3
Beach scraping	3.0	2	1.7	3	3.0	2	2.7	3	2.0	2		0	2.0	1	3.5	2
Beach nourishment	4.0	2	2.7	3	4.0	2	2.7	3	2.0	2		0		0	3.5	2
Extend/repair breakwater	2.3	3	4.0	4	1.0	3	4.3	4	3.3	3	3.0	1	4.0	3	4.3	3
Seawalls and revetments	2.7	3	3.5	4	2.7	3	3.5	4	3.0	3	3.0	1	4.7	3	3.0	3
Groynes	2.5	2	2.0	3	1.0	2	2.7	3	1.0	2		0	2.0	2	2.0	2
Offshore reefs	3.0	2	3.0	3	1.0	2	3.7	3	1.5	2		0	3.0	2	3.5	2
Sand bypassing and back passing systems	2.5	2	2.7	3	1.5	2	3.7	3	1.5	2		0	3.5	2	3.5	2
ICOLL entrance training	2.5	2	2.3	3	2.5	2	3.3	3	1.5	2		0	2.0	1	3.5	2
ICOLL berm management	3.5	2	3.3	3	2.5	2	2.7	3	2.0	2		0	4.0	1	3.5	2
Foreshore levees to prevent inundation	3.5	2	2.7	3	3.5	2	3.3	3	4.0	2		0	3.5	2	3.5	2
Improve/redesign stormwater drainage	4.0	2	3.3	3	3.0	2	4.3	3	4.5	2		0	4.5	2	4.5	2
Relocate assets and alter land use	3.7	3	4.5	4	3.7	3	2.3	4	3.0	3	4.0	2	3.3	3	3.0	3

Figure 9 Results from the scoring exercise

Community Reference Group Workshop 2

Meeting	Community Reference Group Meeting
Project	Trial Bay Visitor Precincts - Coast and Foreshore Protection Strategy
Date & time	Tuesday 27 April 2021, 2:00 pm – 5:00 pm
Venue	South West Rocks Country Club
Attendees	• **Sophia Meehan (Project Manager)** – Manager Landforms and Rehabilitation Unit, NPWS • **Shane Robinson** – Manager Hastings Macleay Area, NPWS • **Ben Stevenson** – Team Leader Rangers Hastings Macleay Area, NPWS • **Josh Chivers** – Senior Project Officer, Landforms and Rehabilitation Unit, NPWS • **Andrew Baker** – Project Officer, Landforms and Rehabilitation Unit, NPWS • **Lisa Walpole** – Project Director, Alluvium Consulting • **Michael Rosenthal** – Project Manager, Alluvium Consulting • **Marcello Sano** – Technical lead, Alluvium Consulting • Lyndsay Charlton – Project support • **Cheryl Blair** – Dunghutti Elder, South West Rocks Figtree Descendants Aboriginal Corporation • **Max Ingram** – resident of 41 years, former Regional Director, Soil Conservation, ex SRA Trust member • **Jim Crisp** – local resident, on the last of the Trusts with the SRA 1998, interested community member • **Terry Flannagan** – Local resident • **Alan Hill** – South West Rocks Dune Care representative • **Alan Yuille** – South West Rocks Dune Care representative

Welcome to Country

Aunty Cheryl Blair, a representative from the Dunghutti People, welcomed the workshop participants to Country. The Welcome was delivered in Dunghutti language.

The group activities from the CRG workshop included:

1. discussion and ranking of adaptation objectives exercise
2. scoring of adaptation options exercise.

Discussion on and ranking of adaptation objectives

Similar to the Technical Reference Group exercise, a discussion regarding the provided adaptation objectives was conducted with the Community Reference Group (CRG). The objective of this exercise was to gain an understanding of the relative importance of each objective to the community members. Members were asked to rank, in their opinion, the five most important objectives as they apply to the Trial Bay Visitor's Precinct.

Key discussion points included:

- The importance of increasing community understanding of the beach system/ecosystem through education and doing it in a fun and engaging way.
- Public enjoyment is crucial and is what should ultimately be maintained.
- There is the opinion that back in the days when Trial Bay was owned in Trust by its community members, they had a better understanding of what was going on. They would like to be more educated and kept in the loop.

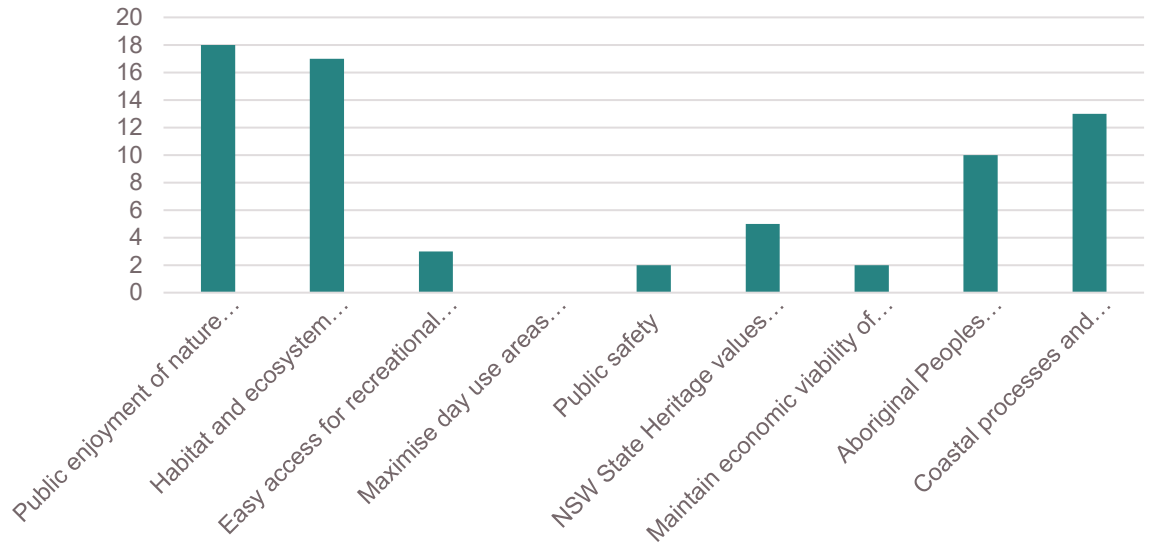


Figure 10 Weighted results from the ranking exercise.

Note: a higher score means the objective performed better in the ranking exercise.

Discussion and scoring of adaptation options

Participants were briefed on the 16 adaptation options applicable to the site, and a discussion of the suitability of these options ensued. Participants were presented with a matrix comparing the 16 options against the adaptation objectives and asked to give each option a score from 1-5 on how well it achieves each objective (1 being very detrimental to the objective, 2 being somewhat detrimental, 3 being neutral, 4 being somewhat beneficial, and 5 being very beneficial).

Key discussion points included:

- Dune Care representatives think it is best to let the beach 'take its natural course' and not try to prevent erosion. They note that the beach's shoreline was historically much further back anyway, and there will always be an intertidal zone no matter the position of the shoreline.
- NPWS cannot take the same view of 'let the beach take its natural course' from a planning perspective – beautification and community amenity works need the beach to remain largely as it is. If NPWS wants to take proactive measures rather than reactive, they can do something sensible, keep those values intact the best they can, and accept that things change.
- Unless something active is done to maintain or repair Laggers Point Breakwater, it will not stay in place over the next 50 to 100 years. It is listed on the State heritage register, which may be a mechanism to gain funding for its repair.
- Half of the community participants are in support of maintaining the breakwater.
- NPWS thinks that moving the natural granite boulders, given this low-energy environment seems like it has a higher chance of success.
- There is not much scope for groynes; however, there could be temporary pilot sandbags placed at strategic locations. Participants were generally in support of this idea.
- Most participants supported ICOLL entrance training as an option; however, a couple were unsure as they saw the changing wave energy as an unknown risk. A compromise could be reached with a pilot geotextile structure to see how it affects the site.

	Adaptation objectives																	
	Public enjoyment of nature and cultural heritage		Habitat and ecosystem conservation		Safe and easy access for recreational activities		Maximise day use areas including dry sandy beach		Public safety		NSW State Heritage values are maintained		Maintain economic viability of site		Aboriginal Peoples connection and access to Country is acknowledged and maintained		Coastal processes and values are preserved	
	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses	Average score	# of responses
Watch and wait (do nothing)	3.2	5	3.6	5	1.8	5	3.0	5	2.2	5	3.6	5	2.8	5	3.8	5	4.2	5
Dune management	4.2	5	4.6	5	4.0	5	3.4	5	3.6	5	4.0	5	3.8	5	4.2	5	4.6	5
Managing public access	4.8	4	4.0	4	5.0	4	4.3	4	4.8	4	3.5	4	4.3	4	4.0	4	3.3	4
Modify assets to increase resilience	4.7	3	3.7	3	4.3	3	4.3	3	4.3	3	4.0	3	4.3	3	2.7	3	3.0	3
Beach scraping	4.3	3	3.7	3	3.7	3	4.3	4	4.0	3	3.7	3	4.0	3	2.7	3	3.7	3
Beach nourishment	1.5	2	2.0	2	2.0	2	2.5	2	2.0	2	1.0	2	2.0	2	1.0	2	2.0	2
Extend/repair breakwater	4.0	3	2.7	3	3.7	3	4.0	3	3.7	3	4.0	3	4.0	3	2.7	3	3.3	3
Seawalls and revetments	4.5	2	4.0	2	4.0	2	4.0	2	4.5	2	3.5	2	4.0	2	3.0	2	3.5	2
Groynes		0		0		0		0		0		0		0		0		0
Offshore reefs		0		0		0		0		0		0		0		0		0
Sand bypassing and back passing systems		0		0		0		0		0		0		0		0		0
ICOLL entrance training	4.0	3	3.7	3	4.7	3	4.7	3	4.3	3	4.0	3	4.0	3	3.0	3	2.5	2
ICOLL berm management	4.0	1	4.0	1	3.0	1	3.0	1	3.0	1	3.0	1	3.0	1	3.0	1	2.0	1
Foreshore levees to prevent inundation	2.0	1	2.0	1	3.0	1	3.0	1	3.0	1	3.0	1	3.0	1	3.0	1	1.0	1
Improve/redesign stormwater drainage		0		0		0		0		0		0		0		0		0
Relocate assets and alter land use	4.0	2	4.0	2	4.0	2	4.0	2	4.5	2	3.0	2	4.0	2	4.0	2	4.0	2

Figure 11 Results from the scoring exercise

	Acceptability					
	Acceptability for implementing at each study area location					
	Northern rocky shoreline		Campground foreshore		Front Beach area	
	Average score	# of responses	Average score	# of responses	Average score	# of responses
Watch and wait (do nothing)	3.7	3	2.7	3	2.3	3
Dune management	3.3	3	3.0	3	4.7	3
Managing public access	4.3	3	4.3	3	5.0	3
Modify assets to increase resilience	3.7	3	4.0	3	4.3	3
Beach scraping	2.0	3	2.7	3	2.0	3
Beach nourishment	2.7	3	2.3	3	2.7	3
Extend/repair breakwater	4.5	2	4.3	3	4.3	3
Seawalls and revetments	2.3	3	1.3	3	1.3	3
Groynes		0		0		0
Offshore reefs		0		0		0
Sand bypassing and back passing systems	1.0	1	1.0	1	1.0	1
ICOLL entrance training	2.0	1	2.5	2	2.5	2
ICOLL berm management	4.0	2	3.5	2	4.0	2
Foreshore levees to prevent inundation	1.0	1	1.0	1	1.0	1
Improve/redesign stormwater drainage	1.0	1	4.0	1	5.0	1
Relocate assets and alter land use	2.0	2	3.0	2	4.0	2

Figure 12 Results from the scoring exercise

Appendix 5: Coastal Processes Hazard Assessment Report

alluvium

REPORT:

Coastal Processes and Hazard Assessment
Trial Bay Coast and Foreshore Protection Strategy

March 2021

Document history

Revision:

Revision no.	01
Author/s	M. Sano M. Rosenthal
Checked	A. Brook
Approved	A. Brook

Distribution:

Revision no.	01
Issue date	February 2021
Issued to	Sophia Meehan (NPWS); Josh Chivers (NPWS)
Description:	Trial Bay Coastal Processes and Hazards Assessment Report

Citation:

Please cite as: NPWS (2021). Coastal Processes and Hazard Assessment Report for the Trial Bay Coast and Foreshore Protection Strategy. Report by Alluvium to National Parks and Wildlife Services.

Executive summary

A coast and foreshore hazard assessment has been carried out to refine the understanding of coastal hazards such as beach recession, foreshore erosion, coastal inundation, and sea level rise. The full Trial Bay Visitor's Precinct Coast and Foreshore Hazard Assessment Report (Alluvium, 2021) is provided in Appendix E.

The Coast and Foreshore Hazard Assessment Report consists of two parts:

1. A review of regional and local coastal processes driving beach dynamics, sediment transport and shoreline realignment, including a conceptual model of the system.

2. A review of coast and foreshore hazards and their extents based on the existing information and revision of coastal hazard extents based on up to date data, and in the context of the CM Act.

Below is a summary of key findings:

- The area of study, particularly the sandy shoreline adjacent to Laggers Point, has been suffering from increasing erosion in the past ten years, with recorded shoreline realignment of approximately 30 m in its eastern corner, reflecting a loss of sand volume for the whole beach profile.

- Based on the current observations, the existing hazard extents identified by in the Kempsey Coastal Processes and Hazard Definition Study (BMT, 2013) (2013 Hazard Definition Study) underestimated the erosion risk to the eastern part of the beach by approximately 30 m. Analysis of the recent shoreline movement over the last ten years supports an amendment of the existing hazard lines in this eastern section. For the western section, the hazard lines remain appropriate and have been retained in their original form.

- Laggers Point breakwater is the main control point responsible for shoreline alignment in Trial Bay, and it has been responsible for the substantial shoreline accretion of approximately 200 m at its widest point since its construction in the 1890s. Degradation of the Laggers Point breakwater would alter the existing control point, resulting in recession, with a potential worst-case scenario of pre-construction beach alignment if the breakwater were completely lost. However, it should be noted this is an extreme worst-case, and even if the breakwater were left to degrade totally, the resulting rubble would still create a control point seaward of the original pre-1890s position.

- Recent observed changes to the shoreline alignment can be caused by a combination of factors, with the following factors being the main controls:

    - long-term climate variability and changes to the wave climate, which may alter the equilibrium form of the beach,

    - changes in the volume of sediment supplied by the longshore sediment transport system around Laggers Point, which may have reduced the overall amount of sand inside the embayment

    - the impact of sand distribution on the offshore banks in recent years, which may have created an end-effect at the end of the sand slug triggering erosion to the exposed area

    - changes in the shape and size (i.e., degradation) of Laggers Point breakwater.

Findings of this study and mapping will be used to develop the Coast and Foreshore Protection Strategy for Trial Bay Visitor Precincts.

Contents

Tables

Figures

1 Introduction

The NSW National Parks and Wildlife Service, in partnership with Alluvium Consulting Australia Pty Ltd (Alluvium), and the community, are developing a Coast and Foreshore Protection Strategy for Trial Bay Visitor Precincts.

This Coast and Foreshore Hazard Assessment is divided into two parts:

1. A review of regional and local coastal processes driving beach dynamics, sediment transport and shoreline realignment, including a conceptual model of the system (Section 2).

2. A review of coast and foreshore hazards and their extents based on the existing information and revision of coastal hazard extents based on up to date data, and in the context of the *Coastal Management Act 2016* (Section 3).

This Coast and Foreshore Hazard Assessment does not intend to replace the existing coastal hazard assessment (BMT 2013) but serves as an update of the findings of that study to better inform the Coast and Foreshore Protection Strategy for Trial Bay Visitor Precincts based on recent local shoreline trends.

2 Coastal processes

The Trial Bay Visitor's precinct is situated within the Arakoon National Park at the northern end of the Smoky Cape Headland. The northern end of the headland forms a peninsula with Trial Bay directly to the east. The foreshore of the Visitor's precinct is a rare example of a western facing shoreline. A map of the location is provided in Figure 1.

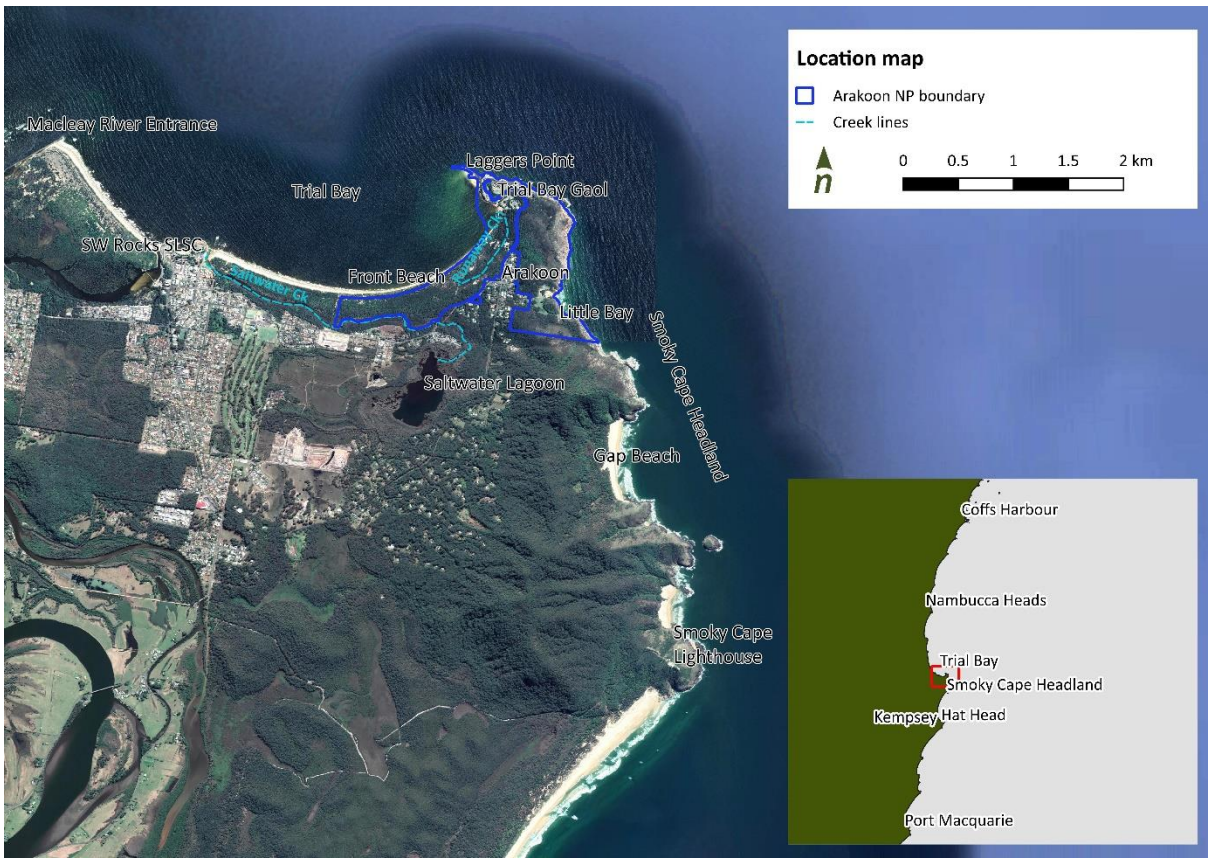


Figure 1. *Location map*

The coastal processes that influence the shorelines of Trial Bay involve not only the immediately surrounding coastal zone, but also adjacent regional systems that interact with the Smoky Cape headland, the east coast of Australia, and even further afield. Astronomical tides and broadscale meteorological events contribute to sea level variance and sediment transport processes. Seasonal wind and weather patterns accompanied by storms occasionally passing through the region create a variable coastal climate with a cumulative effect over time determining the shape of the shoreline. Sediment transport occurs across the whole beach profile, from the upper beach and dunes to the submerged lower limit of the beach – at a depth which depends on the power of the waves – the bigger the waves, the deeper is the lower limit of sand transport.

The coastal climate is also affected by long term climate variability events, such as El Niño and La Niña. Global climate change can trigger changes in the sea level and alter the power and direction of the waves over time. Understanding these coastal processes, and how they are projected to change in the future, enables planning and adaptation for when they threaten assets and values and therefore become hazards.

2.1 Waves

The wave climate of the east coast of Australia is driven by a sequence of storm-generated waves from the S, SE, E, and NE directions. In winter, waves predominantly come from S and SE directions, while waves from the E and NE directions occur more frequently during the summer months. The predominance of the S and SE waves facilitates the northerly longshore sediment transport along the east coast of Australia while NE waves occasionally transport sand in the opposite direction. Figure 2 illustrates the wave climate for Trial Bay. Data from Crowdy Head was used due to the proximity of the Crowdy Head Waverider buoy, of the NSW observation network, to the study site.

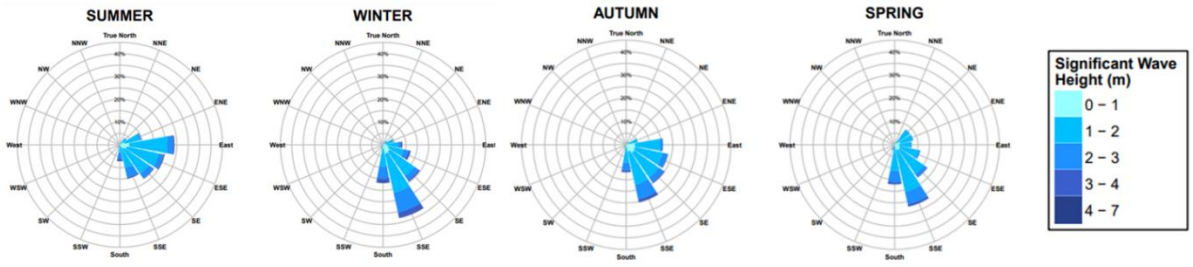


Figure 2. *Wave climate at Crowdy Head, NSW. (Manly Hydraulics Laboratory 2020).*

The predominant wave direction for Trial Bay comes from approximately the SE direction, triggering a net northbound sediment transport potential. Due to the shape of the headland and the alignment of the shoreline at Trial Bay net sediment transport within the bay is effectively in a westerly direction.

Extreme wave analysis shows that for any given year the extreme waves are likely to exceed 5 m Hs (significant wave height for the 1 year ARI) and can be in excess of 8 m Hs (significant wave height for the 100 year ARI) (Table 1). Again, data from the Crowdy Head Waverider buoy was used due to its proximity to the study site.

Table 1. Extreme wave analysis results for Crowdy Head (Glatz et al. 2017)

ARI (yr)	Extreme Wave Analysis Results per Durations									
	1 hour		3 hours		6 hours		12 hours		24 hours	
	Hs (m)	CI (±m)	Hs (m)	CI (±m)	Hs (m)	CI (±m)	Hs (m)	CI (±m)	Hs (m)	CI (±m)
1	5.4	0.2	5.0	0.2	4.7	0.2	4.4	0.1	3.8	0.1
2	5.9	0.2	5.4	0.2	5.1	0.2	4.7	0.2	4.1	0.1
5	6.5	0.3	6.0	0.3	5.6	0.2	5.2	0.2	4.4	0.2
10	7.0	0.3	6.4	0.3	6.0	0.3	5.5	0.2	4.7	0.2
20	7.4	0.3	6.8	0.3	6.4	0.3	5.9	0.3	4.9	0.2
50	8.0	0.4	7.3	0.4	6.8	0.3	6.3	0.3	5.1	0.2
100	8.4	0.4	7.7	0.4	7.2	0.4	6.5	0.3	5.3	0.3

Waves approaching the shoreline are subject to shoaling, diffraction and refraction. With shoaling, the waves increase in height and decrease their period before breaking over the beach. With diffraction, the wave bends its front over irregular bathymetry, with waves decelerating over shallow areas and continuing its course over deeper areas. With diffraction, the waves bend around breakwaters, even in the absence of a shallow bathymetry interaction.

Wave trains travelling into Trial Bay are naturally affected by the shape of the headland, the ever-changing bathymetry and, in the past 120 years, by the Laggers Point breakwater. This results in wave shoaling, diffraction and refraction which, in turn, is responsible for the uneven distribution of the energy on its shorelines, influencing sediment transport and beach realignment.

2.2 Water levels

Total water levels are based on a combination of the astronomical tides, driven by the gravitational forces of the moon and the sun, and by the combination of the effect of winds and waves breaking on the ocean surface and the shore.

The east coast of Australia has semi-diurnal tides (two high tides and two low tides every 24 hours) with a mean spring range of 1.2 m while the mean neap range of 0.8 m. Tidal range varies along the coast with an increase of around 0.2 m from south to north (Manly Hydraulics Lab 2018). The Highest Astronomical Tide (HAT) at South West Rocks is 1.6 m according to the official navigation charts data (Table 2).

Table 2. Tidal levels referred to Datum of Sounding (ref)

Place	Lat	Long	HAT	MHHW	MLHW	MSL	MHLW	MLLW
South West Rocks	30° 54’	153° 01’	1.6	1.3	0.8	0.7	0.6	0.1

In addition to the astronomical tide, storms can trigger a temporary increase in the water level, combining the effects of low atmospheric pressure, water accumulation towards the shore caused by strong winds and breaking waves (wave set up). In NSW, this temporary increase in the water level is mainly caused by two types of storms:

1. Extra-tropical cyclones, tracking south of the tropics and bringing higher than usual water levels for a short period of times (hours).

2. East Coast Lows, a weather system causing large waves from the East, which can increase water levels for longer periods (days).

In addition to low atmospheric pressure and wave set up, the wave run-up determines the highest point reached by a wave, through its final wave dissipation on the shoreface, with wave energy being transferred to water flow moving towards the dune system or other natural or artificial obstacles (Figure 3).

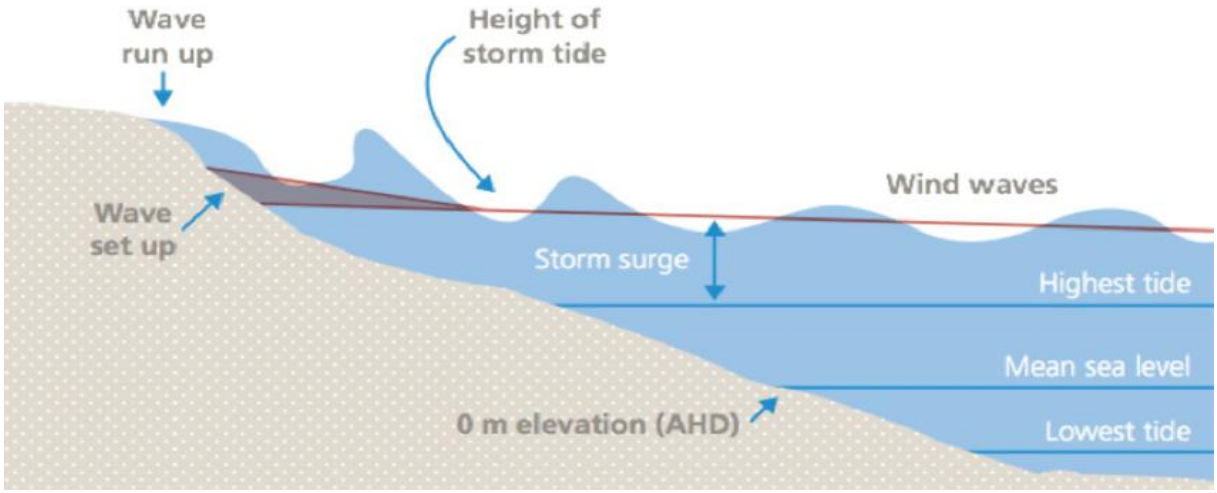


Figure 3. *The total water level is determined by the combination of the tide, storm surge, wave set up and wave run up.*

The total water level for present day in the area of study, excluding wave run up, has been estimated by BMT (2013) for the purposes of coastal hazard planning and based on Fort Denison (Sydney Harbour) data at approximately 2.7 m for a 100 year ARI event in 2013. Assuming approximately 3 mm of sea level rise per year since 2013 (Port Kembla data, see Table 4), this would result in an additional 2.4 cm of sea level rise for the year 2021 (Table 3). The 2050 extreme water level has been reproduced from BMT (2013).

Table 3. Total water level for the current year (BMT 2013)

	Current Year					
ARI (years)	**Still Water Level (Fort Denison) (m AHD)**	**1 hr duration wave height (m)**	**Wave setup (m) (15% of wave height)**	**Extreme Water Levels (m AHD)**	**Extreme water level (m AHD) 2021**	**Extreme water level (m AHD) 2050**
20	1.38	7.40	1.11	2.5	2.52	2.9
100	1.44	8.60	1.29	2.7	2.72	3.2
100 (extreme storm conditions)	1.64	8.60	1.29	2.9	2.92	3.4

2.3 Climate variability

Wind regimes, and consequently the wave climate, can be affected by large scale interannual climate variability, mostly driven by long term temperature changes at the global scale beyond seasonal changes. These changes are mostly temporary oscillation with periods measured in months to years, as opposed to human-induced climate change, which has longer term implications. The most important and better understood of these processes for the east coast of Australia is the El Niño Southern Oscillation (ENSO), which occurs with oscillation in the sea surface temperatures in the central and eastern tropical Pacific Ocean. On Australia's coast, El Niño is mostly associated with drier and less stormy conditions, while La Niña is associated with wetter and stormier conditions.

After approximately 5 years of El Niño, the east coast of Australia, including Trial Bay, is currently (February 2021) under the influence of La Niña, with wetter conditions and stormier seas.

The Interdecadal Pacific Oscillation (IPO) is a longer term process oscillating over a period of decades (15-30 years), with temperature changes stretching from the southern hemisphere into the northern hemisphere. Although still poorly understood, it appears that a negative IPO index has the potential to increase shoreline erosion on the East Coast of Australia (Kelly et al. 2018). As of today (2021) it appears that we are in a strongly

negative period of IPO (NOAA 2021), which has been associated with of higher sea level, increased storminess, and beach erosion (Helman and Tomlinson 2018).

2.4 Climate change

The impacts of human induced climate change include sea level rise and possible changing in the intensity and direction of storms, which ultimately alters the wave climate. While sea level rise has been observed for more than a century, and is projected into the future with climate models, high uncertainty remains around its impact on storms and waves.

The latest projections of sea level rise show a possible rise in global sea levels of approximately 0.3 m to 1.2 m by 2100 (CSIRO 2021) with sea level continuing to rise without breakthrough changes in technology and behaviour in the coming decades. Observations of sea level rise along the Australian coast of approximately the past 30 years confirm a rise of approximately 4 mm per year (average value around Australia), with a lower value of 3.4 mm per year observed at the only NSW station in Port Kembla (BOM 2021 and Table 4). Sea level rise causes inundation of the upper beach and changes in the beach profile causing gradual and constant recession of the shoreline average position. This phenomenon can be explained with the Bruun Rule (Bruun 1962, which correlates the rate of shoreline recession with the rate of sea level rise, combined with other parameters such as depth of closure of the active beach, dune height, slope and grain size. More sophisticated modelling approaches, such as the SEM (Shoreline Erosion Model), also account for wave propagation parameters and bathymetric features and changes over time. A combination of both models was applied to the Kempsey Shire coast by BMT (2013) showing a potential recession of 25 m in 2050 and up to 65 m in 2100. Updated observations of sea level rise rates are included below (BOM 2020) with an observed relative sea level current sea level rise rate of 3.4 mm per year at Port Kembla (Table 4).

Table 4. Overall rates of sea level movement based on SEAFRAME data from installation through December 2020 (BOM 2020)

Location	Date of first data capture	Rate (mm/yr)
Cocos Island	September 1992	7.1
Groote Eylandt	September 1993	4.0
Darwin	May 1990	5.5
Broome	November 1991	5.6
Hillarys	November 1991	6.2
Esperance	March 1992	4.3
Thevenard	March 1992	4.1
Port Stanvac	June 1992	4.7
Portland	July 1991	2.8
Lorne	January 1993	2.4
Stony Point	January 1993	2.5
Burnie	September 1992	2.9
Spring Bay	May 1991	3.5
Port Kembla	July 1992	3.4
Rosslyn Bay	June 1992	4.9
Cape Ferguson	September 1991	4.8
Thursday Island	May 2015	11.2

2.5 Regional Geology

Regional geology determines the orientation of the coastline, the width and slope of the continental shelf, the type and location of headlands, reefs and other structures, embayment width and sediment grain size and type. In general, the NSW coast is controlled by the rock substrate of the continent and the continental shelf, which prevalently consists of granitoid and sedimentary rock (Figure 4).

Figure 4. *General geology of Trial Bay*

2.6 Coastal geomorphology

The rapid post-glacial sea level rise and subsequent period of mid to late Holocene sea level stability has created the conditions for landward migration of the shoreline and readjustment to a new equilibrium with modern coastal processes and sediment supply (Harvey 2006). This has occurred over and around the existing rocky substrate, which emerges on the east coast of Australia in the form of headlands, rocky points and outcrops, providing control points for active modern beaches shape and sizes. The shoreline of Trial Bay combines the hard granite substrate of the headland with more sand deposits of various ages, from more recent deposits on the east side of the beach, to older deposits towards the back and the west of the area of study. This is a typical configuration for the east coast of Australia, which often alternates rocky headlands with soft sedimentary environments, resulting from the Holocene transgression and sea level stability of the past 3,000 years, where sedimentary environments have been consolidating and being covered by vegetation.

2.7 Bathymetry and beach profiles

Water depth affects waves propagation, in particular wave shoaling (increasing wave height and reduced wave period and speed when the wave transfers its energy through the water column, triggering sand movement in sandy bottoms) and wave refraction (change in the wave front alignment due to wave-bottom interaction and reduction in the speed of the wave over shallow waters). This, together with sediment supply in and out of the system, determines the depth and shape of sandy sea floors with the formation of sand banks and sand bars over time. The bathymetry is also a proxy for the overall shape of the beach, which should be considered as a dynamic three dimensional body of sand from the landward limit of the dune system (usually the vegetation line) to the closure depth (the water depth to which sand transport occurs during the strongest storms), which is determined by the wave climate of the area of study.

While the open coast depth of closure for Kempsey Shire can be estimated at about 14 m (BMT 2013), the depth of closure For Trial Bay can be estimated at approximately 6-10 m, with sand accumulation, sand banks and shallower waters being concentrated in the protected side of Laggers Point breakwater (Figure 5). The available bathymetry shows how waves will be diffracted and refracted around Laggers Point, with sand accumulating inside the protected bay. A more detailed, recent bathymetry, however, would be required to better understand the possible effects of sand banks on wave energy dissipation and concentration, to better understand erosion triggers in critical areas south of Laggers Point.

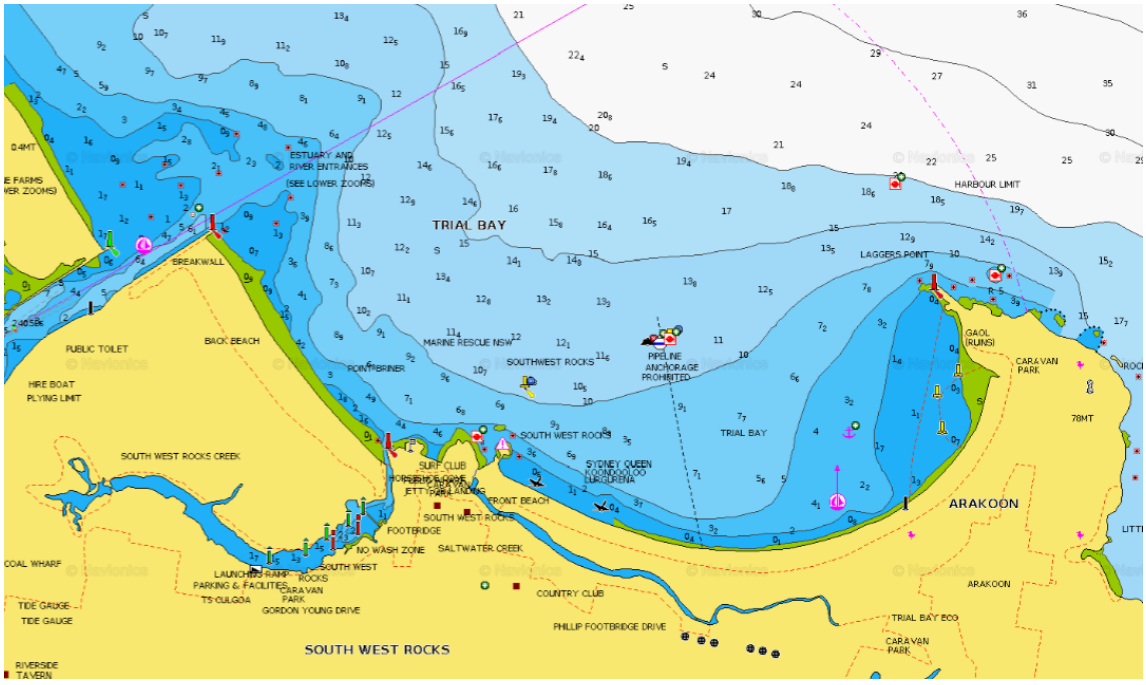


Figure 5. *Bathymetry of Trial Bay for navigation purposes (Navionics 2021)*

2.8 Sediment compartments

A coastal sediment compartment is an area in which coastal processes, and their effects on the geology of the coast, are broadly homogeneous. The Australian coast has been divided into primary and secondary sediment compartments (Short 2020). The compartment boundaries are usually a feature such as a headland or river mouth which effectively divides the compartment and its processes from its neighbour (Thom et al. 2018, CoastAdapt 2021). Trial Bay sits within the primary sediment compartment NSW 02 which spans from Yamba Point to Laggers Point. It sits within the secondary sediment compartment NSW01.02.05 which spans from Nambucca North Heads to Laggers Point and includes the Macleay River and its catchment (Figure 6). Sediment compartments often have inputs and outputs of sand from and into adjacent compartments, due to sediment transport processes and headland bypassing, driven in particular by larger storms.

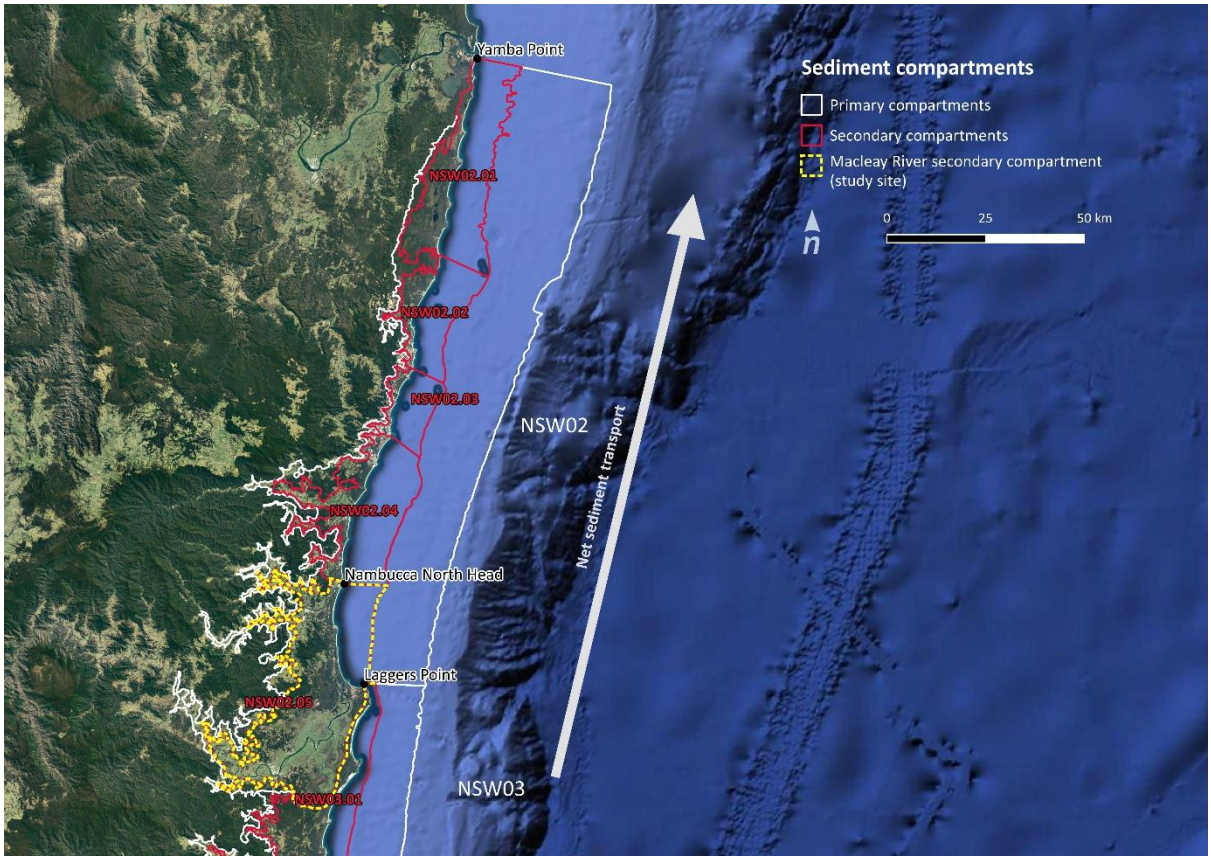


Figure 6. *Coastal sediment compartments (Short 2020)*

2.9 Sediment transport and headland bypassing

Sediment transport is often calculated using the CERC formula which correlates the longshore sediment transport rate to the longshore wave energy flux, combining wave height at the breaker line and its angle (Shore Protection Manual, 1984). Sediment transport within compartment NSW01.02.05 is estimated, using the CERC formula, to be approximately a net of 45,000 m^3 /yr northwards, or in general, upstream towards the main direction of transport (BMT 2013). This represents the net sediment transport, however, sediment movements both upstream and downstream direction may occur throughout the seasons and years, depending on the prevalent wave energy at a given time. It is important to clarify that the net sediment transport on the NSW coast is from the South to the North along the shoreline. However, shoreline orientation can vary, affecting the angle of the incident waves and sediment transport. For Trial Bay's corner affected by erosion, for example, an upstream (North) sediment transport results in sand movement from the NE to SW along the beach.

Even if it appears that headlands are sufficiently prominent to suggest a closed boundary of the sediment compartment, significant wave and tide-driven sediment transport is likely to occur beyond the headland base

during extreme events, especially at low water levels, with tidal currents capable of increasing the closure depth by approximately 30 % (Valiente et al. 2019). This process is quite clear for Trial Bay, where the closure depth appears to be offshore from Laggers Point, in particular during large storms and lower tides, allowing for sediment bypass into Trial Bay and, on the other end, across South West Rock and the Macleay River training walls.

Climate variability has a significant impact on headland bypassing and sand supply rates which is mainly controlled by the angle of the incident waves. The highest rates of transport of approximately 44,000 m^3 /yr occur with SE wave climate. More moderate sand transport of approximately 29,100 m^3 /yr coincides with a more easterly wave climate and a low sediment transport rate of 16,000 m^3 /yr with southerly conditions (Goodwin et al. 2020). The correlation between predominant wave direction and rates of headland bypassing in the period from 1889 to 1988 is illustrated in Figure 7.

In addition, there is a potential for sediment contribution into the nearshore system from the two coastal lagoons in the area, Saltwater Creek and Runaway Creek. Over time, sediments tend to accumulate in these lagoon systems, in particular in the upper beach berm. Sand can be released back into the nearshore during heavy rain and runoff events, however the contribution of this sand and sediments from its catchment is likely negligible to the overall sediment budget.

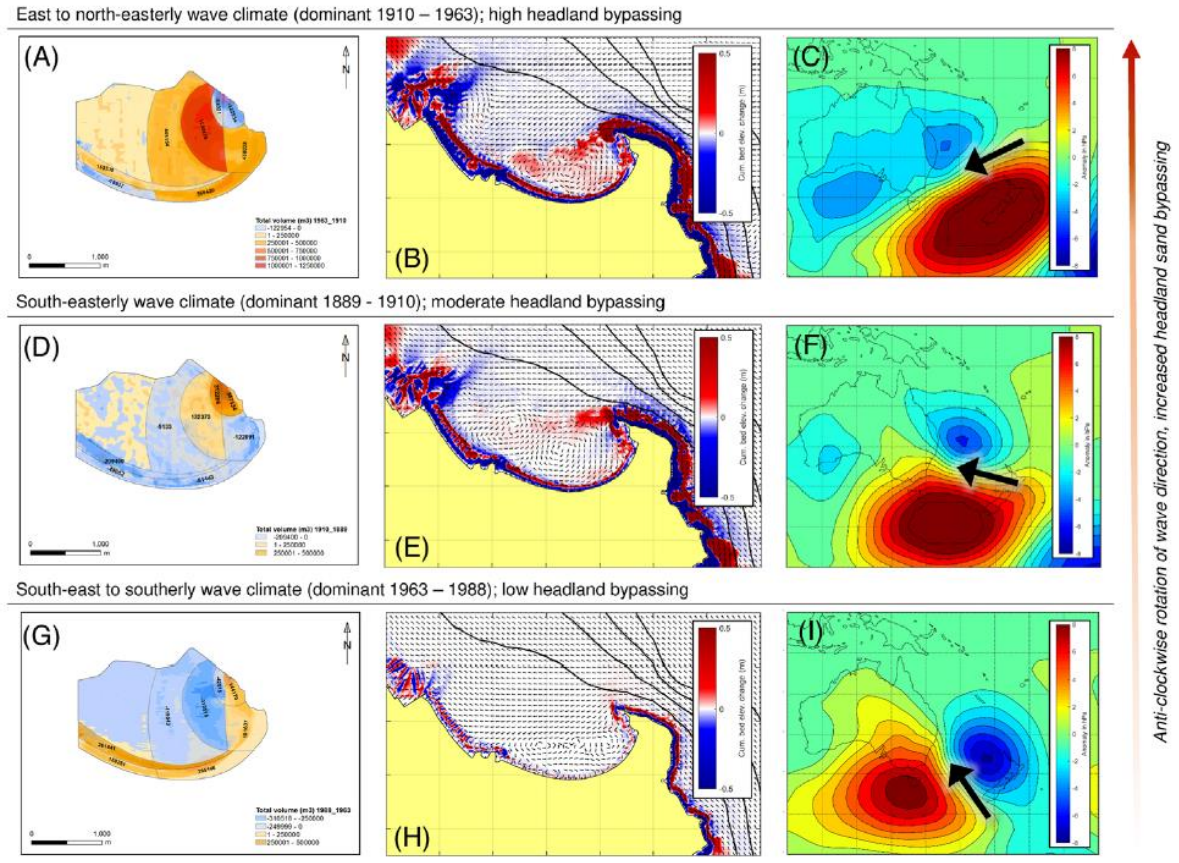


Figure 7. *Observed (A, D, G) and modelled (B, E, H) bathymetric and shoreface sand volume change, headland sand bypassing rates and the contemporaneous synoptic patterns and mean wave direction (C, F, I) for multi-decadal time slices; 1889–1910; 1910–1963; and 1963–1988), at Trial Bay - South West Rocks on the mid-north coast of NSW, Australia. An anti-clockwise (shore-oblique to shore-normal) rotation in wave direction promotes an 'opening' of the sand valve, increased headland bypassing and accretion of the upper shoreface and at this location (Goodwin et al. 2020)*

2.10 Laggers Point breakwater

The construction of the Laggers Point breakwater by the Trial Bay Gaol inmates started in 1889. The initial project was planning to build a 1,500 m breakwater to make Trial Bay a harbour for ships. However, the construction was abandoned in 1903, with only 300 m of breakwater being built. Since then, multiple storm

events have damaged the breakwater, gradually reducing the effective length of the structure as a sediment control point. At present, the breakwater extends to around 215 m, with dislodged rocks forming a fan shape (deflected towards the west) of approximately 80 m in diameter underwater at the end of the breakwater.

Based on initial observations, data analysis and discussions, it appears that the construction of the breakwater has significantly altered the shoreline dynamics and alignment of Trial Bay, resulting in an observed shoreline progradation across the bay of hundreds of meters in some areas (discussed further in section 3.5). The breakwater appears to have been causing wave refraction and diffraction, with consequent energy reduction and sand accumulation in the area protected by waves. This, fed by the continuous sediment transport bypassed around the cape from the south, appears to have caused sand accumulation on the sea floor and on adjacent beaches, with consequent progradation and vegetation stabilisation over time.

Laggers Point breakwater is a part of the Trial Bay Gaol heritage listed precinct and is not designed to today's specification required for this type of coastal defence. At the same time, it appears that the breakwater is slowly degrading and losing its adopted function in controlling the shoreline alignment for Trial Bay.

A qualitative comparison of the extension of the breakwater from 1956 to present day, however, does not show clear signs of shortening of the structure. However, it is possible that the head of the structure has been degraded by wave action with consequent wave overtopping and wave energy filtering into the Bay.

2.11 Conceptual model of the system

A conceptual model of the system has been prepared to illustrate the mechanisms driving sediment transport and shoreline realignment. Trial Bay sits between two control points (Laggers Point and South West Rocks) which are the main determinants of the beach alignment. Sand is fed into the system at a variable rate depending on the season and climate variability, which appears to be ranging between approximately 20,000 and 40,000 m^3 /yr from bypassing of the headland. This sand is transported westerly upstream overtime until it bypasses South West Rock's control point (Figure 8). Sand accumulation has been recorded inside the Bay protected by Laggers Point breakwater, which appears to have triggered a large scale beach realignment and progradation of the original shoreline since its construction in the late 1890s (discussed further in section 3.5).

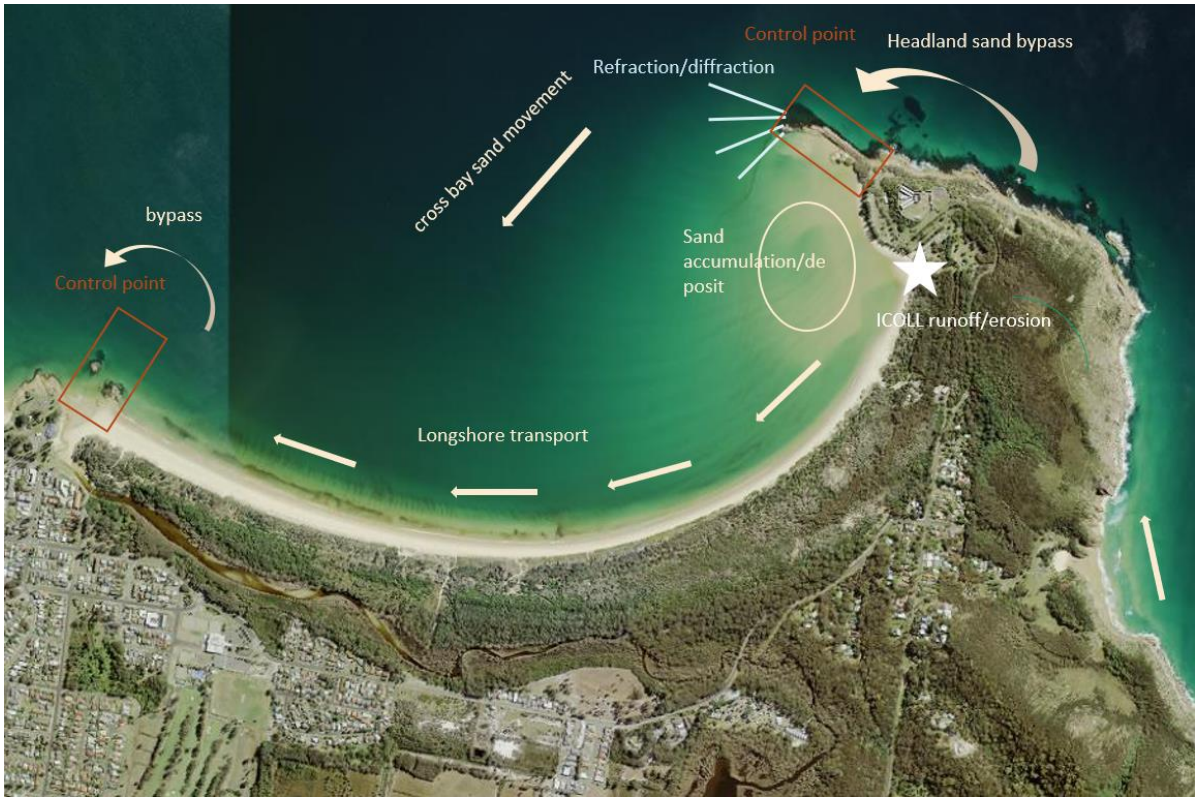


Figure 8. *Conceptual model of sand movement within Trial Bay.*

3 Coast and foreshore hazards

3.1 *Coastal Management Act 2016* and coastal hazards

A key objective of the Trial Bay Coast and Foreshore Protection Strategy is to refine the understanding of coastal hazards in line with the requirements of the *Coastal Management Act 2016* (CM Act). NPWS is a public authority exercising functions in connection with the coastal zone and is required to have regard to the CM Act and related coastal management programs and manuals in the preparation of any plans. The objects of the CM Act include, among others:

- To protect and enhance natural coastal processes and coastal environmental values including natural character, scenic value, biological diversity and ecosystem integrity and resilience
- To support the social and cultural values of the coastal zone and maintain public access, amenity, use and safety, and
- To acknowledge Aboriginal peoples' spiritual, social, customary and economic use of the coastal zone
- To mitigate current and future risks from coastal hazards, taking into account the effects of climate change,
- To recognise that the local and regional scale effects of coastal processes, and the inherently ambulatory and dynamic nature of the shoreline, may result in the loss of coastal land to the sea (including estuaries and other arms of the sea), and to manage coastal use and development accordingly.

The area of study is fully included within a Coastal Environment Area and is partly included into the Coastal Use Area and Coastal Wetlands and Littoral Rainforest Area. The area is also likely to be fully included into the Coastal Vulnerability Area, however the final Coastal Vulnerability mapping report is not available yet at the time of writing. These areas are identified by the CM Act and specified by the SEPP (Coastal Management) 2018 (Figure 9).

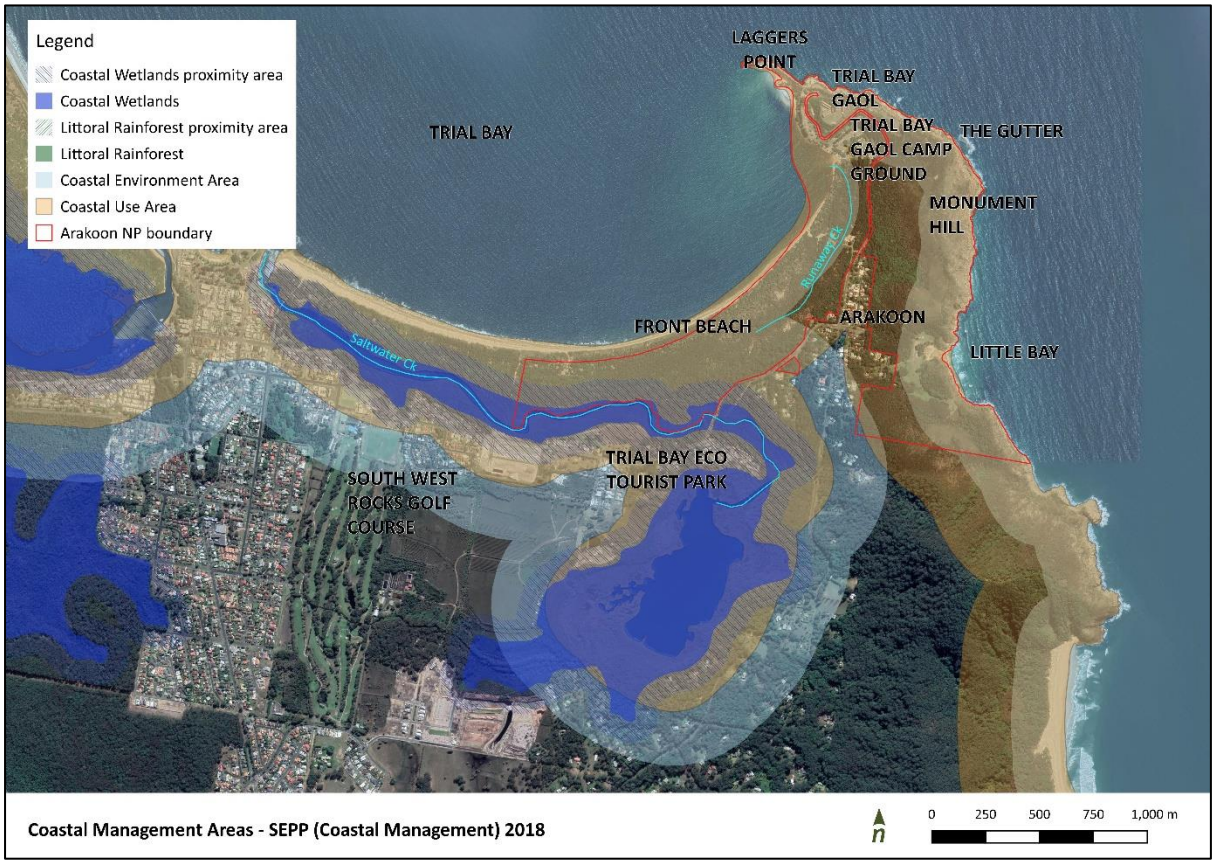


Figure 9. *SEPP Coastal Management Areas for Trial Bay*

For the purpose of the CM Act, a Coastal Vulnerability Area is the land identified by the *SEPP (Coastal Management) 2018* as being subject to the following coastal hazards:

1. Beach erosion,
2. Shoreline recession,
3. Coastal lake or watercourse entrance instability,
4. Coastal inundation,
5. Coastal cliff or slope instability,
6. Tidal inundation,
7. Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters.

At the time of writing, a detailed and updated Coastal Vulnerability Area is being mapped by Kempsey Shire Council with discussions with Kempsey Shire Council and their consultants being underway. The following section is based on the review of the 2013 Kempsey Coastal Processes and Hazard Definition Study, which cover the following hazards only:

- Beach erosion
- Shoreline recession
- Coastal inundation
- Coastal entrances
- Stormwater erosion

Understanding the impacts these coastal hazards have on the Trial Bay Visitor's Precinct is critical for developing an effective strategy.

3.2 Coastal hazard areas

The coastal hazard areas to be used to develop the Trial Bay Coast and Foreshore Protection Strategy will utilise existing coastal hazard areas, however modifications were applied where relevant based on recent data (details on this process are provided in subsequent sections). Table 5 provides a summary of coastal hazard areas used for developing the Trial Bay Coast and Foreshore Protection Strategy including information on planning horizons, likelihood scenarios, original source of data, and comments on any modifications made for the purpose of this Strategy.

Table 5. Summary of coastal hazard areas used for developing the Trial Bay Coast and Foreshore Protection Strategy.

Coastal hazard	Planning horizons	Likelihood scenarios			Original source of data	Modifications
Beach erosion and shoreline recession	Present Day	Almost Certain	Unlikely	Rare	BMT 2013	Hazard lines in western portion retained. Eastern portion corrected to represent 2021 evolution.
	2050,	Almost Certain	Unlikely	Rare	BMT 2013	Erosion widths retained. Alignment in eastern portion modified
	2100	Almost Certain	Unlikely	Rare	BMT 2013	Erosion widths retained. Alignment in eastern portion modified
Coastal Inundation	Present Day	Almost Certain	Unlikely	Rare	BMT 2013	No modifications
	2050,	Almost Certain	Unlikely	Rare	BMT 2013	No modifications
	2100	Almost Certain	Unlikely	Rare	BMT 2013	No modifications

3.3 Previously defined coast and foreshore hazard areas

Previous studies have defined the areas potentially effected by coastal hazards. Further assessment was undertaken during the development of this strategy to refine these hazard area definitions. The 2013 Kempsey Coastal Processes and Hazard Definition Study (BMT 2013) (2013 Hazard Definition Study) considered beach erosion, shoreline recession, coastal inundation, coastal entrances (Runaway Creek ICOLL), and sand drift.

Beach erosion and shoreline recession

For beach erosion, photogrammetric analysis and a shoreline evolution model were utilised to determine the likelihood of hazard events for multiple planning horizons (2010, 2050, and 2100). The components considered to define the erosion extents include:

- short-term erosion,
- long-term shoreline evolution,
- dune slope adjustment,
- reduced foundation capacity.

Short-term erosion potential was defined by analysing photogrammetric datasets to determine the historical shoreline position following erosion events. The short-term component of erosion hazard extents was based upon the most eroded profiles recorded in the photogrammetric data. The following paragraph references the 2013 Hazard Definition Study which defines the method for determining beach erosion likelihoods.

The average erosion value (in m movement from the dune position, i.e. 2, 3 or 4 m AHD) was adopted as the *'almost certain'* probability of occurrence of beach erosion. The maximum erosion value (movement from dune position) at any point along the beach was considered to have an *'unlikely'* probability of occurrence for the whole beach providing the best estimate for planning purposes. To derive the worst case, or *'rare'*, beach erosion scenario, the difference between the average and maximum beach erosion extent was added to the maximum eroded extent.

For Trial Bay, the BMT adopted short-term erosion extents for present day '*almost certain*', '*unlikely*' and '*rare*' erosion extents were determined to be 5 m, 15 m, and 25 m, respectively.

Long term shoreline recession was also considered when determining the erosion extents for 2050 and 2100 planning horizons. The 2013 Hazard Definition Study first considered historical trends which indicate that Trial Bay is exhibiting long term accretion in the form of significant growth of incipient dunes and seaward advancement of the shoreline position (Figure 10). It is noted that this trend has likely been enhanced by the construction of the Lagger's Point breakwater.

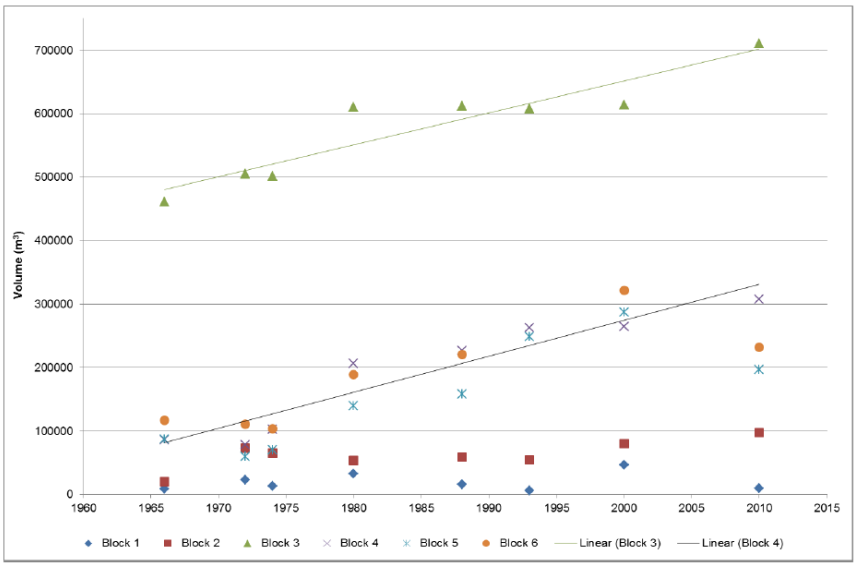


Figure 10. *Cumulative volumes of photogrammetric blocks at Trial Bay (BMT 2013)*

Future shoreline evolution was also estimated with consideration of the effects of projected gradual sea level rise (SLR). A shoreline evolution model (SEM) was applied to the entire Kempsey shoreline. The SEM considered the effects of headlands, reefs, groynes and seawalls, and how these features, along with the shoreface slope, interact with waves to influence longshore and cross shore sediment transport under various sea level rise scenarios. The SEM is based on the equilibrium profile principle, which is similarly relied on by traditional methods of predicting shoreline response to SLR such as the Bruun Rule (1962). However, the SEM used for the 2013 Hazard Definition Study caters for sea level rise factors that the Bruun Rule does not, as it was able to account for the three dimensional nature of the coastline.

Two sea level rise scenarios were analysed using the SEM. The first modelled scenario was based on the projections given by the NSW Government (DECCW 2009) where sea level rise was kept constant until the year 1990, after which a rise of 0.06 m to 2010 occurs, then a linear rise to 0.4 m by 2050 and then to 0.9 m above present by 2100. This first SLR scenario was also simulated with a slightly more easterly wave climate (5 degrees more easterly) to conservatively account for a potential shift in wave climate. The second modelled scenario considered a more significant rate of SLR with a sea level rise of 0.06 m to 2010, then rising linearly to 0.7 m by 2050 then 1.4 m by 2100.

Model results for the sea level rise scenarios demonstrate that due to interruption of northward longshore sediment transport by headlands as sea level rises, the extent of recession due to sea level rise is considerably greater at the eastern end of the beach compared to the western end.

SEM results conclude that for the eastern end of Trial Bay approximately 25 m, and 65 m (for 2050 and 2100, respectively) of shoreline recession can be expected in response to SLR.

The final components of the erosion hazard extents are the zone of dune slope adjustment and the zone of reduced foundation capacity. The zone of dune slope adjustment is the area landward of the vertical erosion escarpment crest that may be expected to collapse after the storm event. The zone of reduced foundation capacity is the area landward of the zone of slope adjustment that is unstable being in proximity to the storm erosion and dune slumping. The 2013 Hazard Definition Study provides an indicative guide to the width of these zones based on dune height.

The 2013 Hazard Definition Study provides maps indicating '*almost certain*', '*unlikely*' and '*rare*' events for erosion and recession. Figure 11 shows the parameters considered when defining the erosion extents for the purpose of hazard mapping.

Probability	Immediate	2050	2100
Almost Certain	'average' beach erosion [1]	Immediate 'average' beach erosion	Immediate 'average' beach erosion
Likely	NM [2]	NM	NM
Possible	NM	NM	NM
Best Estimate (Unlikely)	'maximum' beach erosion at any position along the beach [1]	Immediate 'maximum' beach erosion + 0.4 m SLR	Immediate 'maximum' beach erosion + 0.9 m SLR
Worst Case (Rare)	'extreme' beach erosion [3]	**Worst Case of either:** Immediate 'maximum' beach erosion + 0.7 m SLR **OR** Immediate 'extreme' beach erosion + 0.4 m SLR **OR** Immediate 'maximum' beach erosion + 0.4 m SLR + 5 ° more easterly wave climate	**Worst Case of either:** Immediate 'maximum' beach erosion + 1.4 m SLR **OR** Immediate 'extreme' beach erosion + 0.9 m SLR **OR** Immediate 'maximum' beach erosion + 0.9 m SLR + 5 ° more easterly wave climate

[1] *as measured over the past 4 decades.*
[2] *NM = Not Mapped due to inadequate data to differentiate likelihoods between 'almost certain' and 'unlikely'.*
[3] *Assumed to be 'maximum' erosion plus the difference between 'maximum' and 'average' beach erosion.*

Figure 11. *Beach erosion and shoreline recession probability zones (BMT 2013)*

Coastal inundation

The 2013 Hazards Definition Study also defines the areas potentially exposed to coastal inundation. The components of coastal inundation that were considered include:

- barometric pressure set up,
- wind set up,
- astronomical tide,
- wave set up,
- wave run up.

For the purpose of defining the likelihood of coastal inundation within the immediate timeframe, the 2013 Hazards Definition Study considered '*almost certain*' water level would be equivalent to a 1 in 20 return interval event, the best estimate '*unlikely*' water level would be equivalent to a 1 in 100 year event and worst case '*rare*' water level would be equivalent to a greater than 1 in 100 year event resulting from an extreme climatic condition. For the purpose of defining the likelihood of coastal inundation within the 2050 and 2100 timeframes, water levels included sea level rise as well as minor projected changes to storm surge and wave height. The same water level was used for the '*almost certain*' likelihood for both 2050 and 2100, providing the boundary of the coastal risk planning area.

For 2050, the '*unlikely*' scenario incorporated 0.4 m of SLR onto the 1 in 100 year event, plus increased wave set up and storm surge due to climate change. The '*rare*' scenario was defined as the worst case of either a higher than expected 0.7 m of SLR plus increased wave set up and storm surge due to climate change OR an extreme climatic condition (e.g. a 1 in 1000 year still water level event, excluding wave set up) plus predicted sea level rise of 0.4 m.

For 2100, the '*unlikely*' scenario incorporated 0.9 m of SLR onto the 1 in 100 year event, plus increased wave set up and storm surge due to climate change. The '*rare*' scenario defined as the worst case of either a higher than expected 1.4 m of SLR plus increased wave set up and storm surge due to climate change OR an extreme climatic condition (e.g. a 1 in 1000 year still water level event, excluding wave set up) plus predicted sea level rise of 0.9 m.

Figure 12 shows the parameters considered when defining the coastal inundation extents for the purpose of hazard mapping, as well as the adopted inundation levels used. Coastal inundation mapping utilised a 'bath-tub' approach which overlays the adopted inundation levels onto a digital elevation model of the area, filling in any land that lies at an elevation below the flood height. This approach does not account for hydraulic attenuation of flood waters due to entrance constraints and is therefore limited for back beach areas such as the Runaway Creek ICOLL.

Probability	Immediate	2050	2100
Almost Certain	1 in 20 yr storm surge and wave set up	As per immediate	As per immediate
Likely	NM[1]	NM	NM
Possible	NM	NM	NM
Best Estimate (Unlikely)	1 in 100 yr storm surge and wave set up	1 in 100 yr storm surge and wave set up + 0.4 m SLR and climate change impacts	1 in 100 yr storm surge and wave set up + 0.9 m SLR and climate change impacts
Worst Case (Rare)	1 in 100 yr storm surge and wave set up + extreme climatic conditions (e.g. tropical cyclone, 1 in 1000 year east coast low)	**Worst Case of either:** 1 in 100 yr storm surge and wave set up + extreme climatic conditions + 0.4 m SLR and climate change impacts **OR** 1 in 100 yr storm surge and wave set up + 0.7 m SLR and climate change impacts	**Worst Case of either:** 1 in 100 yr storm surge and wave set up + extreme climatic conditions + 0.9 m SLR and climate change impacts **OR** 1 in 100 yr storm surge and wave set up + 1.4 m SLR and climate change impacts

[1] *NM = Not Mapped*

Adopted Inundation Levels	Immediate (m AHD)	2050 (m AHD)	2100 (m AHD)
Almost Certain	2.5	2.5	2.5
Best Estimate (Unlikely)	2.7	3.2	3.8
Worst Case (Rare)	2.9	3.5	4.3

Figure 12. *Coastal inundation likelihood summary and adopted inundation levels (BMT 2013)*

3.4 Analysis of the beach profiles

The 2013 Hazard Definition Study examined data available at the time with the most recent photogrammetry data collected in 2010. Since then, multiple beach profiles have been recorded in the study area. The UNSW Beach Profile Database provides an excellent source of up to date data that has been used to update and refine the existing hazard extents (UNSW Water Research Laboratory 2020). Detailed data for each profile is provided in Attachment 1.

The beach profile database has categorised the Trial Bay shoreline into 6 blocks (L, M, N, O, P, Q), each with numerous transects (Figure 13). These transects can be used to construct plots of beach volume above 0 m AHD, as well as chainage (or distance) of the 2 m AHD contour line.

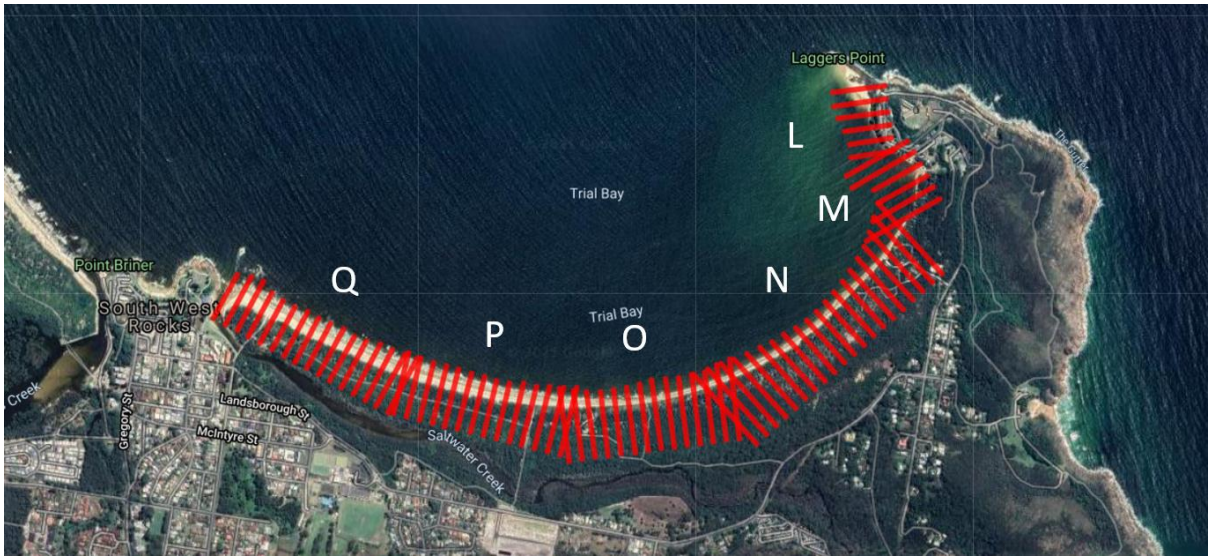


Figure 13. *Beach profile transects and blocks for Trial Bay. (UNSW Water Research Laboratory 2020).*

The analysis undertaken to develop the Trial Bay Coast and Foreshore Protection Strategy examined both the dataset as a whole (long-term) and the most recent 10 years of data. A summary of the findings is presented in Table 6.

Table 6. Summary of beach profile analysis for Trial Bay

Block	Long term trends (~1980s – 2010)	Recent trends (2010 – 2021)
L & M	1984 to 1988 receding 1989 sand dump Oscillating throughout the 1990s Accreting 2000s until 2009	Receding from 2010
N	1984 to 1989 relatively stable 1990 sand looking fuller Minorly receding over the early 1990s Receding (oscillating minorly) until 2000 Accreting over early 2000s and remaining stable	Receding from 2010
O & P	Accreting in the late 1980s Receded from 1989 to 1990, then oscillating in the 90s	Oscillating
Q	Late 1980s starting to recede 1990 onwards accreting 1995-1996 small dip Accreting until 1998, then receding Oscillating 2000s	Oscillating

3.5 Historical shoreline alignment and evolution of Laggers Point breakwater

Investigations of the historical record, including historical photos, information from local heritage resources, old nautical charts, and beach profile data indicate that the position of the Trial Bay shoreline has significantly evolved over the timeframe of the past 120 years (Figure 14, Figure 15).

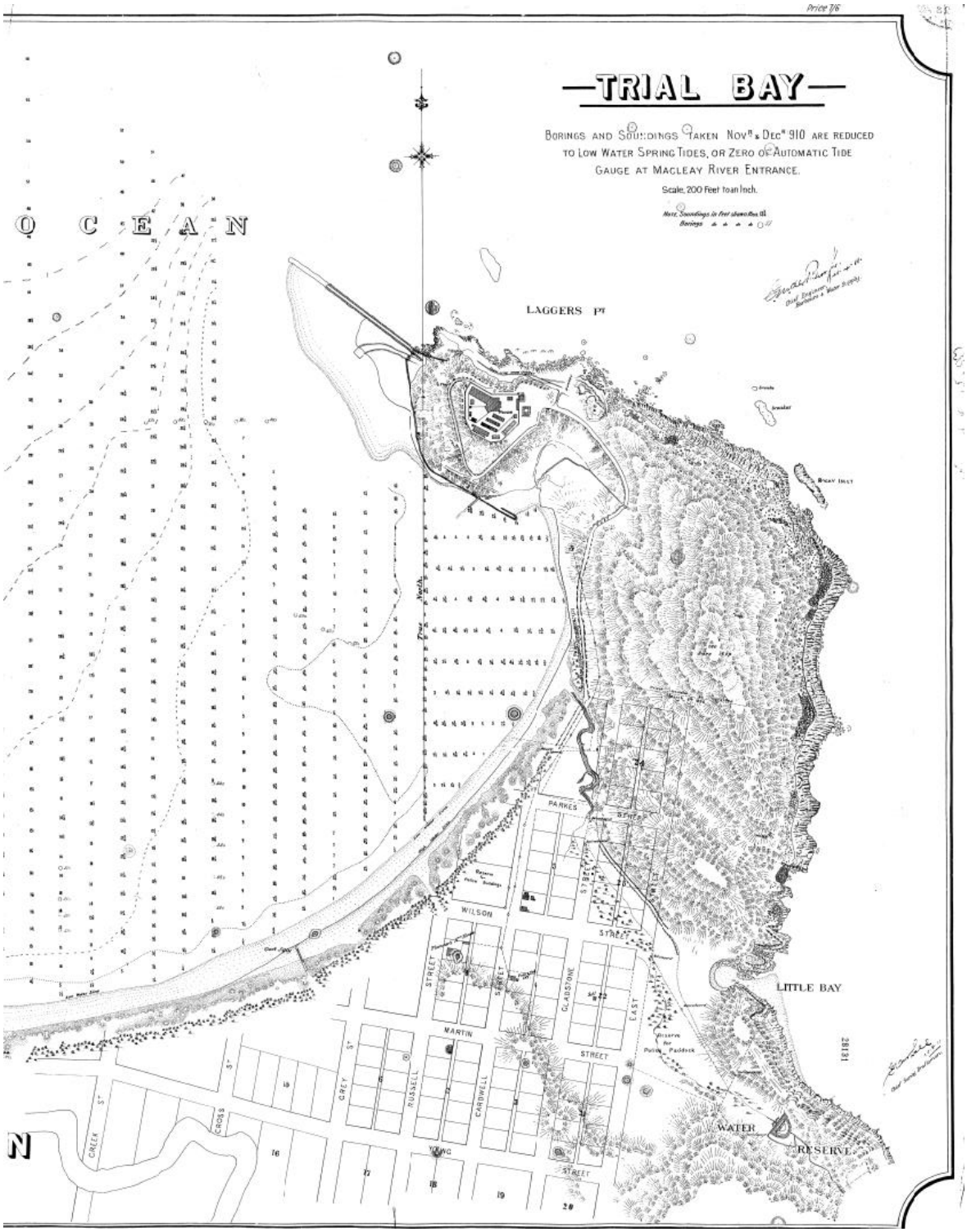


Figure 14. *Depth soundings of Trial Bay and map of headland from 1910. It is noted that the streets that are now inland behind the ICOLL are depicted as directly behind the dunes. Image courtesy of John Schmidt (DPIE)*

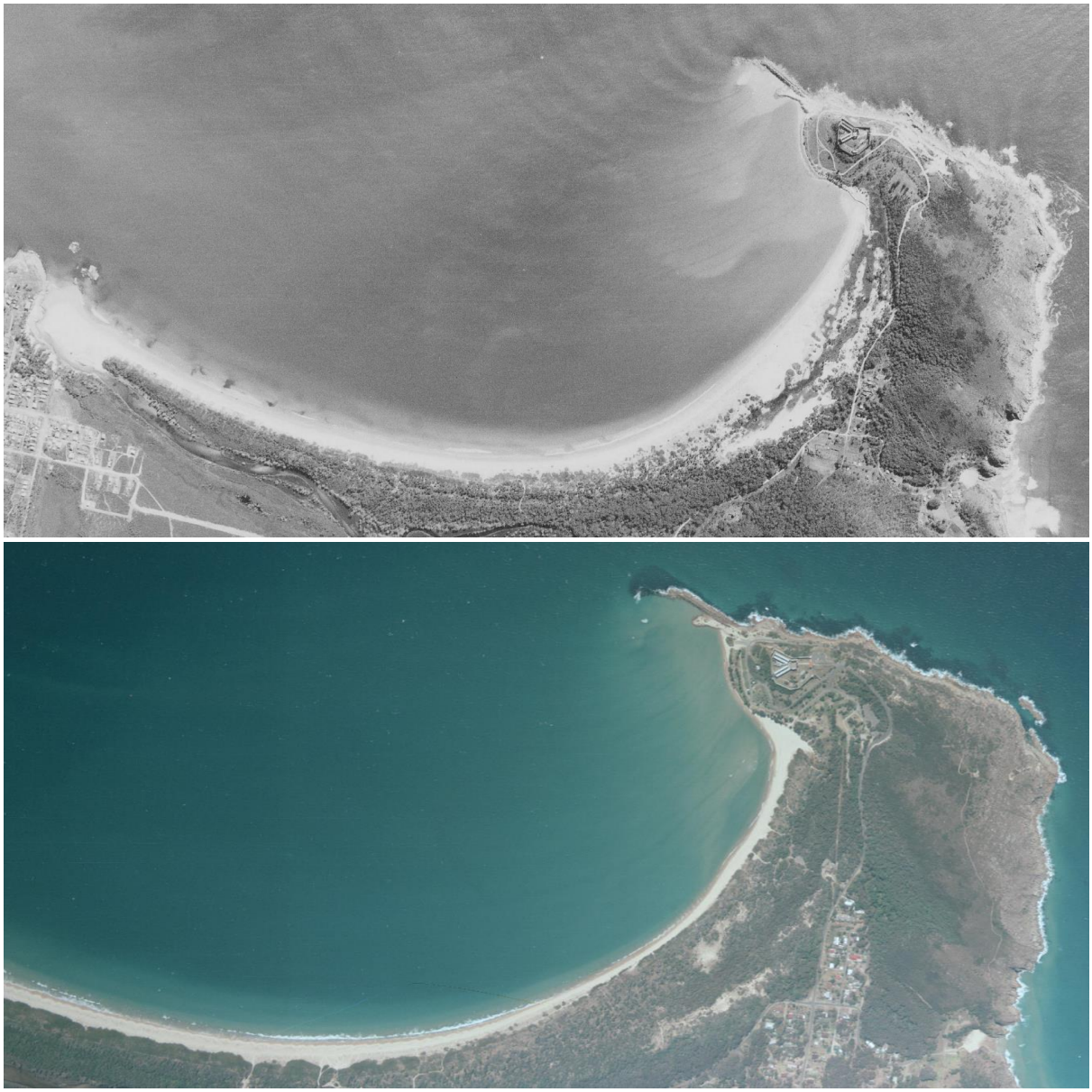
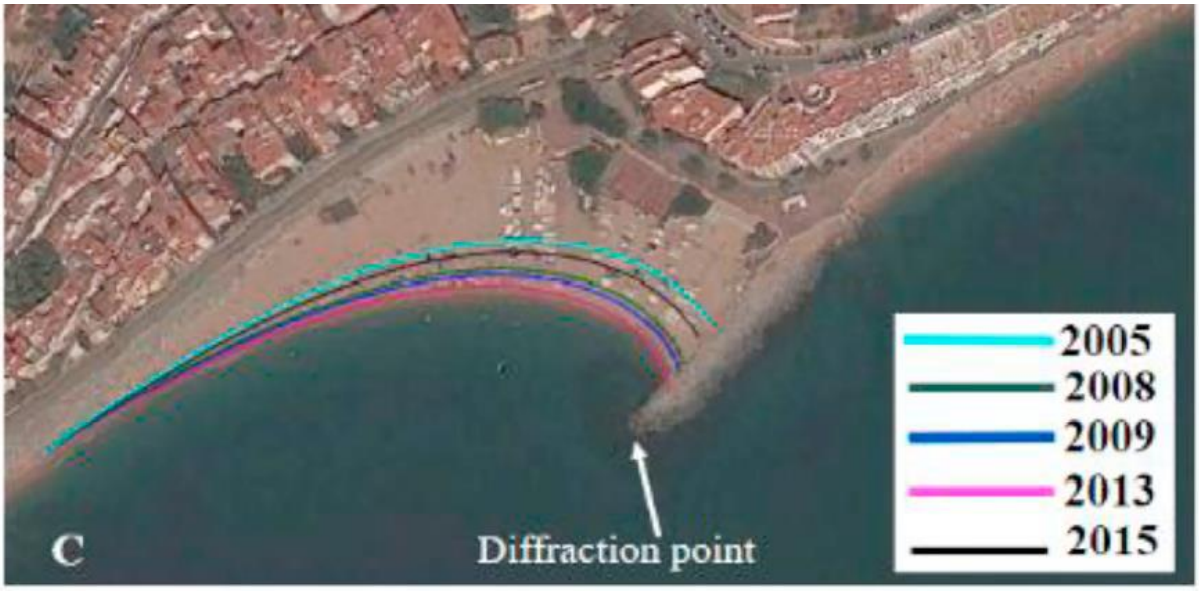


Figure 15. *(top) Aerial imagery from 1954 showing a prograded shoreline with newly established vegetation taking hold on the newly formed dunes. (bottom) Aerial imagery from 1991 shows the vegetation has become well-established as the shoreline settles into a new equilibrium.*

The construction of breakwaters commonly influences the size and shape of headland control points, which, in turn, influences wave and sediment transport dynamics, thus shifting the static and dynamic equilibrium shape of the beach. For Trial Bay, the construction of the breakwater in the 1890s resulted in the shoreline moving forward to its current position, which can be estimated to be approximately 200 m back from the current position. The gradual degradation of Laggers Point breakwater may consequently result in a realignment with its historical position.

As elucidated in Elshinnawy et al. 2018, the shape of an embayed beach is also dictated by the amount of sediment bypassing the headland over time, oscillating between what is known as static equilibrium and dynamic equilibrium. With higher rates of sediment transport the shoreline tends to move seaward to reach its dynamic equilibrium, while with a lower rate of sediment transport the shoreline tends to move landwards to reach static equilibrium. This phenomenon occurs in many beach systems around the world and an example from a beach in Spain is illustrated in Figure 16. This indicates that the gradual degradation of the breakwater is not the sole driver of the recent shoreline erosion in the eastern corner Trial Bay. It is possible the recent shift in shoreline alignment could be due to a shift between a dynamic and static equilibrium due to variable volumes of sediment bypassing the Smoky Cape headland.



Year	Q (m^3/year)
2005	38,000
2008	30,000
2009	50,000
2013	63,000
2015	43,000

Figure 16. *Simulated shoreline alignment for different rates of sediment transport (Q) at different years for a Spanish beach (Elshinnawy et al. 2018)*

3.6 Updated coastal hazard area of influence

Consideration of local and regional coastal processes, previously defined coastal hazard areas, recent beach profile analysis, and historical shoreline alignment for Trial Bay supports a refined understanding of the potential threats that coastal hazards pose to the Trial Bay Visitor's precinct coast and foreshore. This information has been used to refine the previously defined coastal hazard areas so they are fit for purpose for developing the Trial Bay Coast and Foreshore Protection Strategy.

Beach erosion

For beach erosion, the 2013 Kempsey Shire Coastal Processes and Hazards Definition Study defined hazard areas. In creating these hazard areas, considerable analysis was undertaken by BMT (2013) to determine the various components that comprise the erosion hazard extent including short-term erosion, long-term shoreline evolution, dune slope adjustment and zone of reduced foundation capacity.

After considering the newly available beach profile data and satellite imagery it was determined that the sandy shoreline fronting the Trial Bay Visitor's Precinct has been experiencing a period of erosion. Further consideration of the breakwater's effect on shoreline alignment, and the fact that the breakwater is degrading over time, indicates that this erosion trend may not be a typical oscillation due to natural variability of coastal processes. Therefore, in order to capture the most recent data, the erosion likelihood lines from the 2013 Hazards Definition Study were adjusted incorporating the more eroded 2021 shoreline as the starting point.

While the base shoreline for the updated hazard mapping was shifted landward, the distance between erosion lines (i.e hazard likelihoods) was not altered. This approach maintains the technical integrity from the 2013 Hazards Definition Study while incorporating the most up-to-date data at a more refined spatial resolution than the original study. For the 2050 and 2100 planning horizon, an additional nominal buffer area (10 m, and 20 m) has been mapped behind the seawall in front of the campsites and rocky shoreline at the northern foreshore. This aims to account for the potential for the campsite seawall to fail without maintenance, or for drainage issues and wave overtopping to cause a loss of land behind the rocky shoreline. Maps depicting areas potentially impacted by erosion are provided in Attachment 2.

An additional area of influence has been mapped which considers the approximate historical shoreline alignment before construction of the Laggers Point breakwater. This area is indicative of the potential of the shoreline to return to the previous alignment if the breakwater was removed or allowed to continuously degrade. While it is unlikely that the breakwater will be removed due to its NSW State Heritage status, that same status complicates the process for rebuilding, or repairing the structure. Without intervention the breakwater will continue to degrade which would exacerbate erosion in the future. Figure 17 provides a comparison between the lines used for the Trial Bay Coast and Foreshore Protection Strategy and the 2013 Hazards Definition Study, as well as an indicative line representing the approximate historical shoreline alignment of Trial Bay before the construction of Laggers Point breakwater.

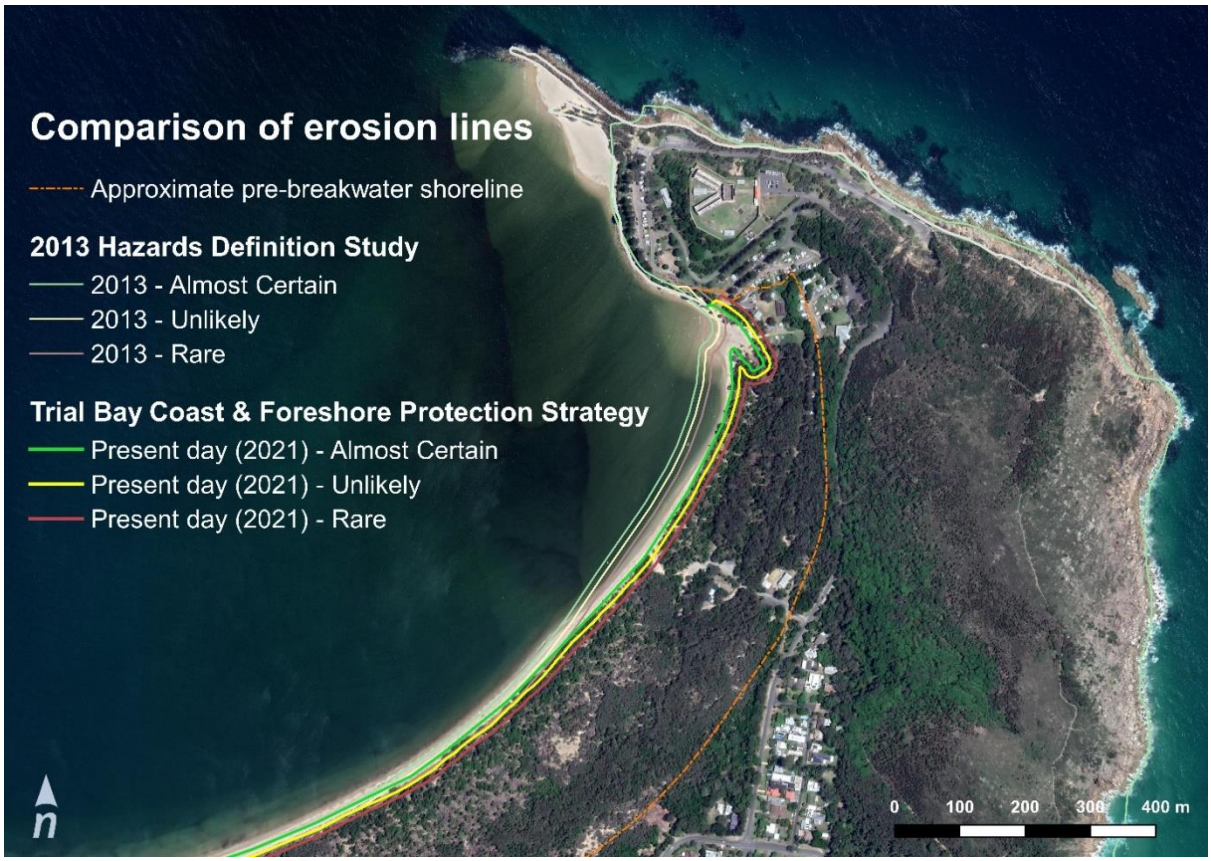


Figure 17. *Comparison of erosion lines (present day) used for the Trial Bay Coast and Foreshore Protection Strategy and the 2013 Hazards Definition Study.*

Coastal inundation

At this stage, no adjustments have been made to the coastal inundation hazard area definitions. The approach used in the 2013 Hazard Definition Study could not be appropriately refined within the scope of preparing the Trial Bay Coast and Foreshore Protection Strategy. It is noted that ongoing work by Kempsey Shire Council is utilising hydrodynamic modelling to more accurately map areas potentially impacted by coastal inundation caused by storm surges and tidal waters due to sea level rise. Due to the proximity of the study area to the open coast, it is unlikely that the new modelling will change the predicted inundation extent significantly, and therefore the existing data is fit for purpose for this Strategy. This is also taking into consideration that erosion is the predominant hazard for Trial Bay Visitor's Precinct. However, if the new data becomes available then it will be used in the exposure and risk assessment.

Storm water runoff

Stormwater runoff has been identified as a coastal hazard by the NPWS ranger and it has been causing issues on cliff stability in specific areas of the north side of the Laggers Point headland. This issue is important for the long term assets management and planning, however, the assessment of the impact of stormwater runoff is beyond the scope of this study.

4 Summary of findings

This Coast and Foreshore Hazard Assessment report for Trial Bay, NSW, has reviewed regional and local coastal processes driving beach dynamics, sediment transport and shoreline realignment, and developed an updated conceptual model of the system. Existing coast and foreshore hazards and hazard lines were also revisited based on the existing studies (BMT 2013) and more recent data and literature.

Below is a summary of findings:

1. The area of study, in particular the sandy shoreline adjacent to Laggers Point, has been suffering from increasing erosion in the past 10 years, with recorded shoreline re-alignment of approximately 30 m in its eastern corner, reflecting a loss of sand volume for the whole beach profile.

2. Based on the current observations, the existing hazard extents identified by BMT (2013) were underestimating the erosion risk to the eastern part of the beach by approximately 30 m. Analysing the recent shoreline movement over the last 10 years Alluvium has amended the existing hazard lines in this eastern section. For the western section, the hazard lines remain appropriate and have been retained in original form.

3. Laggers Point breakwater is the main control point responsible for shoreline alignment in Trial Bay, and it has been responsible for the substantial shoreline accretion of approximately 200 m at its widest point since its construction in the 1890s. Degradation of the Laggers Point breakwater would alter the existing control point, which could result in recession, with a potential worst case scenario of pre-construction beach alignment if the breakwater was totally lost. It should however be noted this is an extreme worst case and even if the breakwater were left to totally degrade the resulting rubble would still create a control point seaward of the original pre-1890s position.

4. Recent observed changes to the shoreline alignment can be caused by a combination of factors with the following factors being the main controls:

    a. Long term climate variability and changes to the wave climate, which may alter the equilibrium form of the beach.

    b. Changes in the volume of sediment supplied by the sand bypass system through Laggers Point, which may have reduced the overall amount of sand inside the embayment.

    c. The impact of sand distribution on the offshore banks in recent years, which may have created an end-effect at the end of the sand slug triggering erosion to the exposed area.

    d. Changes in the shape and size of Laggers Point breakwater.

Findings of this study and mapping will be used to develop the Coast and Foreshore Protection Strategy for Trial Bay Visitor Precincts.

5 References

BMT (2013) Kempsey Shire Coastal Processes and Hazards Definition Study

BOM (2020) Monthly Data Reports - Australian Baseline Sea Level Monitoring Project http://www.bom.gov.au/oceanography/projects/abslmp/reports.shtml

CSIRO (2021) Future sea level changes – sea level projections https://research.csiro.au/slrwavescoast/sea-level/future-sea-level-changes/

Elshinnawy, A. I., Medina, R., & González, M. (2018). Dynamic equilibrium planform of embayed beaches: Part 1. A new model and its verification. Coastal Engineering, 135, 112-122.

Glatz M., Fitzhenry M., Kulmar M. (2017). It's time for an update – extreme wave and directional distributions along the New South Wales coastline. NSW Coastal Conference 2017

Goodwin, I. D., Ribó, M., & Mortlock, T. (2020). Coastal sediment compartments, wave climate and centennial-scale sediment budget. In Sandy Beach Morphodynamics (pp. 615-640). Elsevier.

Harvey, N. (2006). Holocene coastal evolution: Barriers, beach ridges, and tidal flats of South Australia. Journal of Coastal Research, 22(1 (221)), 90-99.

Helman, P., & Tomlinson, R. (2018). Two centuries of climate change and climate variability, East Coast Australia. *Journal of Marine Science and Engineering*, *6*(1), 3

Kelly, J. T., McSweeney, S., Shulmeister, J., & Gontz, A. M. (2019). Bimodal climate control of shoreline change influenced by Interdecadal Pacific Oscillation variability along the Cooloola Sand Mass, Queensland, Australia. *Marine Geology*, *415*, 105971.

Manly Hydraulics Laboratory (2018). NSW Extreme Ocean Water Levels, MHL Report 2236, December 2018.

Manly Hydraulics Laboratory (2020). Seasonal Wave Directional Roses – Crowdy Head. https://mhl.nsw.gov.au/Station-CRHDOW

Morim, J., Hemer, M., Wang, X. L., Cartwright, N., Trenham, C., Semedo, A., ... & Andutta, F. (2019). Robustness and uncertainties in global multivariate wind-wave climate projections. *Nature Climate Change*, *9*(9), 711-718.

NOAA (2021) TPI (IPO) Tripole Index for the Interdecadal Pacific Oscillation. https://psl.noaa.gov/data/timeseries/IPOTPI/tpi.timeseries.ersstv5.data

Shore Protection Manual, 1984. CERC, Waterways Experiment Station, Vicksburg, USA

Short, A. D., (2020) Australian Coastal Systems. Beaches, Barriers and Sediment Compartments. Springer Coastal Research Library Volume 32

da Silva, G. V., Toldo Jr, E. E., Klein, A. H. D. F., Short, A. D., & Woodroffe, C. D. (2016). Headland sand bypassing—Quantification of net sediment transport in embayed beaches, Santa Catarina Island North Shore, Southern Brazil. Marine Geology, 379, 13-27.

Thom, B. G., Eliot, I., Eliot, M., Harvey, N., Rissik, D., Sharples, C., ... & Woodroffe, C. D. (2018). National sediment compartment framework for Australian coastal management. Ocean & coastal management, 154, 103-120.

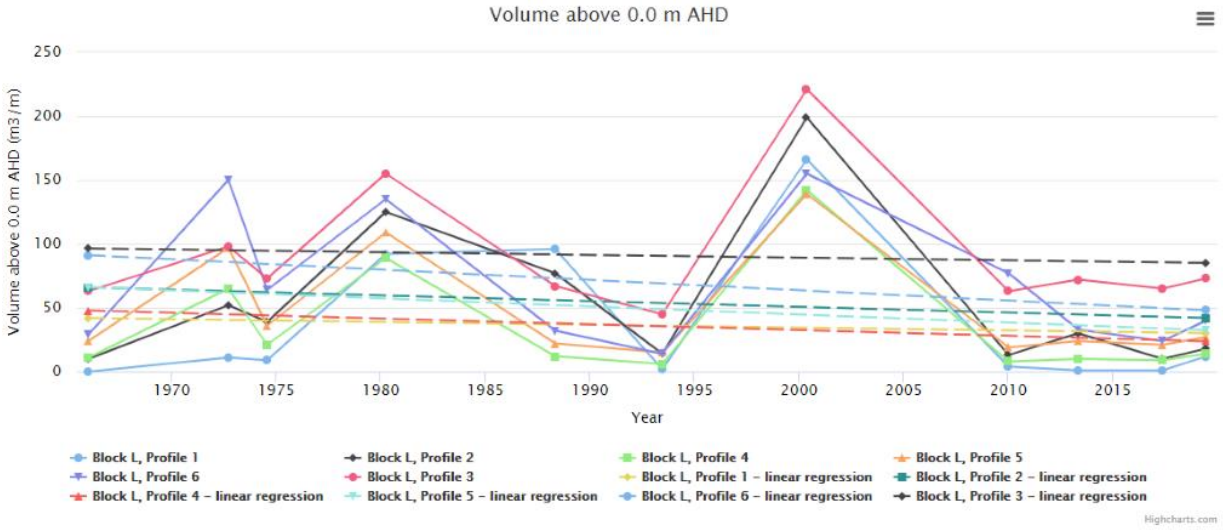
Toimil, A., Camus, P., Losada, I. J., Le Cozannet, G., Nicholls, R. J., Idier, D., & Maspataud, A. (2020). Climate change-driven coastal erosion modelling in temperate sandy beaches: Methods and uncertainty treatment. *Earth-Science Reviews*, *202*, 103110.

UNSW Water Research Laboratory. (2020). *NSW Beach Profile Database*.

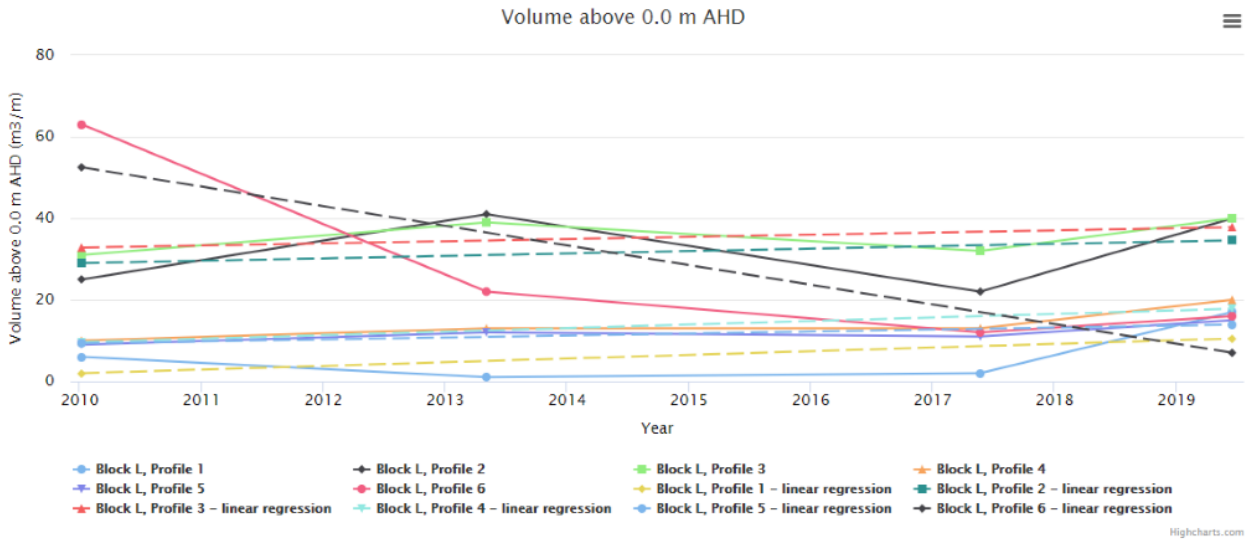
Valiente, N. G., Masselink, G., Scott, T., Conley, D., & McCarroll, R. J. (2019). Role of waves and tides on depth of closure and potential for headland bypassing. Marine Geology, 407, 60-75.

Attachment 1 – Beach profile analysis results

Block L



Profile	Linear Regression Slope (m^3/m/year)	R^2
Block L, Profile 1	-0.22	0.01
Block L, Profile 2	-0.45	0.02
Block L, Profile 4	-0.45	0.04
Block L, Profile 5	-0.63	0.08
Block L, Profile 6	-0.81	0.08
Block L, Profile 3	-0.21	0.01



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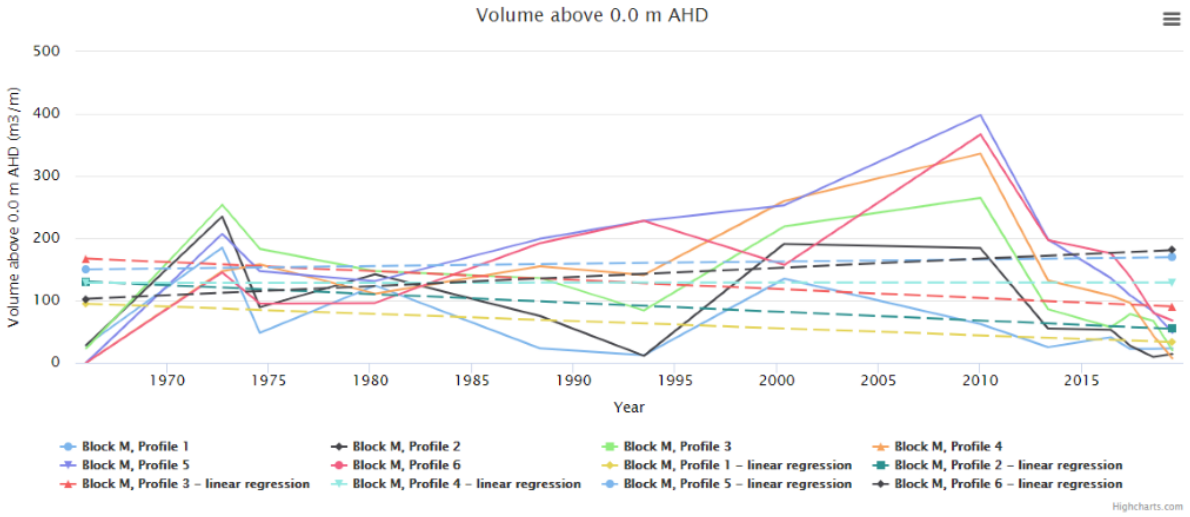
Block L, Profile 3	0.53	0.23
Block L, Profile 4	0.86	0.74
Block L, Profile 5	0.49	0.68
Block L, Profile 6	-4.82	0.74

Block M



Profile	Linear Regression Slope (m^3/m/year)	R^2
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Block M, Profile 2	-1.42	0.14
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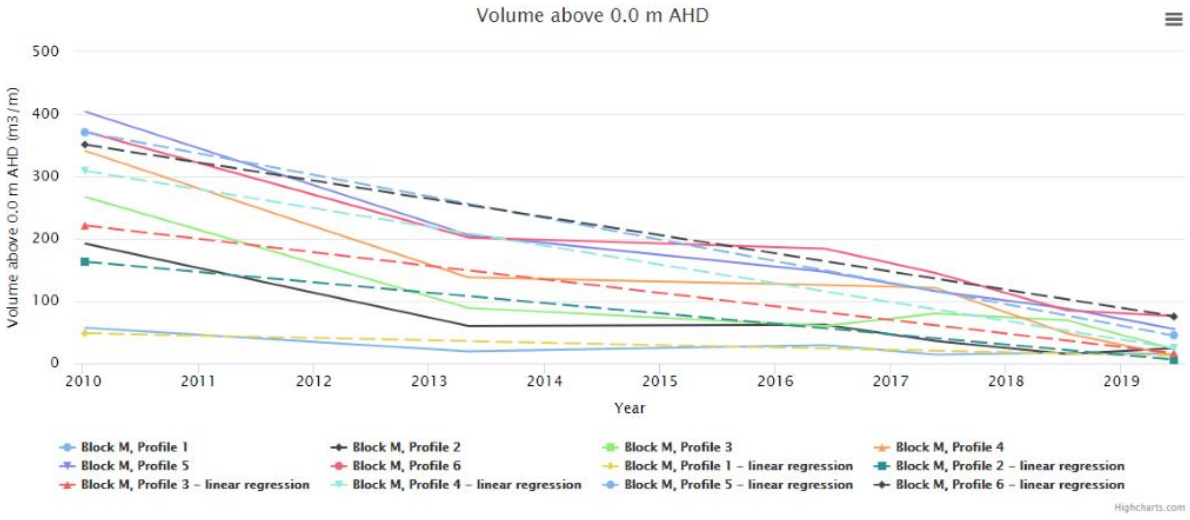
Block M, Profile 4	0.01	0.0
Block M, Profile 5	0.36	0.01
Block M, Profile 6	1.47	0.11



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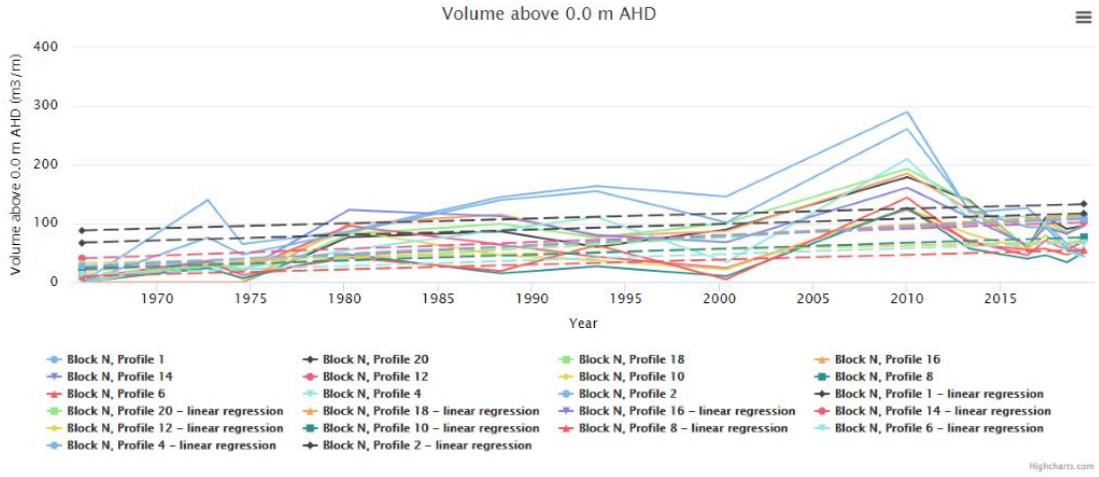
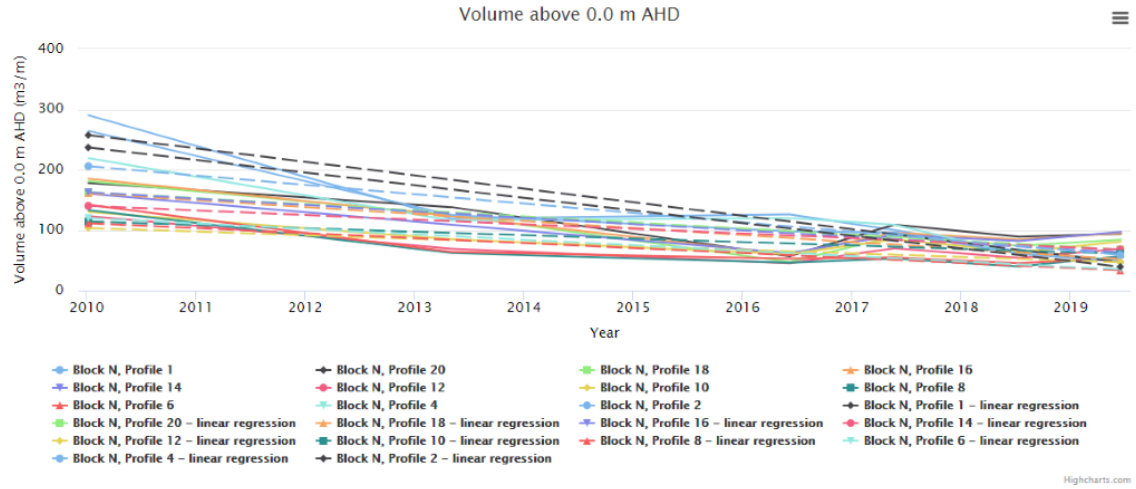
Block M, Profile 3	-21.73	0.79
Block M, Profile 4	-30.16	0.88
Block M, Profile 5	-34.6	0.95
Block M, Profile 6	-29.18	0.93

Block N



Profile	Linear Regression Slope (m^3/m/year)	R^2
Block N, Profile 1	0.83	0.06
Block N, Profile 20	1.84	0.48
Block N, Profile 18	1.76	0.41
Block N, Profile 16	1.56	0.34
Block N, Profile 14	1.15	0.27
Block N, Profile 12	0.68	0.18
Block N, Profile 10	1.0	0.35
Block N, Profile 8	0.83	0.27
Block N, Profile 6	1.01	0.3
Block N, Profile 4	1.51	0.3
Block N, Profile 2	0.93	0.09



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Block N, Profile 14	-7.63	0.55
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Block N, Profile 10	-5.66	0.56
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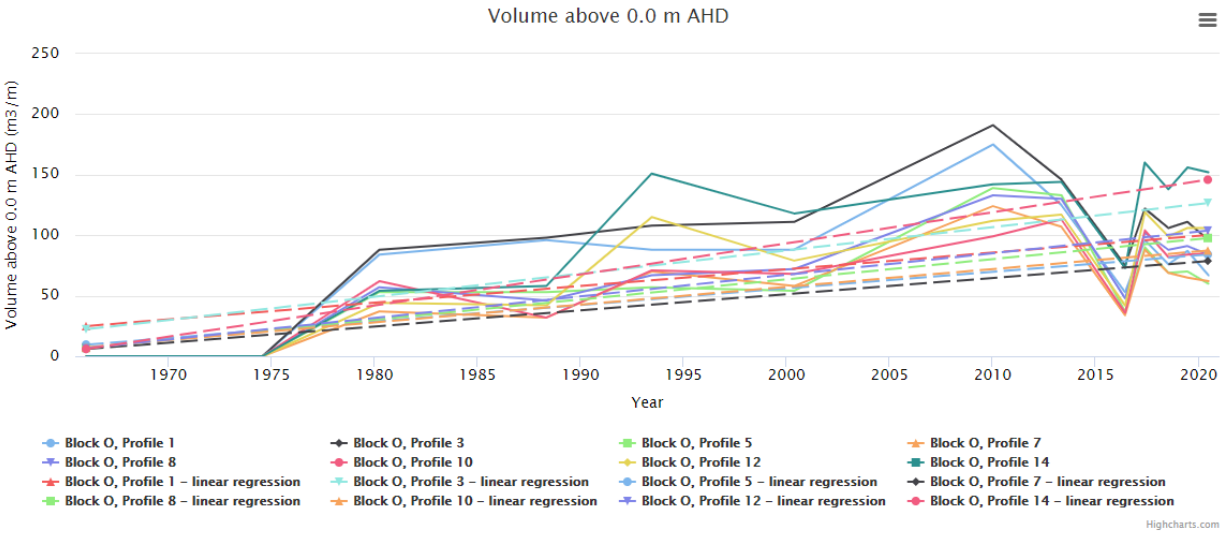
Block O



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Block O, Profile 7	1.34	0.49
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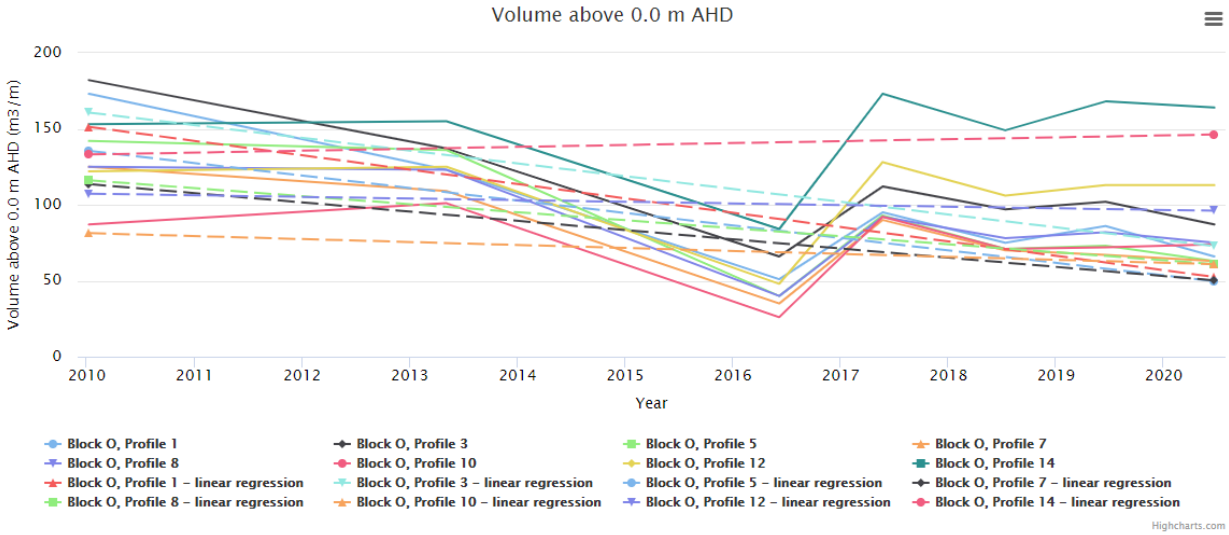
Block O, Profile 14	2.57	0.68



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Block O, Profile 7	-6.07	0.41
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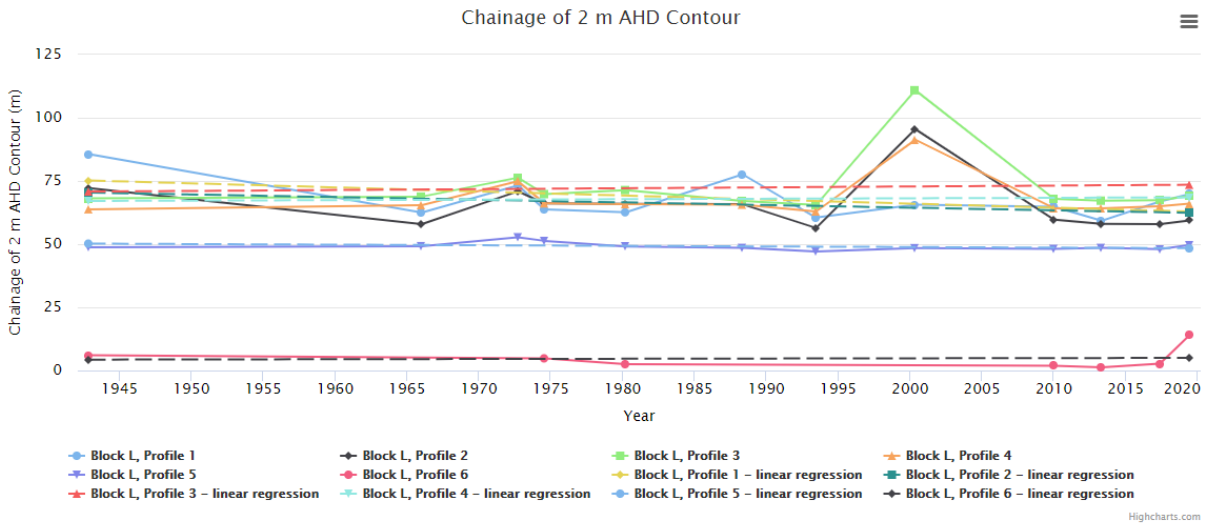
Block L



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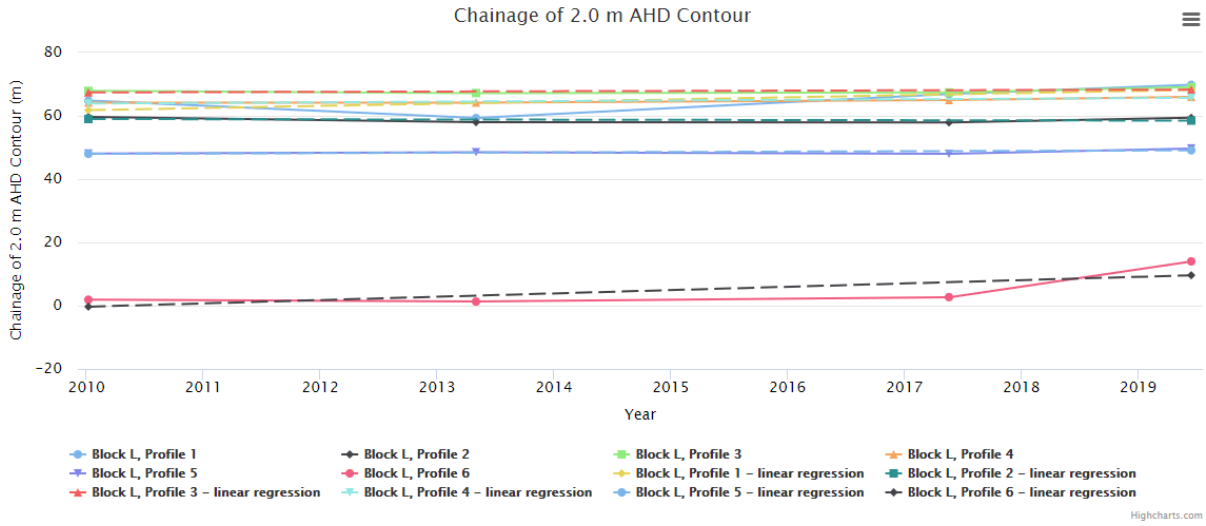
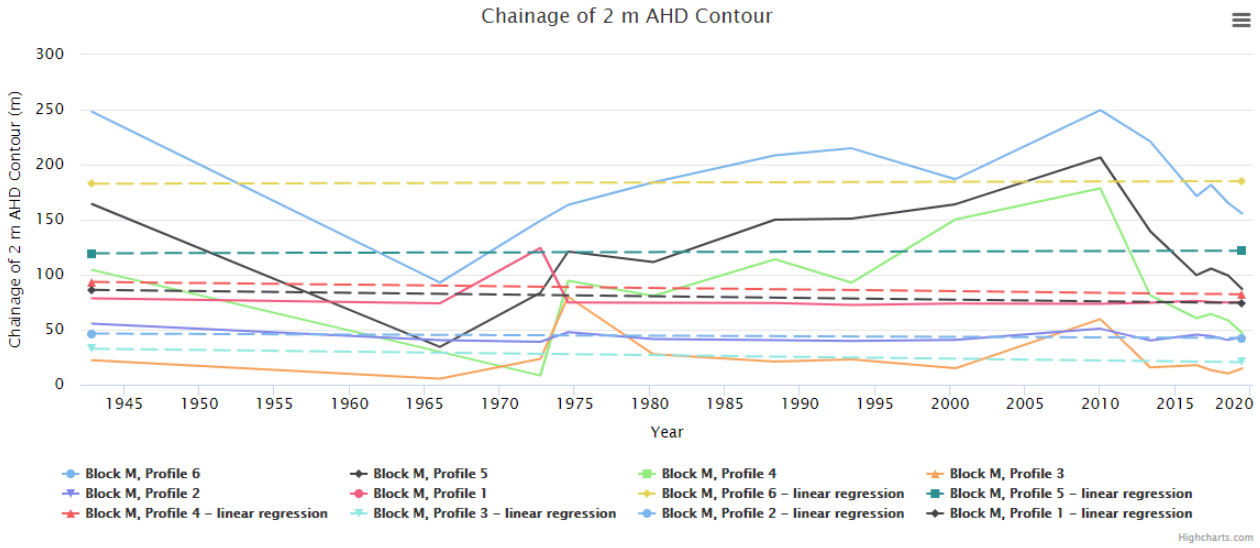


Profile	Linear Regression Slope (m/year)	R^2
Block L, Profile 1	0.68	0.42
Block L, Profile 2	-0.05	0.05
Block L, Profile 3	0.1	0.24
Block L, Profile 4	0.18	0.83
Block L, Profile 5	0.12	0.39
Block L, Profile 6	1.06	0.54

Block M



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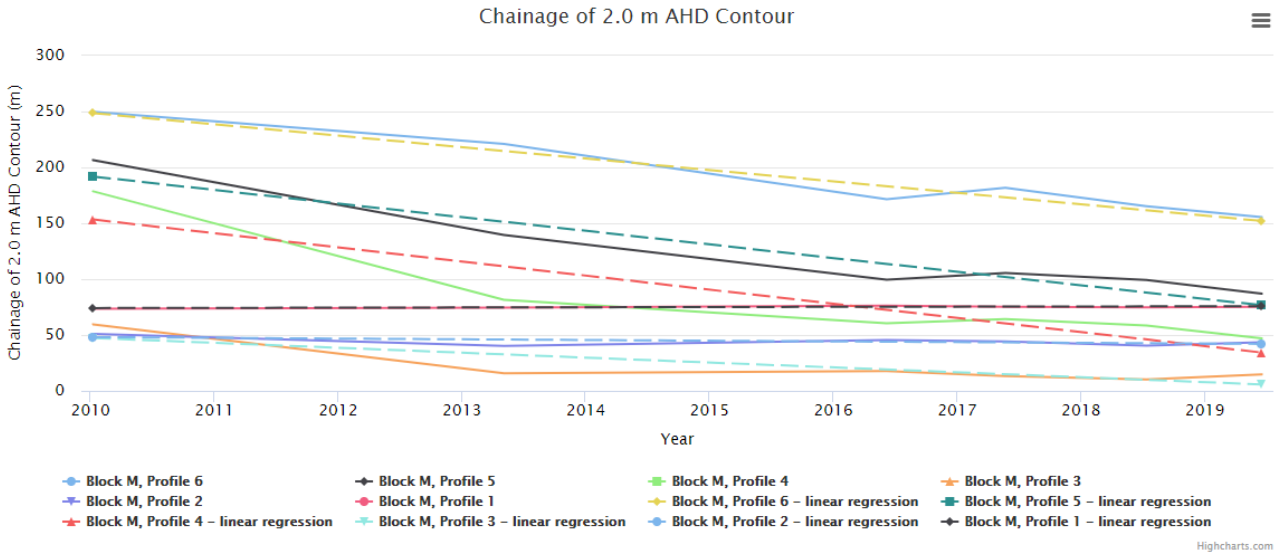

Profile	Linear Regression Slope (m/year)	R^2
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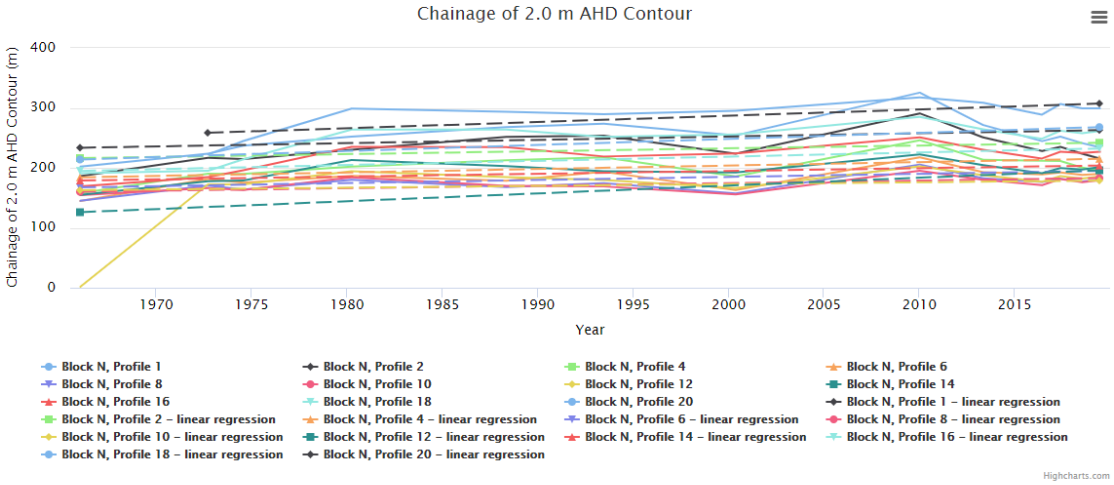
Block N



Profile	Linear Regression Slope (m/year)	R^2
Block N, Profile 1	0.55	0.14
Block N, Profile 2	0.48	0.15
Block N, Profile 4	0.58	0.31
Block N, Profile 6	0.51	0.37
Block N, Profile 8	0.43	0.36
Block N, Profile 10	0.3	0.28
Block N, Profile 12	1.31	0.27
Block N, Profile 14	0.47	0.3
Block N, Profile 16	0.7	0.4
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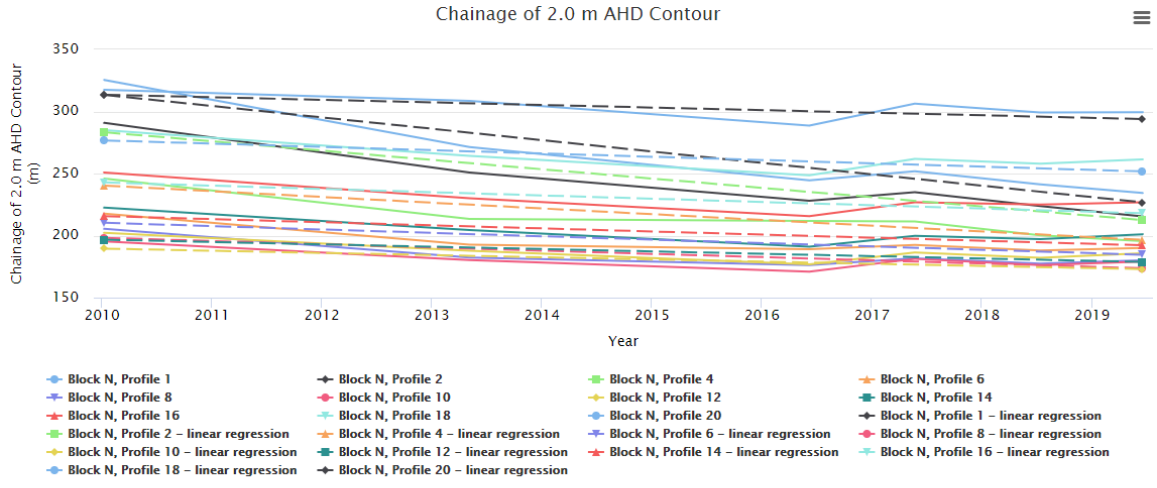

Profile	Linear Regression Slope (m/year)	R^2
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Block N, Profile 6	-2.72	0.71
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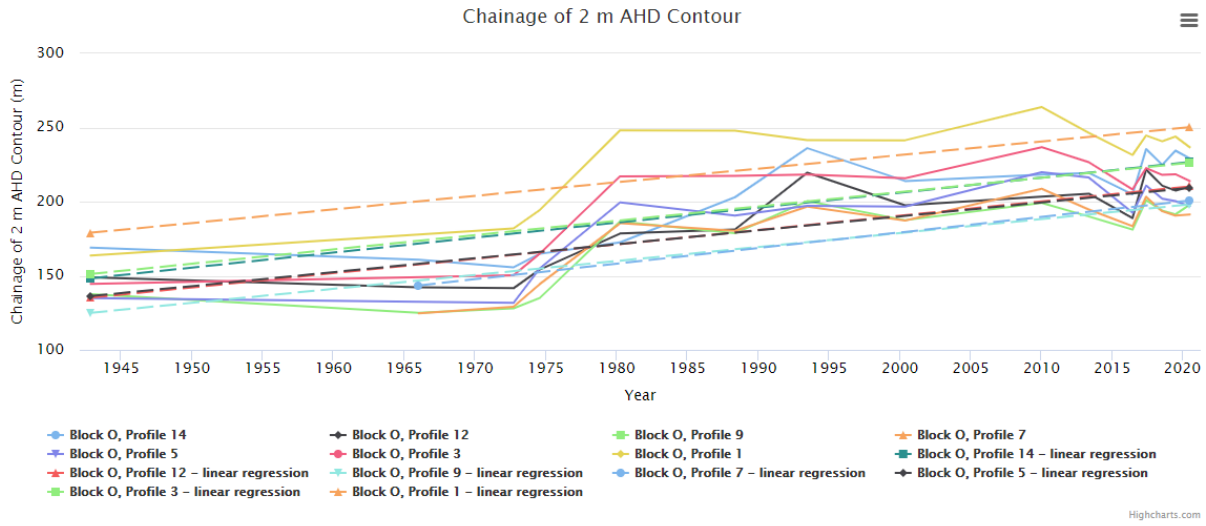
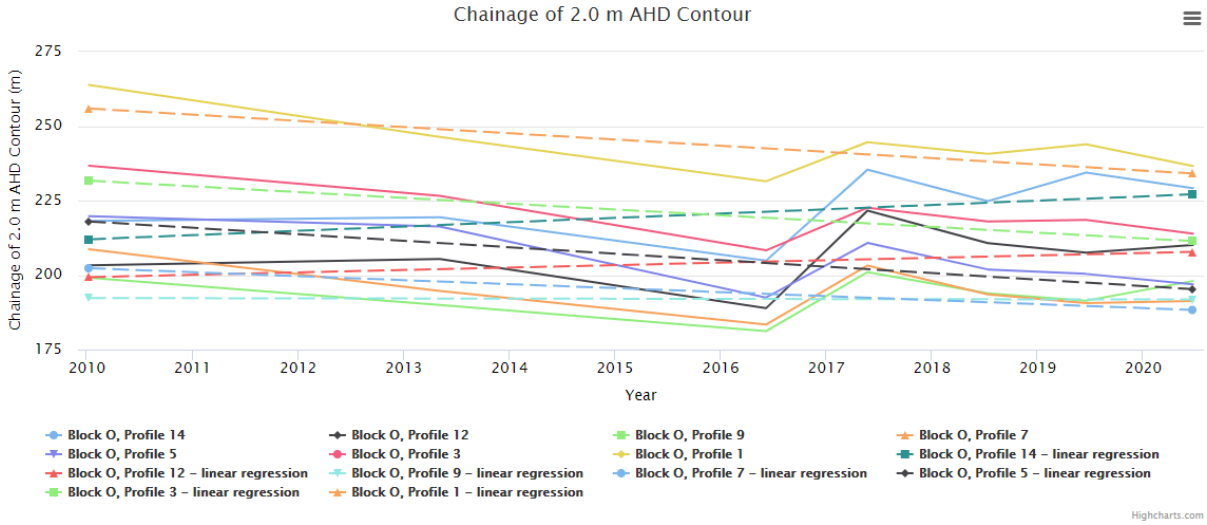
Block N, Profile 14	-2.49	0.57
Block N, Profile 16	-2.63	0.52
Block N, Profile 18	-2.64	0.49
Block N, Profile 20	-2.08	0.41

Block O

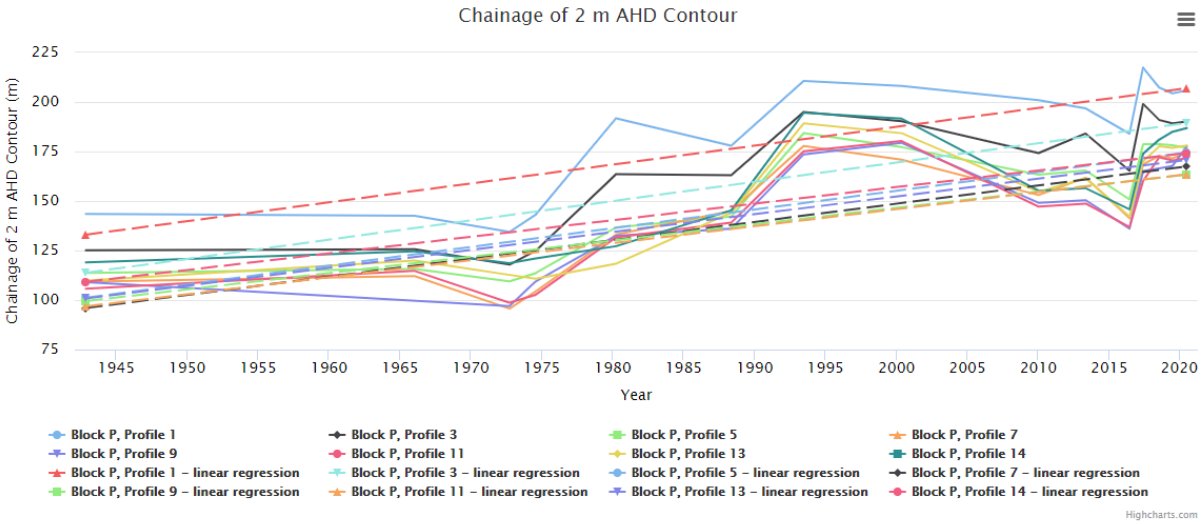


Profile	Linear Regression Slope (m/year)	R^2
Block O, Profile 14	1.01	0.69
Block O, Profile 12	0.97	0.71
Block O, Profile 9	0.94	0.66
Block O, Profile 7	1.05	0.64
Block O, Profile 5	0.94	0.65
Block O, Profile 3	0.97	0.63
Block O, Profile 1	0.92	0.58

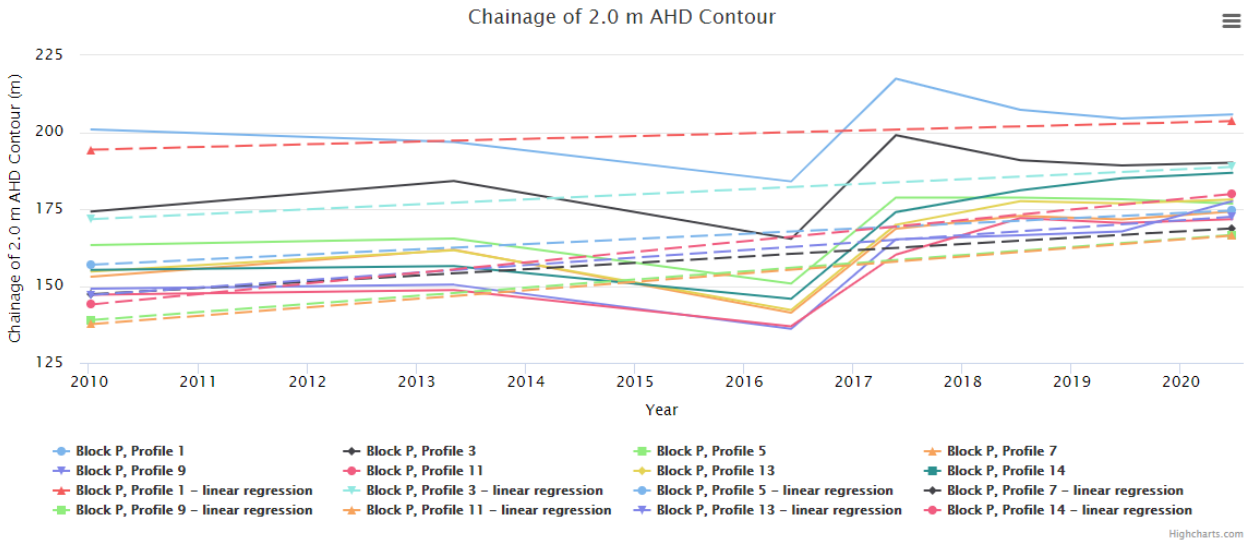


Profile	Linear Regression Slope (m/year)	R^2
Block O, Profile 14	1.45	0.17
Block O, Profile 12	0.81	0.06
Block O, Profile 9	-0.05	0.0
Block O, Profile 7	-1.35	0.27
Block O, Profile 5	-2.17	0.49
Block O, Profile 3	-1.94	0.48
Block O, Profile 1	-2.09	0.47

Block P

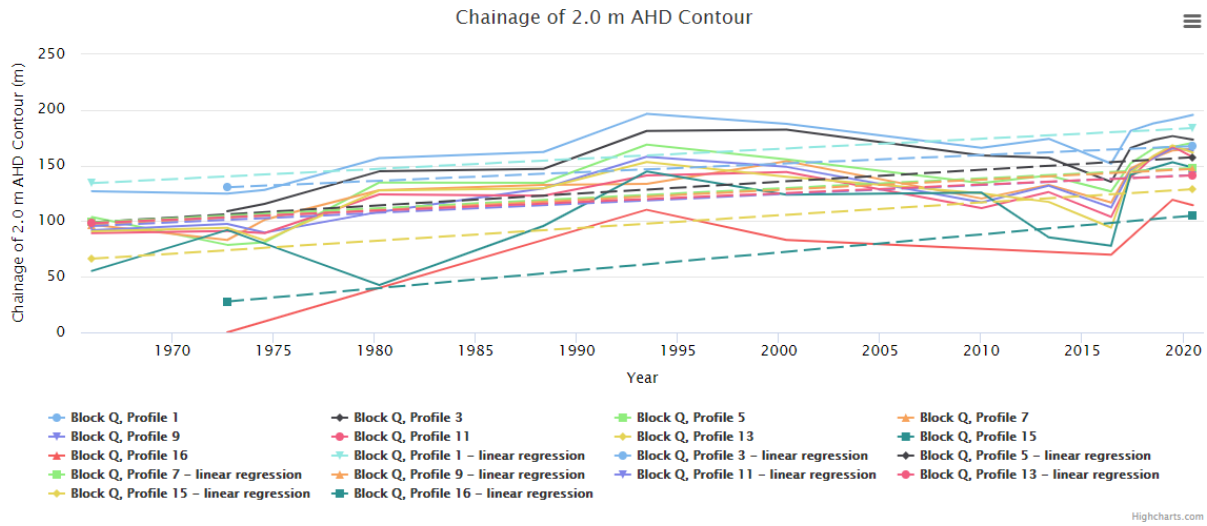


Profile	Linear Regression Slope (m/year)	R^2
Block P, Profile 1	0.95	0.65
Block P, Profile 3	0.97	0.67
Block P, Profile 5	0.94	0.68
Block P, Profile 7	0.92	0.62
Block P, Profile 9	0.82	0.52
Block P, Profile 11	0.86	0.56
Block P, Profile 13	0.9	0.57
Block P, Profile 14	0.84	0.51

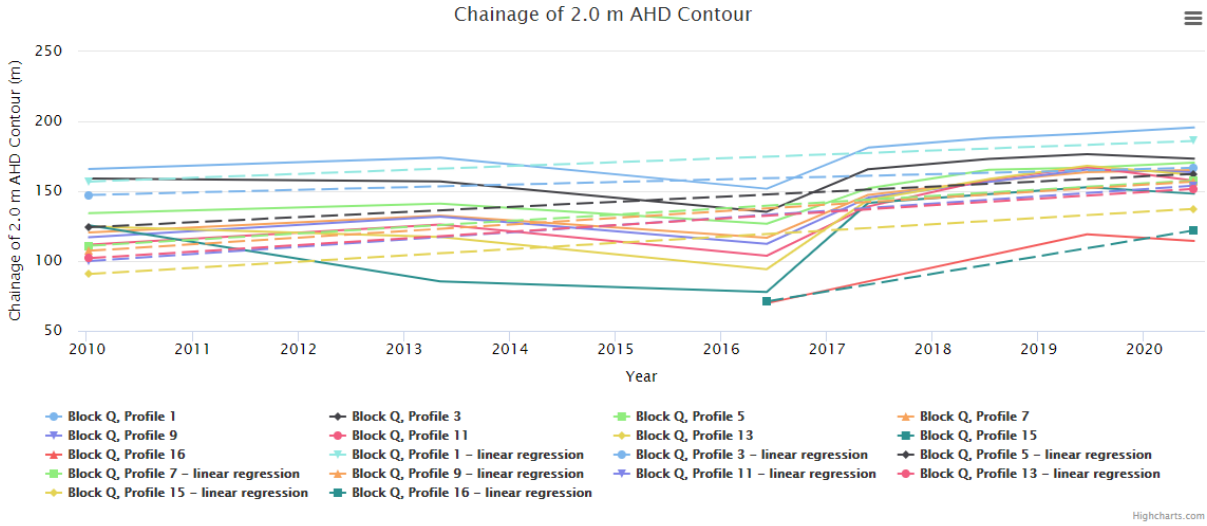


Profile	Linear Regression Slope (m/year)	R^2
Block P, Profile 1	0.89	0.07
Block P, Profile 3	1.63	0.2
Block P, Profile 5	1.69	0.23
Block P, Profile 7	2.05	0.26
Block P, Profile 9	2.64	0.34
Block P, Profile 11	2.76	0.39
Block P, Profile 13	2.43	0.3
Block P, Profile 14	3.43	0.45

Block Q



Profile	Linear Regression Slope (m/year)	R^2
Block Q, Profile 1	0.91	0.5
Block Q, Profile 3	0.78	0.34
Block Q, Profile 5	1.07	0.5
Block Q, Profile 7	0.9	0.5
Block Q, Profile 9	0.92	0.46
Block Q, Profile 11	0.84	0.4
Block Q, Profile 13	0.79	0.29
Block Q, Profile 15	1.15	0.34
Block Q, Profile 16	1.62	0.49



Profile	Linear Regression Slope (m/year)	R^2
Block Q, Profile 1	2.78	0.31
Block Q, Profile 3	1.87	0.15
Block Q, Profile 5	3.66	0.47
Block Q, Profile 7	4.48	0.53
Block Q, Profile 9	4.75	0.51
Block Q, Profile 11	5.15	0.46
Block Q, Profile 13	4.76	0.3
Block Q, Profile 15	4.47	0.21
Block Q, Profile 16	12.59	0.93

Attachment 2 – Trial Bay Coastal Hazard Maps

2021 Coastal Erosion Hazard Map

Trial Bay Visitor's Precinct

n

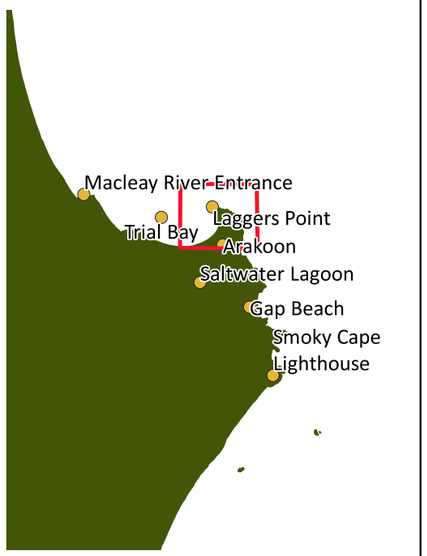
0 2 4 6 8 km

Present Day (2021)
Almost Certain

Present Day (2021)
Unlikely

Present Day (2021)
Rare

Breakwater/Rocky shoreline



Produced by Alluvium Consulting Australia

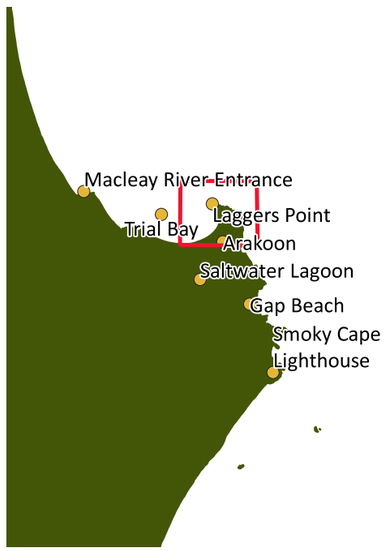
2050 Coastal Erosion Hazard Map

Trial Bay Visitor's Precinct

n

0 2 4 6 8 km

- 2050 - Almost Certain
- 2050 - Unlikely
- 2050 - Rare
- Breakwater/Rocky shoreline
- Nominal buffer (10 m)
- Nominal buffer (20 m)
- Approx historical shoreline before breakwater



Produced by Alluvium Consulting Australia

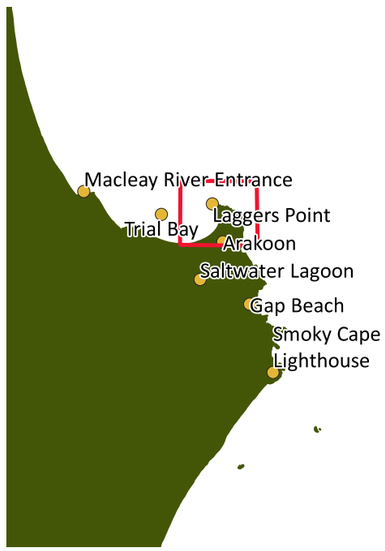
2100 Coastal Erosion Hazard Map

Trial Bay Visitor's Precinct

n

0 2 4 6 8 km

- 2100 - Almost Certain
- 2100 - Unlikely
- 2100 - Rare
- Breakwater/Rock wall
- Nominal buffer (10 m)
- Nominal buffer (20 m)
- Approx historical shoreline before breakwater



Produced by Alluvium Consulting Australia

Appendix 6: Coastal hazards risk assessment

Exposure and risk assessment results

This appendix provides an overview of the exposure and risk assessment results to inform an appreciation of risk at the level required to guide the strategic adaptation response and options. This appendix should be read in conjunction with the Trial Bay Coast and Foreshore Protection Strategy. The exposure and risk observations build on the coastal hazard assessments provided in the Trial Bay Coastal Processes and Hazards Assessment Report found in Appendix 5.

This appendix includes an overview of exposure and risk results for the following asset categories:

- buildings and facilities
- utilities infrastructure
- transport infrastructure
- beach and foreshore assets.

Exposure results are based on hazard extents and likelihoods that are described in the Trial Bay Coastal Processes and Hazards Assessment Report. The following table provides a summary of the coastal hazards, planning horizons, and likelihood scenarios used in the exposure assessment.

Summary of coastal hazards, planning horizons, and likelihood scenarios used in the exposure assessment

Coastal hazard	Planning horizons	Likelihood scenarios			Original source of data	Modifications
Beach erosion and shoreline recession	Present Day	Almost Certain	Unlikely	Rare	BMT 2013	Hazard lines in western portion retained. Eastern portion corrected to represent 2021 evolution.
	2050,	Almost Certain	Unlikely	Rare	BMT 2013	Erosion widths retained. Alignment in eastern portion modified
	2100	Almost Certain	Unlikely	Rare	BMT 2013	Erosion widths retained. Alignment in eastern portion modified
Coastal Inundation	Present Day	Almost Certain	Unlikely	Rare	JBP 2021	No modifications
	2050,	Almost Certain	Unlikely	Rare	JBP 2021	No modifications
	2100	Almost Certain	Unlikely	Rare	JBP 2021	No modifications
Tidal inundation	Present Day	Highest Astronomical Tide			JBP 2021	No modifications

Coastal hazard	Planning horizons	Likelihood scenarios	Original source of data	Modifications
	2050,	Highest Astronomical Tide	JBP 2021	No modifications
	2100	Highest Astronomical Tide	JBP 2021	No modifications

The risk assessment considered the exposure results and applied consequence values to ascertain a risk score for each asset. The consequence scale that provided the basis for assigning a consequence value to each asset type.

The consequence values assigned to each asset type are provided in the table on the following page.

The risk matrix below was used to determine the risk level for each asset.

Table 10 Risk assessment matrix

		Consequence				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Likelihood	Almost Certain	Low	Medium	High	Very high	Very high
	Unlikely	Low	Medium	Medium	High	Very high
	Rare	Low	Low	Medium	Medium	High

A risk profile is developed by considering the evolution of risk across each planning horizon.

Risk is considered separately for storm tide inundation, open coast erosion, and tidal inundation. This approach acknowledges that each hazard presents different consequences of exposure and that adaptation options should be designed to mitigate distinct coastal hazards.

Risk results are reported as the proportion of the length (for linear assets), area (for polygon assets), or count (for point assets) of assets in the study area classified under each risk category. This provides information on the asset types that are most at risk. Information on the risk profile for individual assets can be viewed in the risk maps or in the spatial layers that were produced as a result of the risk assessment.

Risk mapping is provided for reference in Attachment 1.

Table 11 Asset database and assigned consequence.

Asset category	Asset type	Feature type	Consequence (erosion)	Consequence (storm tide)
Beach and Foreshore	Sea Wall	Sea Wall	Major	Moderate
Beach and Foreshore	Sea Wall	Breakwater	Major	Minor
Beach and Foreshore	Beach Access	Trial Bay to day use beach area	Moderate	Minor
Beach and Foreshore	Beach Access	Trial Bay by picnic area	Major	Minor
Beach and Foreshore	Beach Access	Steps - Trial Bay to seafront	Major	Minor
Beach and Foreshore	Beach Access	Steps - Trial Bay Camping Area - 01	Major	Minor
Beach and Foreshore	Beach Access	Steps - Trial Bay Camping Area - 02	Major	Minor
Beach and Foreshore	Beach Access	Steps - Trial Bay CA Beach access	Major	Minor
Beach and Foreshore	Beach Access	Steps - Trial Bay by boat ramp	Major	Minor
Beach and Foreshore	Beach Access	Fisho's Track	Moderate	Minor
Beach and Foreshore	Boating facility	Gaol boat ramp	Major	Minor
Buildings/Facilities	Amenities	Amenity Block	Major	Moderate
Buildings/Facilities	Amenities	Toilet	Moderate	Moderate
Buildings/Facilities	Other building	Shed	Minor	Minor
Buildings/Facilities	Commercial/Retail	Historic Only	Major	Major
Buildings/Facilities	Commercial/Retail	Visitor Centre	Major	Major
Buildings/Facilities	Commercial/Retail	Kiosk	Moderate	Moderate
Buildings/Facilities	Commercial/Retail	Office	Moderate	Moderate
Buildings/Facilities	Recreational assets	BBQ/Fireplace	Moderate	Moderate
Buildings/Facilities	Recreational assets	Bin	Insignificant	Insignificant
Buildings/Facilities	Recreational assets	Picnic Table	Moderate	Minor

Asset category	Asset type	Feature type	Consequence (erosion)	Consequence (storm tide)
Buildings/Facilities	Recreational assets	Seat	Moderate	Minor
Buildings/Facilities	Recreational assets	Shelter	Moderate	Minor
Infrastructure/Utilities	Amenity assets	Bollard	Moderate	Minor
Infrastructure/Utilities	Amenity assets	Edging	Minor	Minor
Infrastructure/Utilities	Amenity assets	Retaining Wall	Major	Moderate
Infrastructure/Utilities	Amenity assets	Roadside Barrier	Moderate	Minor
Infrastructure/Utilities	Water	Culvert	Major	Moderate
Infrastructure/Utilities	Stormwater	Stormwater Drain Pit	Major	Moderate
Infrastructure/Utilities	Other	Oil Separator	Moderate	Minor
Infrastructure/Utilities	Amenity assets	Fence	Moderate	Minor
Infrastructure/Utilities	Amenity assets	Hand Rail Only	Moderate	Minor
Infrastructure/Utilities	Amenity assets	Gate	Moderate	Minor
Infrastructure/Utilities	Water	Hydrant	Moderate	Minor
Infrastructure/Utilities	Water	Inspection Pit	Moderate	Minor
Infrastructure/Utilities	Water	Meter	Moderate	Minor
Infrastructure/Utilities	Water	Ohead Supply Outlet	Moderate	Minor
Infrastructure/Utilities	Water	Outdoor Shower	Moderate	Minor
Infrastructure/Utilities	Water	Washdown Bay	Moderate	Minor
Infrastructure/Utilities	Water	Tap	Moderate	Minor
Infrastructure/Utilities	Sewer	Wastewater Outlet	Major	Moderate
Infrastructure/Utilities	Water	Tank	Major	Moderate
Infrastructure/Utilities	Other	Loading ramp	Major	Moderate
Infrastructure/Utilities	Amenity assets	Viewing Platform	Major	Moderate

Asset category	Asset type	Feature type	Consequence (erosion)	Consequence (storm tide)
Infrastructure/Utilities	Other	Other pipe/channel	Major	Moderate
Infrastructure/Utilities	Water	Water Supply Pipe	Major	Moderate
Infrastructure/Utilities	Sewer	Sewer Pipe	Major	Moderate
Infrastructure/Utilities	Electricity	Power Line	Major	Major
Infrastructure/Utilities	Electricity	Ext Lighting Fixture	Major	Moderate
Infrastructure/Utilities	Electricity	Power Control Board	Major	Major
Infrastructure/Utilities	Electricity	Power Distribution Board	Major	Major
Infrastructure/Utilities	Electricity	Power Generator	Major	Major
Infrastructure/Utilities	Electricity	Power Inspection Pit	Moderate	Moderate
Infrastructure/Utilities	Electricity	Power Outlet	Major	Major
Infrastructure/Utilities	Electricity	Power Switchboard	Major	Major
Infrastructure/Utilities	Amenity assets	Panel Sign	Minor	Insignificant
Infrastructure/Utilities	Amenity assets	Plank Sign	Minor	Insignificant
Infrastructure/Utilities	Amenity assets	Totem Sign	Minor	Insignificant
Infrastructure/Utilities	Amenity assets	Stairway	Major	Moderate
Infrastructure/Utilities	Amenity assets	Steps	Major	Moderate
Infrastructure/Utilities	Sewer	Sewerage Disposal System	Major	Major
Land, Environment and Culture	Beach	Front Beach	Major	Moderate
Land, Environment and Culture	Landuse	Quarry	Major	Moderate
Land, Environment and Culture	Historic Site	Gravesite	Major	Minor
Land, Environment and Culture	Vegetation communities	Dry Sclerophyll Forest & Woodland	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Dry Sclerophyll Forest & Woodland/Graminoid Clay	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Dry Sclerophyll Shrubland	Moderate	Minor

Asset category	Asset type	Feature type	Consequence (erosion)	Consequence (storm tide)
Land, Environment and Culture	Vegetation communities	Graminoid Clay Heathland	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Littoral Rainforest	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Sod Grassland	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Swamp Sclerophyll Forest & Woodland	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Wet Sclerophyll Forest	Moderate	Minor
Land, Environment and Culture	Vegetation communities	Planted Pine	Moderate	Minor
Land, Environment and Culture	Heritage	Historic Ruin	Major	Moderate
Land, Environment and Culture	Heritage	Monument/Plaque	Major	Moderate
Land, Environment and Culture	Landuse	Vehicle Parking Area	Major	Moderate
Land, Environment and Culture	Landuse	Power site pad	Major	Moderate
Land, Environment and Culture	Landuse	Garden	Moderate	Minor
Land, Environment and Culture	Landuse	Little Bay	Major	Moderate
Land, Environment and Culture	Landuse	Depot yard	Major	Moderate
Land, Environment and Culture	Landuse	Terrace Campground	Major	Moderate
Land, Environment and Culture	Landuse	Overnight area	Major	Moderate
Land, Environment and Culture	Landuse	BBQ/Picnic area	Major	Moderate
Land, Environment and Culture	Landuse	Sunrise Hill	Major	Moderate
Land, Environment and Culture	Landuse	Monument	Moderate	Minor
Land, Environment and Culture	Landuse	Beachfront campsites	Major	Moderate
Land, Environment and Culture	Landuse	Parking area lawn	Moderate	Minor
Land, Environment and Culture	Landuse	Gaol visitor area	Major	Moderate
Land, Environment and Culture	Landuse	Mozzy Alley	Moderate	Minor
Land, Environment and Culture	Landuse	Powered sites	Major	Moderate

Asset category	Asset type	Feature type	Consequence (erosion)	Consequence (storm tide)
Land, Environment and Culture	Landuse	Regeneration area	Moderate	Minor
Transport	Elevated Walkway	Pedestrian Bridge	Major	Moderate
Transport	Road	Vehicle Trail	Major	Moderate
Transport	Road	Local Road	Major	Moderate
Transport	Road	Dormant Trail	Moderate	Minor
Transport	Track	Footpath	Major	Moderate
Transport	Track	Walking Track	Major	Moderate
Transport	Visitor Monitoring Point	Vehicle Counter	Insignificant	Insignificant

Buildings and facilities

The buildings and facilities asset list comprise a variety of structures, including the office, visitor centre, kiosk, historical buildings, shelters, toilets, and amenity blocks. Buildings are significant assets as they are relied upon for business, recreation, shelter, and accommodation for locals and visitors. Most buildings are considered permanent structures and are expensive to build, repair or replace. Some of the smaller recreational facilities, including bins, picnic tables, seats, shelters, and BBQs/fireplaces, are considered are semi-permanent or moveable.

The risk associated with buildings depends on the consequence of their exposure to coastal hazards. Buildings critical to the functioning of the Trial Bay Visitor Precinct have been assigned a higher consequence. Another factor is the design of the building. For example, buildings with raised floors are less at risk of damage from flooding compared to buildings at ground level. Buildings can be built or retrofitted to increase resilience to coastal hazards by incorporating design elements such as raised electrical infrastructure and other appliances.

Results from the risk assessment for buildings and facilities in the study area are provided in the proceeding tables.

Summary of results

Key buildings at risk include the office, some amenity blocks, some shelters, and the shed. Risk to buildings is predominantly from storm tide inundation hazard.

Open coast erosion

The risk of open coast erosion for buildings is minimal, with no buildings at risk in the present day and only one building (the amenity block) at high risk in 2050 to 2100.

Multiple smaller recreational assets are in the low to high risk category presently (including 3 BBQs, 1 bin, 3 picnic tables, and 1 seat). There is a significant increase in risk by 2050 to include an additional 11 BBQs, 2 bins, 15 picnic tables, 1 seat, and 2 shelters at risk. This risk remains the same by 2100.

None of the buildings or facilities are situated in the very high risk zone from present-day to 2100.

Storm tide inundation

At present, 3 buildings are at medium to high risk of storm tide inundation (including the amenity block, visitor precinct office, and shed). This risk remains the same by 2050 and 2100.

Many of the recreational assets are at low to high risk of storm tide inundation at some point. Presently, this includes 2 BBQs, 1 bin, 5 picnic tables, and 1 shelter. The risk only slightly increases by 2050 to include 1 additional picnic table and 1 seat. It again increases minimally by 2100 to include another 2 BBQs, and 2 picnic tables.

None of the buildings or facilities are situated in the very high risk zone from present-day to 2100.

Tidal areas

At present, only two buildings are at medium to very high risk for tidal areas (the amenity block and shed). There is a negligible change in risk for buildings by 2050; however, by 2100, the risk increases to include the office at high risk.

Several recreational assets are situated in the high risk category at present (including 7 BBQs, 9 picnic tables, and 1 shelter). This risk increases by 2050, with an additional 2 BBQs, 2 picnic tables, 1 seat and 1 shelter placed in the high risk category, along with 2 bins in the low risk category for tidal areas. By 2100, the risk increases again slightly to include another 3 BBQs, 5 picnic tables, 1 seat, and 1 bin.

Table 12 Open coast erosion exposure assessment results – Buildings/facilities

Buildings/Facilities – Exposure	Total area (m^2) or count within study area	Open coast erosion exposure															
		PD						2050						2100			
		Almost Certain	%	Unlikely	%	Rare	%	Almost Certain	%	Unlikely	%	Rare	%	Almost Certain	%	Unlikely	%	Rare	%
Point assets	**Count**																		
Recreational assets																			
BBQ/Fireplace	24	3	13%	0	0%		0%	3	13%	6	25%	5	21%	3	13%	7	29%	4	17%
Bin	9		0%		0%	1	11%		0%	2	22%	1	11%		0%	2	22%	1	11%
Picnic Table	34	2	6%		0%	1	3%	2	6%	9	26%	7	21%	2	6%	11	32%	5	15%
Seat	15		0%	1	7%		0%		0%	2	13%		0%		0%	2	13%		0%
Shelter	6		0%		0%		0%		0%	1	17%	1	17%		0%	1	17%	1	17%
Polygons	**Area (m^2)**																		
Amenities																			
Amenity Block	812		0%		0%		0%		0%	45	6%	84	10%		0%	204	25%	348	43%
Toilet	61		0%		0%		0%		0%		0%		0%		0%		0%		0%
Commercial/Retail																			
Historic Only	1,786		0%		0%		0%		0%		0%		0%		0%		0%		0%
Kiosk	475		0%		0%		0%		0%		0%		0%		0%		0%		0%
Office	24		0%		0%		0%		0%		0%		0%		0%		0%		0%
Visitor Centre	119		0%		0%		0%		0%		0%		0%		0%		0%		0%
Other building																			
Shed	676		0%		0%		0%		0%		0%		0%		0%		0%		0%

Table 13 Open coast erosion risk assessment results – Buildings/facilities

Buildings/Facilities – Risk	Total area (m^2) or count within study area	Open coast erosion risk																	
		PD								2050								2100							
		Low	%	Medium	%	High	%	Very high	%	Low	%	Medium	%	High	%	Very high	%	Low	%	Medium	%	High	%	Very high	%
Point assets	**Count**																								
Recreational assets																									
BBQ/Fireplace	24		0%		0%	3	13%		0%		0%	11	46%	3	13%		0%		0%	11	46%	3	13%		0%
Bin	9	1	11%		0%		0%		0%	3	33%		0%		0%		0%	3	33%		0%		0%		0%
Picnic Table	34	2	6%	1	3%		0%		0%	2	6%	16	47%		0%		0%	2	6%	16	47%		0%		0%
Seat	15		0%	1	7%		0%		0%		0%	2	13%		0%		0%		0%	2	13%		0%		0%
Shelter	6		0%		0%		0%		0%		0%	2	33%		0%		0%		0%	2	33%		0%		0%
Linear assets	**Area (m^2)**																								
Amenities																									
Amenity Block	812		0%		0%		0%		0%		0%		0%	84	10%		0%		0%		0%	348	43%		0%
Toilet	61		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%

Buildings/Facilities – Risk	Total area (m^2) or count within study area	Open coast erosion risk											
		PD				2050				2100			
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high
		%	%	%	%	%	%	%	%	%	%	%	%
Commercial/Retail													
Historic Only	1,786	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kiosk	475	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Office	24	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Visitor Centre	119	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other building													
Shed	676	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 14 Storm tide inundation exposure assessment results – Buildings/facilities

Buildings/Facilities – Exposure	Total area (m^2) or count in the study area	Storm tide inundation exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Recreational assets																			
BBQ/Fireplace	24	1	4%	1	4%		0%	1	4%	1	4%		0%	1	4%	3	13%		0%
Bin	9		0%		0%	1	11%		0%	1	11%	1	11%		0%	2	22%		0%
Picnic Table	34	4	12%	1	3%		0%	4	12%	1	3%	1	3%	4	12%	3	9%	1	3%
Seat	15		0%		0%		0%		0%		0%	1	7%		0%	1	7%		0%
Shelter	6	1	17%		0%		0%	1	17%		0%		0%	1	17%		0%		0%
Polygon assets	**Area (m^2)**																		
Amenities																			
Amenity Block	812	348	43%		0%		0%	348	43%		0%		0%	348	43%		0%		0%
Toilet	61		0%		0%		0%		0%		0%		0%		0%		0%		0%
Commercial/Retail																			
Historic Only	1,786		0%		0%		0%		0%		0%		0%		0%		0%		0%
Kiosk	475		0%		0%		0%		0%		0%		0%		0%		0%		0%
Office	24		0%	19	79%	5	21%		0%	24	100%		0%		0%	24	100%		0%
Visitor Centre	119		0%		0%		0%		0%		0%		0%		0%		0%		0%
Other building																			
Shed	676	330	49%	272	40%	74	11%	330	49%	347	51%		0%	330	49%	347	51%		0%

Table 15 Storm tide inundation risk assessment results – Buildings/facilities

Buildings/Facilities – Exposure	Total area (m^2) or count in the study area	Storm tide inundation exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Recreational assets																			
BBQ/Fireplace	24	1	4%	1	4%		0%	1	4%	1	4%		0%	1	4%	3	13%		0%
Bin	9		0%		0%	1	11%		0%	1	11%	1	11%		0%	2	22%		0%
Picnic Table	34	4	12%	1	3%		0%	4	12%	1	3%	1	3%	4	12%	3	9%	1	3%
Seat	15		0%		0%		0%		0%		0%	1	7%		0%	1	7%		0%
Shelter	6	1	17%		0%		0%	1	17%		0%		0%	1	17%		0%		0%
Polygon assets	**Area (m^2)**																		
Amenities																			
Amenity Block	812	348	43%		0%		0%	348	43%		0%		0%	348	43%		0%		0%
Toilet	61		0%		0%		0%		0%		0%		0%		0%		0%		0%
Commercial/Retail																			
Historic Only	1,786		0%		0%		0%		0%		0%		0%		0%		0%		0%
Kiosk	475		0%		0%		0%		0%		0%		0%		0%		0%		0%
Office	24		0%	19	79%	5	21%		0%	24	100%		0%		0%	24	100%		0%
Visitor Centre	119		0%		0%		0%		0%		0%		0%		0%		0%		0%
Other building																			
Shed	676	330	49%	272	40%	74	11%	330	49%	347	51%		0%	330	49%	347	51%		0%

Table 16 Tidal area exposure assessment results – Buildings/facilities

Buildings/Facilities – Exposure	Total area (m^2) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Point assets	**Count**						
Recreational assets							
BBQ/Fireplace	24	7	29%	9	38%	12	50%
Bin	9		0%	2	22%	3	33%
Picnic Table	34	9	26%	11	32%	16	47%
Seat	15		0%	1	7%	2	13%
Shelter	6	1	17%	2	33%	2	33%
Polygon assets	**Area (m^2)**						
Amenities							
Amenity Block	812	348	43%	348	43%	348	43%
Toilet	61		0%		0%		0%
Commercial/Retail							
Historic Only	1,786		0%		0%		0%
Kiosk	475		0%		0%		0%
Office	24		0%		0%	24	100%
Visitor Centre	119		0%		0%		0%
Other building							
Shed	676	166	24%	156	23%	676	100%

Table 17 Tidal area risk assessment results – Buildings/facilities

Buildings/ Facilities – Risk	Total area (m^2) or count in the study area	Tidal areas risk																	
		PD					2050								2100				
		Low		Medium		High		Very high		Low		Medium		High		Very high		Low	
		%		%		%		%		%		%		%		%		%	
Point assets	**Count**																		
Recreational assets																			
BBQ/Fireplace	24	0	%	0%	7	29	%	0%	0%		0%	9	38	%	0%	0%		0%	12
Bin	9	0	%	0%		0%		0%	2	22	%	0%		0%	0%	3	33	%	0%
Picnic Table	34	0	%	0%	9	26	%	0%	0%		0%	11	32	%	0%	0%		0%	16
Seat	15	0	%	0%		0%		0%	0%		0%	1	7%		0%	0%		0%	2
Shelter	6	0	%	0%	1	17	%	0%	0%		0%	2	33	%	0%	0%		0%	2
Polygon assets	**Area (m^2)**																		
Amenities																			
Amenity Block	812	0	%	0%		0%	348	43	%	0%		0%		0%	348	43	%	0%	
Toilet	61	0	%	0%		0%		0%	0%		0%		0%		0%	0%		0%	
Commercial/Retail																			
Historic Only	1,786	0	%	0%		0%		0%	0%		0%		0%		0%	0%		0%	
Kiosk	475	0	%	0%		0%		0%	0%		0%		0%		0%	0%		0%	
Office	24	0	%	0%		0%		0%	0%		0%		0%		0%	0%		0%	24
Visitor Centre	119	0	%	0%		0%		0%	0%		0%		0%		0%	0%		0%	
Other building																			
Shed	676	0	%	166	24	%		0%	0%		0%	156	23	%	0%	0%		0%	676

Beach and foreshore assets

Beach and foreshore assets comprise predominately of recreational/tourism assets such as beach access points, picnic and day use areas, boat ramps, and viewing platforms, as well as coastal protection structures such as sea walls.

The nature of the coastal protection structures, including the Laggers Point Breakwater and campground foreshore sea wall, means that they are the last line of defence against coastal hazards and therefore are within the at-risk category by their very nature. The effectiveness of these structures in protecting the shoreline is dependent on their design and condition, and as such, should be regularly assessed for damage and durability. As these assets are important for community protection and recreation, they have been assigned a high consequence. Combined with a likelihood of 'likely', these assets are considered at very high risk.

These types of assets are designed to have resilience to the coastal hazards, so while at very high risk, their risk of failure for anything but an extreme event should be low if they are maintained in good condition. Discretion should be applied when interpreting this risk for these assets considering their condition and maintenance program.

Results from the risk assessment for beach and foreshore assets in the study area are provided in the proceeding tables.

Summary of results

Open coast erosion

The risk of open coast erosion for beach and foreshore assets is significant. One-hundred per cent of coastal protection structures (i.e., sea wall and breakwater) fall within the high to very high risk categories from present-day to 2100, as well as Fisho's track, the Trial Bay day use and picnic areas, and 3 of the 5 sets of beach access steps.

This risk remains the same by 2050 and 2100.

Storm tide inundation

At present, 100% of the coastal protection structures fall within the medium to high risk categories for storm tide inundation. Additionally, the gaol boat ramp and 3 of the 5 sets of beach access steps are at high risk.

By 2050, this risk increases slightly to include Fisho's track and the day use beach area in the high risk category. By 2100, Trial Bay picnic area also falls into the high risk category.

Tidal areas

At present, 100% of the coastal protection structures are at very high risk from tidal areas, along with 3 of the 5 sets of beach access steps, Trial Bay picnic area, and the gaol boat ramp.

There is a slight increase in risk by 2050, with the boat ramp access steps and the day use beach area also situated in the high to very high risk categories. This risk remains the same by 2100.

Table 18 Open coast erosion exposure assessment results – Beach and foreshore

Beach and Foreshore – Exposure	Total length (m) or count within study area	Open coast erosion exposure											
		PD				2050				2100			
		Almost Certain	%	Unlikely %	Rare %	Almost Certain	%	Unlikely %	Rare %	Almost Certain	%	Unlikely %	Rare %
Point assets	**Count**												
Beach Access													
Fisho's Track	1	1	100%	0%	0%	1	100%	0%	0%	1	100%	0%	0%
Steps - Trial Bay by boat ramp	1		0%	0%	0%		0%	0%	0%		0%	0%	0%
Steps - Trial Bay CA Beach access	1	1	100%	0%	0%	1	100%	0%	0%	1	100%	0%	0%
Steps - Trial Bay Camping Area - 01	1	1	100%	0%	0%	1	100%	0%	0%	1	100%	0%	0%
Steps - Trial Bay Camping Area - 02	1	1	100%	0%	0%	1	100%	0%	0%	1	100%	0%	0%
Steps - Trial Bay To Seafront	1		0%	0%	0%		0%	0%	0%		0%	0%	0%
Trial Bay by picnic area	1	1	100%	0%	0%	1	100%	0%	0%	1	100%	0%	0%
Trial Bay to day use beach area	1	1	100%	0%	0%	1	100%	0%	0%	1	100%	0%	0%
Boating facility													
Gaol boat ramp	1		0%	0%	0%		0%	0%	0%		0%	0%	0%
Amenity assets													
Viewing Platform	2		0%	0%	0%		0%	0%	0%		0%	0%	0%
Point assets	**Length (m)**												
Sea Wall													
Breakwater	256	256	100%	0%	0%	256	100%	0%	0%	256	100%	0%	0%
Sea Wall	414	414	100%	0%	0%	414	100%	0%	0%	414	100%	0%	0%

Table 19 Open coast erosion risk assessment results – Beach and foreshore

Beach and Foreshore – Risk	Total length (m) or count within study area	Open coast erosion risk											
		PD				2050				2100			
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high
		%	%	%	%	%	%	%	%	%	%	%	%
Point assets	**Count**												
Beach Access													
Fisho's Track	1	0 %	0 %	1 100 %	0%	0 %	0 %	1 100 %	0%	0 %	0 %	1 100 %	0%
Steps - Trial Bay by boat ramp	1	0 %	0 %	0%	0%	0 %	0 %	0%	0%	0 %	0 %	0%	0%
Steps - Trial Bay CA Beach access	1	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %
Steps - Trial Bay Camping Area - 01	1	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %
Steps - Trial Bay Camping Area - 02	1	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %
Steps - Trial Bay To Seafront	1	0 %	0 %	0%	0%	0 %	0 %	0%	0%	0 %	0 %	0%	0%
Trial Bay by picnic area	1	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %	0 %	0 %	0%	1 100 %
Trial Bay to day use beach area	1	0 %	0 %	1 100 %	0%	0 %	0 %	1 100 %	0%	0 %	0 %	1 100 %	0%
Boating facility													
Gaol boat ramp	1	0 %	0 %	0%	0%	0 %	0 %	0%	0%	0 %	0 %	0%	0%
Amenity assets													
Viewing Platform	2	0 %	0 %	0%	0%	0 %	0 %	0%	0%	0 %	0 %	0%	0%
Linear assets	**Length (m)**												
Sea Wall													
Breakwater	256	0 %	0 %	0%	256 100 %	0 %	0 %	0%	256 100 %	0 %	0 %	0%	256 100 %
Sea Wall	414	0 %	0 %	0%	414 100 %	0 %	0 %	0%	414 100 %	0 %	0 %	0%	414 100 %

Table 20 Storm tide inundation exposure assessment results – Beach and foreshore

Beach and Foreshore – Exposure	Total length (m) or count in the study area	Storm tide inundation exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets																			
Beach Access																			
Fisho's Track	1		0%		0%		0%		0%	1	100%		0%		0%	1	100%		0%
Steps - Trial Bay by boat ramp	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Steps - Trial Bay CA Beach access	1	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%		0%
Steps - Trial Bay Camping Area - 01	1		0%	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%
Steps - Trial Bay Camping Area - 02	1	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%		0%
Steps - Trial Bay To Seafront	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Trial Bay by picnic area	1		0%		0%		0%		0%		0%		0%		0%	1	100%		0%
Trial Bay to day use beach area	1		0%		0%		0%		0%	1	100%		0%		0%	1	100%		0%
Boating facility																			
Gaol boat ramp	1		0%		0%	1	100%		0%	1	100%		0%		0%	1	100%		0%
Amenity assets																			
Viewing Platform	2		0%		0%		0%		0%		0%		0%		0%		0%		0%
Linear assets																			
Sea Wall																			
Breakwater	256	221	86%		0%	1	0%	221	86%	2	1%	2	1%	221	86%	9	3%	7	3%
Sea Wall	414	203	49%	33	8%	2	1%	203	49%	61	15%	42	10%	203	49%	128	31%	63	15%

Table 21 Storm tide inundation risk assessment results – Beach and foreshore

Beach and Foreshore – Risk	Total length (m) or count in the study area	Storm tide inundation risk															
		PD								2100							
		Low		Medium		High		Very high		Low		Medium		High		Very high	
			%		%		%		%		%		%		%		%
Point assets																	
Beach Access																	
Fisho's Track	1	0	%		0%		0%	0	%	0	%		0%	1	100 %	0	%
Steps - Trial Bay by boat ramp	1	0	%		0%		0%	0	%	0	%		0%		0%	0	%
Steps - Trial Bay CA Beach access	1	0	%		0%	1	100 %	0	%	0	%		0%	1	100 %	0	%
Steps - Trial Bay Camping Area - 01	1	0	%		0%	1	100 %	0	%	0	%		0%	1	100 %	0	%
Steps - Trial Bay Camping Area - 02	1	0	%		0%	1	100 %	0	%	0	%		0%	1	100 %	0	%
Steps - Trial Bay To Seafront	1	0	%		0%		0%	0	%	0	%		0%		0%	0	%
Trial Bay by picnic area	1	0	%		0%		0%	0	%	0	%		0%		0%	0	%
Trial Bay to day use beach area	1	0	%		0%		0%	0	%	0	%		0%	1	100 %	0	%
Boating facility																	
Gaol boat ramp	1	0	%		0%	1	100 %	0	%	0	%		0%	1	100 %	0	%
Amenity assets																	
Viewing Platform	2	0	%		0%		0%	0	%	0	%		0%		0%	0	%
Linear assets																	
Sea Wall																	
Breakwater	256	0	%	222	87 %		0%	0	%	0	%	224	88 %		0%	0	%	0	%	237	92 %		0%	0	%
Sea Wall	414	0	%	35	9%	203	49%	0	%	0	%	103	25 %	203	49%	0	%	0	%	191	46 %	203	49%	0	%

Table 22 Tidal area exposure assessment results – Beach and foreshore

Beach and Foreshore – Exposure	Total length (m) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Point assets	**Count**						
Beach Access							
Fisho's Track	1		0%		0%		0%
Steps - Trial Bay by boat ramp	1		0%	1	100%	1	100%
Steps - Trial Bay CA Beach access	1	1	100%	1	100%	1	100%
Steps - Trial Bay Camping Area - 01	1	1	100%	1	100%	1	100%
Steps - Trial Bay Camping Area - 02	1	1	100%	1	100%	1	100%
Steps - Trial Bay To Seafront	1		0%		0%		0%
Trial Bay by picnic area	1	1	100%	1	100%	1	100%
Trial Bay to day use beach area	1		0%	1	100%	1	100%
Boating facility							
Gaol boat ramp	1	1	100%	1	100%	1	100%
Amenity assets							
Viewing Platform	2		0%		0%		0%
Linear assets	**Length**						
Sea Wall							
Breakwater	256	202	79%	229	89%	237	92%
Sea Wall	414	366	88%	413	100%	413	100%

Table 23 Tidal area risk assessment results – Beach and foreshore

Beach and Foreshore – Risk	Total length (m) or count in the study area	Tidal areas risk															
		PD				2050								2100			
		Low		Medium		High		Very high		Low		Medium		High		Very high	
		%		%		%		%		%		%		%		%	
Point assets	**Count**																
Beach Access																	
Fisho's Track	1	0%		0%		0%		0%		0%		0%		0%		0%	
Steps - Trial Bay by boat ramp	1	0%		0%		0%		0%		0%		0%		0%	1	100%	
Steps - Trial Bay CA Beach access	1	0%		0%		0%	1	100%		0%		0%		0%	1	100%	
Steps - Trial Bay Camping Area - 01	1	0%		0%		0%	1	100%		0%		0%		0%	1	100%	
Steps - Trial Bay Camping Area - 02	1	0%		0%		0%	1	100%		0%		0%		0%	1	100%	
Steps - Trial Bay To Seafront	1	0%		0%		0%		0%		0%		0%		0%		0%	
Trial Bay by picnic area	1	0%		0%		0%	1	100%		0%		0%		0%	1	100%	
Trial Bay to day use beach area	1	0%		0%		0%		0%	1	100%		0%		0%		0%	
Boating facility																	
Gaol boat ramp	1	0%		0%		0%	1	100%		0%		0%		0%	1	100%	
Amenity assets																	
Viewing Platform	2	0%		0%		0%		0%		0%		0%		0%		0%	
Linear assets	**Length**																
Sea Wall																	
Breakwater	256	0%		0%		0%	202	79%		0%		0%	229	89%		0%	237	92%
Sea Wall	414	0%		0%		0%	366	88%		0%		0%	413	100%		0%	413	100%

Utilities and infrastructure

Utility infrastructure assets assessed include electrical, sewer, stormwater, and water assets. Results from the risk assessment for utilities and infrastructure assets in the study area are provided in the proceeding tables.

Summary of results

Open coast erosion

At present, the risk of open coast erosion for utility infrastructure is minimal. 0% of water, stormwater, sewer, or electrical assets are situated in the risk zone. However, in terms of amenity assets, 8 signs and 6% of bollards by length are at medium to high risk.

By 2050, the risk for erosion increases significantly, with 1 gate, 28 signs, 2 switchboards, 1 stormwater drain pit, 7 water inspection pits, and 2 taps at medium to high risk. Additionally, 32% of bollards, 14% of fences, 9% of retaining walls, 16% of roadside barriers and 21% of water supply pipe by length are at risk by 2050.

The risk increases again by 2100 to include 2 gates, 31 signs, 1 external lighting fixture, 3 power outlets, 3 power switchboards, 3 wastewater outlets, 1 stormwater drain pit, 2 hydrants, 7 water inspection pits, 1 outdoor shower, 11 taps, 38% of bollards, 20% of fences, 22% of retaining walls, 16% of roadside barriers, 7% of power lines, 8% of sewer pipes, and 43% of water supply pipes by length in the medium to high risk categories.

Storm tide inundation

At present, the risk of storm tide inundation for utility infrastructure is relatively higher. Water and stormwater assets are presently most vulnerable, with 4 of the stormwater drain pits (19%), 3 of the water inspection pits (33%), 22% of water supply pipes by length, 1% of sewer pipes by length, 1 overhead supply outlet (100%), 1 washdown bay (100%), 2 of the outdoor showers (50%), and 6 of the taps (17%) situated in the medium to high risk categories. Additionally, several electricity assets are at medium to very high risk (17% of power lines by length, 1 power control board, and 3 power switchboards), as well as several amenity assets (11% of bollards, 9% of gates, 1% of handrails, 12% of retaining walls, 3 gates and 9 signs), and 2 other assets (1 loading ramp and 1 oil separator).

By 2050, the risk for storm tide inundation increases slightly, from 22% of water supply pipes by length presently at risk to 23% by 2050, 2 of the outdoor showers presently to 3 by 2050 (75%), 0 to 1 of the meters by 2050 (33%), and 6 of the taps to 8 (23%) by 2050 situated in the medium to high risk categories. The risk also increases slightly for electricity assets (from 17% of power lines by length to 18% at medium to high risk), as well as for the amenity assets (11% of bollards by length to 13%, 1% of handrails to 3%, 12% of retaining walls to 18%, and 9 signs to 12 signs at medium to very high risk).

The risk increases again by 2100. For water, stormwater, and sewer assets, a total of 29% of water supply pipes by length, 9% of sewer pipes by length, 1 hydrant, 4 inspection pits, 1 meter, 1 overhead supply outlet, 3 outdoor showers, 17 taps, and 1 washdown bay will be at medium to high risk by 2100. For electricity assets, 35% of power lines by length, 1 power control board, 5 power outlets, and 3 power switchboards will be at medium to very high risk by 2100. In terms of amenity and other assets, 20% of bollards by length, 22% of fences, 6% of handrails, 36% of retaining walls, 1 loading ramp, 1 oil separator, 4 gates, and 21 signs will be situated in the medium to very high risk zones by 2100.

Tidal areas

At present, several assets are at medium to very high risk from tidal areas. This includes multiple amenity assets (23% of bollards by length, 7% of fences by length, 15% of retaining walls by length, 1 gate, and 15 signs), electricity assets (14% of power lines by length, 1 power control board, 1 power outlet, and 1 power switchboard), and water/stormwater/sewer assets (2% of sewer pipes by length, 21% of water supply pipes by length, 6 taps, 6 inspection pits, 1 stormwater drain pit, and 1 wastewater outlet).

By 2050, there is a slight increase in risk for several assets, from 23% of bollards by length at present to 31% by 2050 at medium to very high risk, from 7% of fences to 13% by 2050, from 0% of handrails to 8%, 15% of retaining walls to 25%, 0% of roadside barriers to 11%, 1 gate to 3, 15 signs to 27, 1 power outlet to 2, 3 power switchboards to 4, 0 loading ramps to 1, 21% of water supply pipes to 34%, 6 taps to 10, 0 outdoor showers to 2, 6 inspection pits to 7, and 1 wastewater outlet to 2 at risk by 2050.

By 2050, there is a more significant increase in risk from tidal areas, resulting in the following assets to be at medium to very high risk: 52% of bollards by length, 37% of edging, 22% of fences, 16% of handrails, 39% of retaining walls, 31% of roadside barriers, 3 gates, 42 signs, 1 set of steps, 80% of power lines by length, 1 power control board, 1 power distribution board, 2 power inspection pits, 12 power outlets, 5 power switchboards, 1 loading ramp, 1 oil separator, 61% of water supply pipes, 26% of sewer pipes, 12 wastewater outlets, 4 stormwater drain pits, 1 hydrant, 7 inspection pits, 1 meter, 1 overhead supply outlet, 3 outdoor showers, 27 taps, and 1 washdown bay. Of all the amenity, electricity, water, stormwater, sewer, and other assets, water assets are most vulnerable to tidal areas by 2100.

Table 23 Open coast erosion exposure assessment results – Utilities and infrastructure

Infrastructure/Utilities – Exposure	Total length (m) or count within study area	Open coast erosion exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Amenity assets																			
Gate	4		0%		0%		0%		0%		0%	1	25%		0%	1	25%	1	25%
Panel Sign	110	2	2%	1	1%	2	2%	2	2%	10	9%	5	5%	2	2%	12	11%	6	5%
Plank Sign	32	3	9%		0%		0%	3	9%	5	16%	1	3%	3	9%	5	16%	1	3%
Stairway	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Steps	4		0%		0%		0%		0%		0%		0%		0%		0%	1	25%
Totem Sign	28		0%		0%		0%		0%		0%	2	7%		0%		0%	2	7%
Viewing Platform	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Electricity																			
Ext Lighting Fixture	8		0%		0%		0%		0%		0%		0%		0%		0%	1	13%
Power Control Board	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Distribution Board	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Generator	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Inspection Pit	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Outlet	13		0%		0%		0%		0%		0%		0%		0%		0%	3	23%
Power Switchboard	11		0%		0%		0%		0%		0%	2	18%		0%	2	18%	1	9%
Other	**2**		0%		0%		0%		0%		0%		0%		0%		0%		0%
Loading ramp	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Oil Separator	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Sewer																			
Sewerage Disposal System	2		0%		0%		0%		0%		0%		0%		0%		0%		0%
Wastewater Outlet	12		0%		0%		0%		0%		0%		0%		0%		0%	3	25%
Stormwater																			
Stormwater Drain Pit	21		0%		0%		0%		0%		0%	1	5%		0%	1	5%		0%
Water																			
Culvert	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Hydrant	5		0%		0%		0%		0%		0%		0%		0%		0%	2	40%
Inspection Pit	9		0%		0%		0%		0%		33%	4	44%		0%	5	56%	2	22%
Meter	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Ohead Supply Outlet	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Outdoor Shower	4		0%		0%		0%		0%		0%		0%		0%		0%	1	25%
Tank	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Tap	35		0%		0%		0%		0%		0%	2	6%		0%	3	9%	8	23%
Washdown Bay	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Linear assets	**Length (m)**																		
Amenity assets																			
Bollard	1,059	31	3%	34	3%	61	6%	31	3%	258	24%	338	32%	31	3%	321	30%	406	38%

Infrastructure/Utilities – Exposure	Total length (m) or count within study area	Open coast erosion exposure													
		PD			2050						2100				
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare			
		%		%		%		%		%		%		%	
Edging	7	0%		0%		0%		0%		0%		0%		0%	
Fence	998	0%		0%		0%	39	4%	139	14%		0%	74	7%	201	20%
Hand Rail Only	282	0%		0%		0%		0%		0%		0%		0%	
Retaining Wall	390	0%		0%		0%	6	2%	34	9%		0%	40	10%	84	22%
Roadside Barrier	437	0%		0%		0%		0%	70	16%		0%		0%	70	16%
Electricity															
Power Line	346	0%		0%		0%		0%		0%		0%		0%	25	7%
Other															
Other pipe/channel	21	0%		0%		0%		0%		0%		0%		0%		0%
Sewer															
Sewer Pipe	662	0%		0%		0%		0%		0%		0%		0%	50	8%
Water															
Water Supply Pipe	1,398	0%		0%	3	0%		0%	96	7%	297	21%		0%	215	15%	605	43%

Table 24 Open coast erosion risk assessment results – Utilities and infrastructure

Infrastructure/Utilities	Total length (m) or count within study area	Open coast erosion risk																			
		PD					2050									2100					
		Low		Medium		High	Very high	Low		Medium		High		Very high	Low		Medium		High		Very high
		%		%		%	%	%		%		%		%	%		%		%		%
Point assets	**Count**																				
Amenity assets																					
Gate	4	0%		0%		0%	0%	0%	1	25%		0%		0%	0%	2	50%		0%		0%
Panel Sign	110	0%	5	5%		0%	0%	0%	17	15%		0%		0%	0%	20	18%		0%		0%
Plank Sign	32	0%	3	9%		0%	0%	0%	9	28%		0%		0%	0%	9	28%		0%		0%
Stairway	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Steps	4	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%	1	25%		0%
Totem Sign	28	0%		0%		0%	0%	0%	2	7%		0%		0%	0%	2	7%		0%		0%
Viewing Platform	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Electricity																					
Ext Lighting Fixture	8	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%	1	13%		0%
Power Control Board	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Power Distribution Board	3	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Power Generator	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Power Inspection Pit	3	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Power Outlet	13	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%	3	23%		0%
Power Switchboard	11	0%		0%		0%	0%	0%		0%	2	18%		0%	0%		0%	3	27%		0%
Other	**2**	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Loading ramp	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Oil Separator	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Sewer																					
Sewerage Disposal System	2	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Wastewater Outlet	12	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%	3	25%		0%
Stormwater																					
Stormwater Drain Pit	21	0%		0%		0%	0%	0%		0%	1	5%		0%	0%		0%	1	5%		0%
Water																					
Culvert	3	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Hydrant	5	0%		0%		0%	0%	0%		0%		0%		0%	0%	2	40%		0%		0%
Inspection Pit	9	0%		0%		0%	0%	0%	7	78%		0%		0%	0%	7	78%		0%		0%
Meter	3	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Ohead Supply Outlet	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Outdoor Shower	4	0%		0%		0%	0%	0%		0%		0%		0%	0%	1	25%		0%		0%
Tank	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Tap	35	0%		0%		0%	0%	0%	2	6%		0%		0%	0%	11	31%		0%		0%
Washdown Bay	1	0%		0%		0%	0%	0%		0%		0%		0%	0%		0%		0%		0%
Linear assets	**Length (m)**																				
Amenity assets																					
Bollard	1,059	0%	30	3%	31	3%	0%	0%	307	29%	31	3%		0%	0%	375	35%	31	3%		0%

Infrastructure/Utilities	Total length (m) or count within study area	Open coast erosion risk													
		PD				2050				2100					
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high		
		%	%	%	%	%	%	%	%	%	%	%	%		
Edging	7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
Fence	998	0%	0%	0%	0%	0%	139 14%	0%	0%	0%	201 20%	0%	0%		
Hand Rail Only	282	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
Retaining Wall	390	0%	0%	0%	0%	0%	0%	34 9%	0%	0%	0%	84 22%	0%		
Roadside Barrier	437	0%	0%	0%	0%	0%	70 16%	0%	0%	0%	70 16%	0%	0%		
Electricity															
Power Line	346	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	25 7%	0%		
Other															
Other pipe/channel	21	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
Sewer															
Sewer Pipe	662	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50 8%	0%		
Water															
Water Supply Pipe	1,398	0%	0%	3 0%	0%	0%	0%	297 21%	0%	0%	0%	605 43%	0%		

Table 25 Storm tide inundation exposure assessment results – Utilities and infrastructure

Infrastructure/Utilities – Exposure	Total length (m) or count in the study area	Storm tide inundation exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Amenity assets																			
Gate	4	3	75%		0%		0%	3	75%		0%		0%	3	75%		0%	1	25%
Panel Sign	110	6	5%	1	1%		0%	6	5%	1	1%	3	3%	6	5%	5	5%	3	3%
Plank Sign	32	2	6%		0%		0%	2	6%		0%		0%	2	6%		0%	4	13%
Stairway	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Steps	4		0%		0%		0%		0%		0%		0%		0%		0%		0%
Totem Sign	28		0%		0%		0%		0%		0%		0%		0%		0%	1	4%
Viewing Platform	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Electricity																			
Ext Lighting Fixture	8		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Control Board	1	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%		0%
Power Distribution Board	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Generator	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Inspection Pit	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Outlet	13		0%		0%		0%		0%		0%		0%		0%	2	15%	3	23%
Power Switchboard	11	2	18%		0%	1	9%	2	18%	1	9%		0%	2	18%	1	9%		0%
Other																			
Loading ramp	1	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%		0%
Oil Separator	1		0%	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%
Sewer																			
Sewerage Disposal System	2		0%		0%		0%		0%		0%		0%		0%		0%		0%
Wastewater Outlet	12		0%		0%		0%		0%		0%		0%		0%	2	17%	3	25%
Stormwater																			
Stormwater Drain Pit	21	1	5%	3	14%		0%	1	5%	3	14%		0%	1	5%	3	14%		0%
Water																			
Culvert	3		0%		0%		0%		0%		0%		0%		0%		0%		0%
Hydrant	5		0%		0%		0%		0%		0%		0%		0%		0%	1	20%
Inspection Pit	9	3	33%		0%		0%	3	33%		0%		0%	3	33%	1	11%		0%
Meter	3		0%		0%		0%		0%	1	33%		0%		0%	1	33%		0%
Ohead Supply Outlet	1		0%	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%
Outdoor Shower	4	2	50%		0%		0%	2	50%		0%	1	25%	2	50%	1	25%		0%
Tank	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Tap	35	3	9%	3	9%		0%	3	9%	3	9%	2	6%	3	9%	9	26%	5	14%
Washdown Bay	1		0%	1	100%		0%		0%	1	100%		0%		0%	1	100%		0%
Linear assets	**Length (m)**																		
Amenity assets																			

Infrastructure/Utilities – Exposure	Total length (m) or count in the study area	Storm tide inundation exposure																	
		PD						2050						2100					
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Bollard	1,059	72	7%	29	3%	13	1%	72	7%	55	5%	15	1%	72	7%	83	8%	53	5%
Edging	7		0%		0%		0%		0%		0%		0%		0%		0%		0%
Fence	998	75	8%	14	1%	0	0%	75	8%	15	1%		0%	75	8%	44	4%	98	10%
Hand Rail Only	282	0	0%	2	1%	2	1%	0	0%	4	1%	4	2%	0	0%	8	3%	9	3%
Retaining Wall	390	32	8%	0	0%	16	4%	32	8%	20	5%	19	5%	32	8%	52	13%	59	15%
Roadside Barrier	437		0%		0%		0%		0%		0%		0%		0%		0%		0%
Electricity																			
Power Line	346	46	13%	10	3%	4	1%	46	13%	15	4%	1	0%	46	13%	23	7%	52	15%
Other																			
Other pipe/channel	21		0%		0%		0%		0%		0%		0%		0%		0%		0%
Sewer																			
Sewer Pipe	662	3	0%	1	0%	2	0%	3	0%	5	1%	3	0%	3	0%	27	4%	36	5%
Water																			
Water Supply Pipe	1,398	311	22%	3	0%	3	0%	311	22%	8	1%	8	1%	311	22%	27	2%	73	5%

Table 26 Storm tide inundation risk assessment results – Utilities and infrastructure

Infrastructure/Utilities – Risk	Total length (m) or count in the study area	Storm tide inundation risk																	
		PD								2050								2100	
		Low		Medium		High		Very high		Low		Medium		High		Very high			
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Amenity assets																			
Gate	4		0%		0%	3	75%		0%		0%		0%	3	75%		0%		0%	4	100%		0%
Panel Sign	110	7	6%		0%		0%		0%	10	9%		0%		0%		0%	14	13%		0%		0%
Plank Sign	32	2	6%		0%		0%		0%	2	6%		0%		0%		0%	6	19%		0%		0%
Stairway	1		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Steps	4		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Totem Sign	28		0%		0%		0%		0%		0%		0%		0%		0%	1	4%		0%		0%
Viewing Platform	1		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Electricity																			
Ext Lighting Fixture	8		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Control Board	1		0%		0%		0%	1	100%		0%		0%		0%	1	100%		0%		0%	1	100%
Power Distribution Board	3		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Generator	1		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Inspection Pit	3		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power Outlet	13		0%		0%		0%		0%		0%		0%		0%		0%		0%	5	38%		0%
Power Switchboard	11		0%	1	9%		0%	2	18%		0%	1	9%		0%	2	18%		0%	1	9%		0%	2	18%
Other																			
Loading ramp	1		0%	1	100%		0%		0%		0%	1	100%		0%		0%		0%	1	100%		0%
Oil Separator	1		0%		0%	1	100%		0%		0%		0%	1	100%		0%		0%		0%	1	100%		0%
Sewer																			

Infrastructure/Utilities – Risk	Total length (m) or count in the study area	Storm tide inundation risk											
		PD				2050				2100			
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high
		%	%	%	%	%	%	%	%	%	%	%	%
Sewerage Disposal System	2	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	0%	0%
Wastewater Outlet	12	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	5 42%	0%
Stormwater													
Stormwater Drain Pit	21	0 %	1 5%	3 14%	0%	0 %	1 5%	3 14%	0%	0%	1 5%	3 14%	0%
Water													
Culvert	3	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	0%	0%
Hydrant	5	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	1 20%	0%
Inspection Pit	9	0 %	0%	3 33%	0%	0 %	0%	3 33%	0%	0%	0%	4 44%	0%
Meter	3	0 %	0%	0%	0%	0 %	0%	1 33%	0%	0%	0%	1 33%	0%
Ohead Supply Outlet	1	0 %	0%	1 100 %	0%	0 %	0%	1 100 %	0%	0%	0%	1 100 %	0%
Outdoor Shower	4	0 %	0%	2 50%	0%	0 %	0%	3 75%	0%	0%	0%	3 75%	0%
Tank	1	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	0%	0%
Tap	35	0 %	0%	6 17%	0%	0 %	0%	8 23%	0%	0%	0%	17 49%	0%
Washdown Bay	1	0 %	0%	1 100 %	0%	0 %	0%	1 100 %	0%	0%	0%	1 100 %	0%
Linear assets	**Length (m)**												
Amenity assets													
Bollard	1,059	0 %	11 4 11%	0%	0%	0 %	14 2 13%	0%	0%	0%	20 9 20%	0%	0%
Edging	7	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	0%	0%
Fence	998	0 %	90 9%	0%	0%	0 %	90 9%	0%	0%	0%	21 7 22%	0%	0%
Hand Rail Only	282	0 %	3 1%	0%	0%	0 %	8 3%	0%	0%	0%	17 6%	0%	0%
Retaining Wall	390	0 %	16 4%	32 8%	0%	0 %	39 10%	32 8%	0%	0%	11 1 28%	32 8%	0%

Infrastructure/Utilities – Risk	Total length (m) or count in the study area	Storm tide inundation risk															
		PD				2050				2100							
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high				
		%	%	%	%	%	%	%	%	%	%	%	%				
Roadside Barrier	437	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	0%	0%				
Electricity																	
Power Line	346	0 %	0%	14	4%	46	13%	0 %	0%	16	5%	46	13%	0%	0%	75	22%	46	13%
Other																	
Other pipe/channel	21	0 %	0%	0%	0%	0 %	0%	0%	0%	0%	0%	0%	0%				
Sewer																	
Sewer Pipe	662	0 %	3	0%	3	0%	0%	0 %	8	1%	3	0%	0%	0%	63	9%	3	0%	0%
Water																	
Water Supply Pipe	1,398	0 %	6	0%	311	22%	0%	0 %	17	1%	311	22%	0%	0%	100	7%	311	22%	0%

Table 27 Tidal area exposure assessment results – Utilities and infrastructure

Infrastructure/Utilities – Exposure	Total length (m) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Point assets	**Count**						
Amenity assets							
Gate	4	1	25%	3	75%	3	75%
Panel Sign	110	7	6%	17	15%	29	26%
Plank Sign	32	8	25%	10	31%	12	38%
Stairway	1		0%		0%		0%
Steps	4		0%		0%	1	25%
Totem Sign	28		0%		0%	1	4%
Viewing Platform	1		0%		0%		0%
Electricity							
Ext Lighting Fixture	8		0%		0%		0%
Power Control Board	1	1	100%	1	100%	1	100%
Power Distribution Board	3		0%		0%	1	33%
Power Generator	1		0%		0%		0%
Power Inspection Pit	3		0%		0%	2	67%
Power Outlet	13	1	8%	2	15%	12	92%
Power Switchboard	11	3	27%	4	36%	5	45%
Other							
Loading ramp	1		0%	1	100%	1	100%
Oil Separator	1		0%		0%	1	100%

Infrastructure/Utilities – Exposure	Total length (m) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Sewer							
Sewerage Disposal System	2		0%		0%		0%
Wastewater Outlet	12	1	8%	2	17%	12	100%
Stormwater							
Stormwater Drain Pit	21	1	5%	1	5%	4	19%
Water							
Culvert	3		0%		0%		0%
Hydrant	5		0%		0%	1	20%
Inspection Pit	9	6	67%	7	78%	7	78%
Meter	3		0%		0%	1	33%
Ohead Supply Outlet	1		0%		0%	1	100%
Outdoor Shower	4		0%	2	50%	3	75%
Tank	1		0%		0%		0%
Tap	35	6	17%	10	29%	27	77%
Washdown Bay	1		0%		0%	1	100%
Linear assets	**Length (m)**						
Amenity assets							
Bollard	1,059	243	23%	330	31%	549	52%
Edging	7		0%		0%	3	37%
Fence	998	66	7%	131	13%	220	22%

Infrastructure/Utilities – Exposure	Total length (m) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Hand Rail Only	282		0%	22	8%	46	16%
Retaining Wall	390	57	15%	98	25%	153	39%
Roadside Barrier	437		0%	47	11%	134	31%
Electricity							
Power Line	346	50	14%	46	13%	278	80%
Other							
Other pipe/channel	21		0%		0%		0%
Sewer							
Sewer Pipe	662	13	2%	13	2%	170	26%
Water							
Water Supply Pipe	1,398	298	21%	481	34%	850	61%

Table 28 Tidal area risk assessment results – Utilities and infrastructure

Infrastructure/Utilities – Risk	Total length (m) or count in the study area	Tidal areas risk																	
		PD								2050								2100			
		Low		Medium		High		Very high		Low		Medium		High		Very high		Low		Medium		High		Very high	
		%		%		%		%		%		%		%		%		%		%		%		%	
Point assets	**Count**																								
Amenity assets																									
Gate	4	0	0%	1	25%		0%	0	0%	3	75%		0%	0	0%	3	75%		0%
Panel Sign	110	0	7	6%		0%		0%	0	17	15%		0%		0%	0	29	26%		0%		0%
Plank Sign	32	0	8	25%		0%		0%	0	10	31%		0%		0%	0	12	38%		0%		0%
Stairway	1	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%		0%		0%
Steps	4	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%		0%	1	25%
Totem Sign	28	0	0%		0%		0%	0	0%		0%		0%		0%	0	1	4%		0%		0%
Viewing Platform	1	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%		0%		0%
Electricity																									
Ext Lighting Fixture	8	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%		0%		0%
Power Control Board	1	0	0%		0%	1	100%	0	0%		0%		0%	1	100%	0	0%		0%		0%	1	100%
Power Distribution Board	3	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%		0%	1	33%
Power Generator	1	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%		0%		0%
Power Inspection Pit	3	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%	2	67%		0%
Power Outlet	13	0	0%		0%	1	8%	0	0%		0%		0%	2	15%	0	0%		0%		0%	12	92%
Power Switchboard	11	0	0%		0%	3	27%	0	0%		0%		0%	4	36%	0	0%		0%		0%	5	45%
Other																									
Loading ramp	1	0	0%		0%		0%	0	0%		0%		0%	1	100%	0	0%		0%		0%	1	100%
Oil Separator	1	0	0%		0%		0%	0	0%		0%		0%		0%	0	0%		0%	1	100%		0%
Sewer																									

Infrastructure/Utilities – Risk	Total length (m) or count in the study area	Tidal areas risk																							
		PD								2050								2100							
		Low		Medium		High		Very high		Low		Medium		High		Very high		Low		Medium		High		Very high	
			%		%		%		%		%		%		%		%		%		%		%		%
Sewerage Disposal System	2		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Wastewater Outlet	12		0%		0%		0%	1	8%		0%		0%		0%	2	17%		0%		0%		0%	12	100%
Stormwater																									
Stormwater Drain Pit	21		0%		0%		0%	1	5%		0%		0%		0%	1	5%		0%		0%		0%	4	19%
Water																									
Culvert	3		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Hydrant	5		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	1	20%		0%
Inspection Pit	9		0%		0%	6	67%		0%		0%		0%	7	78%		0%		0%		0%	7	78%		0%
Meter	3		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	1	33%		0%
Ohead Supply Outlet	1		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	1	100%		0%
Outdoor Shower	4		0%		0%		0%		0%		0%		0%	2	50%		0%		0%		0%	3	75%		0%
Tank	1		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Tap	35		0%		0%	6	17%		0%		0%		0%	10	29%		0%		0%		0%	27	77%		0%
Washdown Bay	1		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	1	100%		0%
Linear assets	**Length (m)**																								
Amenity assets																									
Bollard	1,059		0%		0%	243	23%		0%		0%		0%	330	31%		0%		0%		0%	549	52%		0%
Edging	7		0%		0%		0%		0%		0%		0%		0%		0%		0%	3	37%		0%		0%
Fence	998		0%		0%	66	7%		0%		0%		0%	131	13%		0%		0%		0%	220	22%		0%
Hand Rail Only	282		0%		0%		0%		0%		0%		0%	22	8%		0%		0%		0%	46	16%		0%
Retaining Wall	390		0%		0%		0%	57	15%		0%		0%		0%	98	25%		0%		0%		0%	153	39%

Infrastructure/Utilities – Risk	Total length (m) or count in the study area	Tidal areas risk															
		PD				2050						2100					
		Low		Medium	High		Very high		Low		Medium	High			Very high		
		%		%	%		%		%		%	%			%		
Roadside Barrier	437	0	%	0%	0%		0%		0	%	0%	47	11	%	0%	0	%	0%	134	31%		0%
Electricity																						
Power Line	346	0	%	0%	0%	50	14%		0	%	0%		0%	46	13%	0	%	0%		0%	278	80%
Other																						
Other pipe/channel	21	0	%	0%	0%		0%		0	%	0%		0%		0%	0	%	0%		0%		0%
Sewer																						
Sewer Pipe	662	0	%	0%	0%	13	2%		0	%	0%		0%	13	2%	0	%	0%		0%	170	26%
Water																						
Water Supply Pipe	1,398	0	%	0%	0%	298	21%		0	%	0%		0%	481	34%	0	%	0%		0%	850	61%

Transport assets

Transport infrastructure assessed include local roads, tracks and trails, footpaths, and pedestrian bridges.

Results from the risk assessment for transport assets in the study area are provided in the proceeding tables

Summary of results

Open coast erosion

At present, the risk of open coast erosion on transport assets is very minimal. 1% of vehicles trails by length are at high risk, and no other transport infrastructure is situated in the erosion risk zone.

By 2050 the risk of erosion is higher, with 22% of vehicle trails and 10% of footpaths by length situated in the high risk zone. By 2100, there is a significant increase in risk to include 25% of pedestrian bridges, 100% of dormant trails, 9% of local roads, 30% of vehicle trails, and 21% of footpaths in the medium to high risk categories.

Storm tide inundation

Storm tide inundation generally poses a greater risk to transport infrastructure across all assets.

Presently, 100% of dormant trails, 23% of vehicle trails, 15% of local roads, and 11% of footpaths by length are at medium to high risk. 1 of the 2 vehicle counters is in the low risk zone, and 1 of the 4 pedestrian bridges is in the medium risk zone.

There is a negligible increase in risk by 2050; however, by 2100 the risk increases to include 31% of vehicle trails, 18% of local roads, 14% of footpaths, and 8% of walking tracks in the medium to high risk categories.

Tidal area

At present, 21% of footpaths, 13% of vehicle trails, and 2% of local roads by length are at very high risk from tidal areas. Additionally, 1 of the 4 pedestrian bridges is also at very high risk.

There is a significant increase in risk by 2050 to include 100% of dormant trails, 29% of vehicle trails, 12% of local roads, and less than 1% of walking tracks in the high to very high risk categories.

By 2100, there is another increase in risk, placing 50% of pedestrian bridges, 45% of vehicle trails, 20% of local roads, and 1% of walking tracks at high to very high risk of tidal areas.

Table 29 Open coast erosion exposure assessment results – Transport assets

Transport – Exposure	Total length (m) or count within study area	Open coast erosion exposure															
		PD				2050						2100					
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
		%		%		%		%		%		%		%		%		%	
Point assets	**Count**																		
Elevated Walkway																			
Pedestrian Bridge	4	0%		0%		0%		0%		0%		0%		0%		0%		1	25%
Visitor Monitoring Point																			
Vehicle Counter	2	0%		0%		0%		0%		0%		0%		0%		0%			0%
Linear assets	**Length (m)**																		
Road																			
Dormant Trail	35	0%		0%		0%		0%		0%		0%		0%		0%		35	100%
Local Road	1,333	0%		0%		0%		0%		0%		0%		0%		0%		118	9%
Vehicle Trail	2,402	0%		0%	29	1%		0%	150	6%	525	22%		0%	229	10%	714		30%
Track																			
Footpath	134	0%		0%		0%		0%	13	10%	13	10%		0%	13	10%	28		21%
Walking Track	2,954	0%		0%		0%		0%		0%		0%		0%		0%			0%

Table 30 Open coast erosion risk assessment results – Transport assets

Transport – Risk	Total length (m) or count within study area	Open coast erosion risk																	
		PD					2050						2100						
		Low		Medium		High	Very high	Low		Medium		High	Very high	Low		Medium		High	Very high
		%		%		%	%	%		%		%	%	%		%		%	%
Point assets	**Count**																		
Elevated Walkway																			
Pedestrian Bridge	4	0%		0%		0%	0%	0%		0%		0%	0%	0%		0%	1	25%	0%
Visitor Monitoring Point																			
Vehicle Counter	2	0%		0%		0%	0%	0%		0%		0%	0%	0%		0%		0%	0%
Linear assets	**Length (m)**																		
Road																			
Dormant Trail	35	0%		0%		0%	0%	0%		0%		0%	0%	0%	35	100%		0%	0%
Local Road	1,333	0%		0%		0%	0%	0%		0%		0%	0%	0%		0%	118	9%	0%
Vehicle Trail	2,402	0%		0%	29	1%	0%	0%		0%	525	22%	0%	0%		0%	714	30%	0%
Track																			
Footpath	134	0%		0%		0%	0%	0%		0%	13	10%	0%	0%		0%	28	21%	0%
Walking Track	2,954	0%		0%		0%	0%	0%		0%		0%	0%	0%		0%		0%	0%

Table 31 Storm tide inundation exposure assessment results – Transport assets

Transport – Exposure	Total length (m) or count in the study area	Storm tide inundation exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Elevated Walkway																			
Pedestrian Bridge	4	1	25%		0%		0%	1	25%		0%		0%	1	25%		0%		0%
Visitor Monitoring Point																			
Vehicle Counter	2	1	50%		0%		0%	1	50%		0%		0%	1	50%		0%		0%
Linear assets	**Length (m)**																		
Road																			
Dormant Trail	35	35	100%		0%		0%	35	100%		0%		0%	35	100%		0%		0%
Local Road	1,333	177	13%	15	1%	10	1%	177	13%	32	2%	14	1%	177	13%	53	4%	16	1%
Vehicle Trail	2,402	530	22%	16	1%	16	1%	530	22%	50	2%	29	1%	530	22%	91	4%	133	6%
Track																			
Footpath	134	15	11%		0%		0%	15	11%		0%	1	1%	15	11%	2	1%	3	2%
Walking Track	2,954	1	0%	1	0%	1	0%	1	0%	3	0%	6	0%	1	0%	10	0%	220	7%

Table 32 Storm tide inundation risk assessment results – Transport assets

Transport – Risk	Total length (m) or count in the study area	Storm tide inundation risk											
		PD				2050				2100			
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high
		%	%	%	%	%	%	%	%	%	%	%	%
Point assets	**Count**												
Elevated Walkway													
Pedestrian Bridge	4	0%	1 25%	0%	0%	0%	1 25%	0%	0%	0%	1 25%	0%	0%
Visitor Monitoring Point													
Vehicle Counter	2	1 50%	0%	0%	0%	1 50%	0%	0%	0%	1 50%	0%	0%	0%
Linear assets	**Length (m)**												
Road													
Dormant Trail	35	0%	35 100%	0%	0%	0%	35 100%	0%	0%	0%	35 100%	0%	0%
Local Road	1,333	0%	25 2%	177 13%	0%	0%	46 3%	177 13%	0%	0%	68 5%	177 13%	0%
Vehicle Trail	2,402	0%	32 1%	530 22%	0%	0%	79 3%	530 22%	0%	0%	225 9%	530 22%	0%
Track													
Footpath	134	0%	0%	15 11%	0%	0%	1 1%	15 11%	0%	0%	4 3%	15 11%	0%
Walking Track	2,954	0%	2 0%	1 0%	0%	0%	9 0%	1 0%	0%	0%	230 8%	1 0%	0%

Table 33 Tidal area exposure assessment results – Transport assets

Transport – Exposure	Total length (m) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Point assets	**Count**						
Elevated Walkway							
Pedestrian Bridge	4	1	25%	1	25%	2	50%
Visitor Monitoring Point							
Vehicle Counter	2		0%		0%	1	50%
Linear assets	**Length (m)**						
Road							
Dormant Trail	35		0%	35	100%	35	100%
Local Road	1,333	24	2%	159	12%	272	20%
Vehicle Trail	2,402	314	13%	706	29%	1,093	45%
Track							
Footpath	134	28	21%	28	21%	28	21%
Walking Track	2,954		0%	13	0%	24	1%

Table 34 Tidal area risk assessment results – Transport assets

Transport – Risk	Total length (m) or count in the study area	Tidal areas risk															
		PD					2050					2100					
		Low		Medium	High	Very high	Low		Medium	High	Very high	Low		Medium	High	Very high	
		%		%	%	%	%		%	%	%	%		%	%	%	
Point assets	**Count**																
Elevated Walkway		0%		0%	0%	1 25%	0%		0%	0%	1 25%	0%		0%	0%	2 50%	
Pedestrian Bridge	4																
Visitor Monitoring Point		0%		0%	0%	0%	0%		0%	0%	0%	1 50%		0%	0%	0%	
Vehicle Counter	2																
Linear assets	**Length (m)**																
Road																	
Dormant Trail	35	0%		0%	0%	0%	0%		0%	0%	35 100%			0%	0%	35 100%	
Local Road	1,333	0%		0%	0%	24 2%	0%		0%	0%	159 12%	0%		0%	0%	272 20%	
Vehicle Trail	2,402	0%		0%	0%	314 13%	0%		0%	0%	706 29%	0%		0%	0%	1,093 45%	
Track																	
Footpath	134	0%		0%	0%	28 21%	0%		0%	0%	28 21%	0%		0%	0%	28 21%	
Walking Track	2,954	0%		0%	0%	0%	0%		0%	0%	13 0%	0%		0%	0%	24 1%	

Land, environment and culture

Further consideration is given in this section to risk from coastal hazards at present and by 2100 for historic sites, environmental assets and values, and land use.

Many environmental assets and values at risk from coastal hazards have some inherent resilience to the dynamic coastal processes considered hazards. Coastal ecosystems have evolved over many generations to thrive alongside periodic disturbances such as erosion and storm tide inundation. However, some ecosystems will experience changing baseline conditions as climate change introduces higher sea levels, warmer temperatures, and different weather patterns.

Results from the risk assessment for land, environment, and culture assets in the study area are provided in the proceeding tables.

Summary of results

Open coast erosion

At present, none of the heritage or historic assets are situated in the risk zone for open coast erosion. The risk increases slightly by 2050, with 1 of the 9 historic ruins at high risk from 2050 to 2100.

In terms of land use areas, 27% of BBQ/picnic areas, 7% of regeneration areas, and less than 1% of vehicle parking areas and overnight areas are presently in the high to very high risk zones. This risk increases by 2050 to include 84% of BBQ/picnic areas, 45% of beachfront campsite areas, 64% of overnight areas, 18% of power site pads, 31% of regeneration areas, and 18% of vehicle parking areas at medium to very high risk by 2050. By 2100, the risk increases again slightly to include 81% of Mozzy alley areas, 100% of overnight areas, 83% of power site pads, 5% of Terrace Campground area, and 24% of vehicle parking area at medium to very high risk.

The Front Beach is at very high risk of erosion, with 92% of the total area situated in the high to very risk categories from present-day to 2100.

In terms of vegetation communities, dry sclerophyll shrubland is presently most at risk, with 28% of this vegetation by area situated in the medium to high risk categories. Additionally, 9% of dry sclerophyll forest and woodland, 1% of littoral rainforest, and 2% of swamp sclerophyll forest and woodland by area are at medium to high risk of erosion at present day. The risk for vegetation communities increases significantly by 2050, with 43% of dry sclerophyll shrubland, 34% of planted pine, 19% of dry sclerophyll forest and woodland, 2% of littoral rainforest, and 6% of swamp sclerophyll forest and woodland areas in the medium to high risk categories by 2050. By 2100, there is another minor increase in risk to include 53% of dry sclerophyll shrubland, 39% of planted pine, 22% of dry sclerophyll forest and woodland, 6% of littoral rainforest, and 18% of swamp sclerophyll forest and woodland areas, and 2% of wet sclerophyll forest at medium to high risk.

Storm tide inundation

None of the heritage or historic assets are situated in the risk zone for storm tide inundation from present-day to 2050. The risk increases slightly by 2100, with 1 of the 9 historic ruins at high risk from 2050 to 2100.

In terms of land use areas, the depot yard, overnight area, and Mozzy alley are presently most at risk (with 100%, 100% and 84% of these areas respectively situated in the medium to high risk categories). Additionally, 13% of BBQ/picnic areas, 29% of vehicle parking areas, 1% of regeneration areas, and less than 1% of powered sites are presently in the

medium to high risk zones. This risk only increases slightly by 2050 to include 100% of depot yard and overnight areas, 88% of Mozzy alley area, 17% of BBQ/picnic areas, 29% of vehicle parking areas, 3% of regeneration areas, and 6% of powered sites at medium to high risk. By 2100, the risk increases substantially for regeneration areas and powered sites (from 3% in 2050 to 18% by 2100, and from 6% in 2050 to 61% by 2100, respectively). The risk of storm tide inundation for BBQ/picnic areas also increases significantly by 2100 (from 17% to 30% at risk) as well as for Mozzy alley (from 88% to 92% at risk).

The Front Beach is at very high risk of storm tide inundation, with 87% of its total area situated in the medium to high risk categories in present-day. This risk increases over time, from 87% to 99% at risk by 2050, and 100% at risk by 2100.

In terms of vegetation communities, dry sclerophyll shrubland and swamp sclerophyll forest and woodland are presently most at risk (with 46% and 44% of these vegetation areas respectively situated in the medium risk category). Additionally, 11% of dry sclerophyll forest and woodland, 12% of littoral rainforest, and 2% of wet sclerophyll forest are at medium risk of storm tide inundation in present-day. The risk for vegetation communities increases by 2050, with 63% of dry sclerophyll shrubland, 44% of swamp sclerophyll forest and woodland, 16% of dry sclerophyll forest and woodland, 13% of littoral rainforest, and 3% of wet sclerophyll forest at medium risk. By 2100, these numbers jump to 70%, 77%, 21%, 44% and 14% respectively.

Tidal area

Only one heritage asset (a historic ruin) is situated in the very high risk zone for tidal areas from present-day to 2100.

In terms of land use areas, the overnight area, Mozzy Alley, and the BBQ/picnic areas are presently most at risk (with 100%, 60% and 43% of these areas respectively situated in the high to very high risk categories). Additionally, 31% of power site pads, 15% of regeneration areas, 12% of vehicle parking areas, and 1% of beachfront campsites by area are at high to very high risk at present. The risk increases by 2050 to include 47% of BBQ/picnic areas, 10% of beachfront campsites, 92% of Mozzy Alley, 2% of parking lawn areas, 35% of power site pads, 23% of regeneration areas, and 20% of vehicle parking areas at high to very high risk (along with 100% of the overnight areas, again). By 2100, the assets most at risk include the depot yard, Mozzy Alley, overnight areas, and power site pads (with 100%, 96%, 100%, and 100% of these areas respectively situated in the high to very high risk zones). There is a significant increase in risk for the other assets too, with 51% of BBQ/picnic areas, 55% of beachfront campsites, 20% of garden areas, 35% of parking lawn areas, 25% of regeneration areas, 35% of the Terrace Campground area and 31% of vehicle parking areas at high to very high risk by 2100.

The Front Beach is at very high risk from tidal areas, with 93% of its total area situated in the very high risk category at present-day, 97% of the total area at very high risk by 2050, and 98% at very high risk by 2100.

In terms of vegetation communities, almost all vegetation types have a small proportion of their area situated in the high risk category at present (except for dry sclerophyll forest and woodland/graminoid clay, and wet sclerophyll forest). The communities most at risk include swamp sclerophyll forest, and woodland, sod grassland and dry sclerophyll shrubland (with 27%, 21%, and 21% of their areas respectively at high risk). 11% of the dry sclerophyll forest and woodland is also currently at high risk, along with 5% of the littoral rainforest vegetation, 4% of the planted pine vegetation, and less than 1% of the graminoid clay heathland. By 2050, there is a significant increase in risk for swamp sclerophyll forest and woodland (to 43% of the area at high risk) and for dry sclerophyll shrubland (to 59%), along with minor increases in risk for dry sclerophyll forest and woodland (to 17%), littoral rainforest (to 12%), planted pine (to 9%), sod grassland (to 22%), and wet sclerophyll forest (to 3% at risk). By

2100, these numbers increase again to reach 45%, 67%, 21%, 19%, 28%, 45% and 5% respectively at high risk. Swamp sclerophyll forest and woodland, sod grassland, and dry sclerophyll shrubland remain the most vulnerable communities to tidal areas by 2100.

Table 35 Open coast erosion exposure assessment results – Land, environment and culture

Land, Environment and Culture – Exposure	Total area (m^2) or count within study area	Open coast erosion exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Heritage																			
Historic Ruin	9		0%		0%		0%		0%	1	11%		0%		0%	1	11%		0%
Monument/Plaque	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Historic Site																			
Gravesite	4		0%		0%		0%		0%		0%		0%		0%		0%		0%
Landuse																			
Quarry	1		0%		0%		0%		0%		0%		0%		0%		0%		0%
Polygons	**Area (m^2)**																		
Beach																			
Front Beach	173,985	151,996	87%	159,602	92%	161,194	93%	152,229	87%	161,157	93%	161,116	93%	152,231	87%	161,079	93%	161,025	93%
Landuse																			
BBQ/Picnic area	6,087	1,173	19%	1,665	27%	1,687	28%	1,174	19%	3,525	58%	5,102	84%	1,174	19%	3,524	58%	5,102	84%
Beachfront campsites	5,490		0%		0%		0%		0%	739	13%	2,457	45%		0%	739	13%	2,457	45%
Depot yard	246		0%		0%		0%		0%		0%		0%		0%		0%		0%
Gaol visitor area	4,441		0%		0%		0%		0%		0%		0%		0%		0%		0%
Garden	444		0%		0%		0%		0%		0%		0%		0%		0%		0%
Little Bay	21,068		0%		0%		0%		0%		0%		0%		0%		0%		0%
Monument	172		0%		0%		0%		0%		0%		0%		0%		0%		0%
Mozzy Alley	3,419		0%		0%		0%		0%		0%		0%		0%	319	9%	2,778	81%
Overnight area	2,048		0%		0%	0	0%		0%	313	15%	1,302	64%		0%	1,996	97%	2,048	100%
Parking area lawn	1,418		0%		0%		0%		0%		0%		0%		0%		0%		0%
Power site pad	259		0%		0%		0%		0%	11	4%	47	18%		0%	90	35%	216	83%
Powered sites	2,025		0%		0%		0%		0%	105	5%	274	14%		0%	436	22%	1,155	57%
Regeneration area	8,798	577	7%	577	7%	577	7%	577	7%	2,008	23%	2,649	30%	577	7%	2,008	23%	2,649	30%
Sunrise Hill	2,275		0%		0%		0%		0%		0%		0%		0%		0%		0%
Terrace Campground	4,815		0%		0%		0%		0%		0%		0%		0%		0%	218	5%
Vehicle Parking Area	3,759		0%		0%	4	0%		0%	201	5%	608	16%		0%	589	16%	889	24%
Vegetation communities																			

Land, Environment and Culture – Exposure	Total area (m^2) or count within study area	Open coast erosion exposure																	
		PD						2050						2100					
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Dry Sclerophyll Forest & Woodland	184,276	8,631	5%	12,218	7%	15,955	9%	8,665	5%	24,706	13%	34,141	19%	8,860	5%	31,292	17%	39,627	22%
Dry Sclerophyll Forest & Woodland / Graminoid Clay	74,169		0%		0%		0%		0%		0%		0%		0%		0%		0%
Dry Sclerophyll Shrubland	13,366	2,344	18%	3,225	24%	3,672	27%	2,776	21%	5,104	38%	5,850	44%	2,776	21%	5,932	44%	7,043	53%
Graminoid Clay Heathland	129,519		0%		0%		0%		0%	40	0%	220	0%		0%	40	0%	220	0%
Littoral Rainforest	26,408	137	1%	137	1%	137	1%	137	1%	298	1%	431	2%	137	1%	313	1%	1,539	6%
Planted Pine	3,033		0%		0%		0%		0%	353	12%	1,042	34%		0%	415	14%	1,179	39%
Sod Grassland	1,746		0%		0%		0%		0%		0%		0%		0%		0%		0%
Swamp Sclerophyll Forest & Woodland	110,983	422	0%	1,423	1%	2,386	2%	798	1%	3,257	3%	5,866	5%	1,035	1%	10,308	9%	20,049	18%
Wet Sclerophyll Forest	39,537		0%		0%		0%		0%		0%		0%		0%		0%	746	2%

Table 36 Open coast erosion risk assessment results – Land, environment and culture

Land, Environment and Culture – Risk	Total area (m^2) or count within study area	Open coast erosion risk															
		PD					2050					2100					
		Low		Medium		High		Very high		Low		Medium		High		Very high	
			%		%		%		%		%		%		%		%
Point assets	**Count**																
Heritage																	
Historic Ruin	9	0	0%	0	0%	0	0%	0	0%	0	0%	1	11%	0	0%	0	0%	0%	1	11%	0	0%
Monument/Plaque	1	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%
Historic Site																	
Gravesite	4	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%
Landuse																	
Quarry	1	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%
Polygons	**Area (m^2)**																
Beach																	
Front Beach	173,985	0	0%	0	0%	9,238	5%	151,996	87%	0	0%	0	0%	9,005	5%	152,229	87%	0%	0	0%	9,003	5%	152,231	87%
Landuse																	
BBQ/Picnic area	6,087	0	0%	0	0%	513	8%	1,173	19%	0	0%	0	0%	3,928	65%	1,174	19%	0%	0	0%	3,928	65%	1,174	19%
Beachfront campsites	5,490	0	0%	0	0%	0	0%	0	0%	0	0%	2,457	45%	0	0%	0	0%	0%	0	0%	2,457	45%	0	0%
Depot yard	246	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%	0	0%
Gaol visitor area	4,441	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%	0	0%
Garden	444	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%	0	0%
Little Bay	21,068	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%	0	0%
Monument	172	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%	0	0%
Mozzy Alley	3,419	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	2,778	81%	0	0%	0	0%
Overnight area	2,048	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	1,302	64%	0	0%	0%	0	0%	2,048	100%	0	0%
Parking area lawn	1,418	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0%	0	0%	0	0%	0	0%
Power site pad	259	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	47	18%	0	0%	0%	0	0%	216	83%	0	0%
Powered sites	2,025	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	274	14%	0	0%	0%	0	0%	1,155	57%	0	0%
Regeneration area	8,798	0	0%	0	0%	577	7%	0	0%	0	0%	2,073	24%	577	7%	0	0%	0%	2,073	24%	577	7%	0	0%

Land, Environment and Culture – Risk	Total area (m^2) or count within study area	Open coast erosion risk											
		PD				2050				2100			
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high
		%	%	%	%	%	%	%	%	%	%	%	%
Sunrise Hill	2,275	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Terrace Campground	4,815	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	218 5%	0%
Vehicle Parking Area	3,759	0%	0% 4	0%	0%	0%	0%	608 16%	0%	0%	0%	889 24%	0%
Vegetation communities													
Dry Sclerophyll Forest & Woodland	184,276	0%	7,323 4%	8,631 5%	0%	0%	25,476 14%	8,665 5%	0%	0%	30,767 17%	8,860 5%	0%
Dry Sclerophyll Forest & Woodland /Graminoid Clay	74,169	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry Sclerophyll Shrubland	13,366	0%	1,328 10%	2,344 18%	0%	0%	3,074 23%	2,776 21%	0%	0%	4,267 32%	2,776 21%	0%
Graminoid Clay Heathland	129,519	0%	0%	0%	0%	0%	224 0%	0%	0%	0%	224 0%	0%	0%
Littoral Rainforest	26,408	0%	0% 137	1%	0%	0%	295 1%	137 1%	0%	0%	1,403 5%	137 1%	0%
Planted Pine	3,033	0%	0%	0%	0%	0%	1,042 34%	0%	0%	0%	1,179 39%	0%	0%
Sod Grassland	1,746	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Swamp Sclerophyll Forest & Woodland	110,983	0%	1,964 2%	422 0%	0%	0%	5,067 5%	798 1%	0%	0%	19,014 17%	1,035 1%	0%
Wet Sclerophyll Forest	39,537	0%	0%	0%	0%	0%	0%	0%	0%	0%	746 2%	0%	0%

Table 37 Storm tide inundation exposure assessment results – Land, environment and culture

Land, Environment and Culture – Exposure	Total area (m^2) or count in the study area	Storm tide inundation exposure															
		PD						2050						2100			
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Point assets	**Count**																		
Heritage																			
Historic Ruin	9		0%		0%		0 %		0%		0%		0%		0%		0%	1	11 %
Monument/Plaque	1		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Historic Site																			
Gravesite	4		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Landuse																			
Quarry	1		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Polygon assets	**Area (m^2)**																		
Beach																			
Front Beach	173,985	144,850	83%	4,183	2%	2,351	1 %	144,850	83%	19,862	11%	7,142	4%	144,850	83%	28,396	16%	414	0%
Landuse																			
BBQ/Picnic area	6,087	1	0%	490	8%	273	4 %	1	0%	878	14%	166	3%	1	0%	1,505	25%	303	5%
Beachfront campsites	5,490		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Depot yard	246		0%	246	100 %		0 %		0%	246	100 %		0%		0%	246	100 %		0%
Gaol visitor area	4,441		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Garden	444		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Little Bay	21,068		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Monument	172		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Mozzy Alley	3,419	2,668	78%	108	3%	82	2 %	2,668	78%	266	8%	81	2%	2,668	78%	388	11%	88	3%
Overnight area	2,048	2,048	100 %		0%		0 %	2,048	100 %		0%		0%	2,048	100 %		0%		0%
Parking area lawn	1,418		0%		0%		0 %		0%		0%		0%		0%		0%		0%

Land, Environment and Culture – Exposure	Total area (m^2) or count in the study area	Storm tide inundation exposure																	
		PD						2050						2100					
		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare		Almost Certain		Unlikely		Rare	
			%		%		%		%		%		%		%		%		%
Power site pad	259		0%		0%		0 %		0%		0%		0%		0%	0	0%	147	57 %
Powered sites	2,025		0%		0%	3	0 %		0%	12	1%	104	5%		0%	390	19%	848	42 %
Regeneration area	8,798	59	1%	34	0%	18	0 %	59	1%	147	2%	98	1%	59	1%	381	4%	1,179	13 %
Sunrise Hill	2,275		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Terrace Campground	4,815		0%		0%		0 %		0%		0%		0%		0%		0%	6	0%
Vehicle Parking Area	3,759	892	24%	125	3%	75	2 %	892	24%	205	5%		0%	892	24%	205	5%		0%
Vegetation communities																			
Dry Sclerophyll Forest & Woodland	184,276	10,545	6%	5,387	3%	4,776	3 %	10,545	6%	16,373	9%	2,786	2%	10,545	6%	22,119	12%	5,156	3%
Dry Sclerophyll Forest & Woodland/Graminoid Clay	74,169		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Dry Sclerophyll Shrubland	13,366	4,836	36%	953	7%	307	2 %	4,836	36%	2,014	15%	1,619	12 %	4,836	36%	4,031	30%	482	4%
Graminoid Clay Heathland	129,519		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Littoral Rainforest	26,408	2,534	10%	345	1%	200	1 %	2,534	10%	741	3%	179	1%	2,534	10%	1,153	4%	7,989	30 %
Planted Pine	3,033		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Sod Grassland	1,746		0%		0%		0 %		0%		0%		0%		0%		0%		0%
Swamp Sclerophyll Forest & Woodland	110,983	47,446	43%	531	0%	633	1 %	47,446	43%	1,376	1%	224	0%	47,446	43%	1,838	2%	35,983	32 %
Wet Sclerophyll Forest	39,537	589	1%	133	0%	211	1 %	589	1%	602	2%	177	0%	589	1%	949	2%	3,855	10 %

Table 38 Storm tide inundation risk assessment results – Land, environment and culture

Land, Environment and Culture – Risk	Total area (m^2) or count in the study area	Storm tide inundation risk											
		PD				2050				2100			
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high
		%	%	%	%	%	%	%	%	%	%	%	%
Point assets	**Count**												
Heritage													
Historic Ruin	9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1 11%	0%
Monument/Plaque	1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Historic Site													
Gravesite	4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Landuse													
Quarry	1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Polygon assets	**Area (m^2)**												
Beach													
Front Beach	173,985	0%	6,534 4%	144,851 83%	0%	0%	27,004 16%	144,851 83%	0%	0%	28,810 17%	144,851 83%	0%
Landuse													
BBQ/Picnic area	6,087	0%	763 13%	1 0%	0%	0%	1,044 17%	1 0%	0%	0%	1,808 30%	1 0%	0%
Beachfront campsites	5,490	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Depot yard	246	0%	246 100%	0%	0%	0%	246 100%	0%	0%	0%	246 100%	0%	0%
Gaol visitor area	4,441	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Garden	444	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Little Bay	21,068	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Monument	172	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mozzy Alley	3,419	0%	2,858 84%	0%	0%	0%	3,016 88%	0%	0%	0%	3,145 92%	0%	0%
Overnight area	2,048	0%	0%	2,048 100%	0%	0%	0%	2,048 100%	0%	0%	0%	2,048 100%	0%
Parking area lawn	1,418	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Power site pad	259	0%	0%	0%	0%	0%	0%	0%	0%	0%	147 57%	0%	0%
Powered sites	2,025	0%	3 0%	0%	0%	0%	116 6%	0%	0%	0%	1,238 61%	0%	0%

Land, Environment and Culture – Risk	Total area (m^2) or count in the study area	Storm tide inundation risk													
		PD				2050				2100					
		Low	Medium	High	Very high	Low	Medium	High	Very high	Low	Medium	High	Very high		
		%	%	%	%	%	%	%	%	%	%	%	%		
Regeneration area	8,798	0%	111	1%	0%	0%	0%	304	3%	0%	0%	0%	1,619	18%	0%	0%
Sunrise Hill	2,275	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%
Terrace Campground	4,815	0%		0%	0%	0%	0%		0%	0%	0%	0%	6	0%	0%	0%
Vehicle Parking Area	3,759	0%	200	5%	892	24%	0%	0%	205	5%	892	24%	0%	0%	205	5%	892	24%	0%
Vegetation communities																			
Dry Sclerophyll Forest & Woodland	184,276	0%	20,708	11%	0%	0%	0%	29,704	16%	0%	0%	0%	37,820	21%	0%	0%
Dry Sclerophyll Forest & Woodland/Graminoid Clay	74,169	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%
Dry Sclerophyll Shrubland	13,366	0%	6,096	46%	0%	0%	0%	8,469	63%	0%	0%	0%	9,348	70%	0%	0%
Graminoid Clay Heathland	129,519	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%
Littoral Rainforest	26,408	0%	3,080	12%	0%	0%	0%	3,454	13%	0%	0%	0%	11,677	44%	0%	0%
Planted Pine	3,033	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%
Sod Grassland	1,746	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%
Swamp Sclerophyll Forest & Woodland	110,983	0%	48,610	44%	0%	0%	0%	49,047	44%	0%	0%	0%	85,266	77%	0%	0%
Wet Sclerophyll Forest	39,537	0%	933	2%	0%	0%	0%	1,368	3%	0%	0%	0%	5,393	14%	0%	0%

Table 39 Tidal area exposure assessment results – Land, environment and culture

Land, Environment and Culture – Exposure	Total area (m^2) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Point assets	**Count**						
Heritage							
Historic Ruin	9	1	11%	1	11%	1	11%
Monument/Plaque	1		0%		0%		0%
Historic Site							
Gravesite	4		0%		0%		0%
Landuse							
Quarry	1		0%		0%		0%
Polygon assets	**Area (m^2)**						
Beach							
Front Beach	173,985	162,523	93%	168,405	97%	170,144	98%
Landuse							
BBQ/Picnic area	6,087	2,604	43%	2,862	47%	3,133	51%
Beachfront campsites	5,490	31	1%	560	10%	3,030	55%
Depot yard	246		0%		0%	246	100%
Gaol visitor area	4,441		0%		0%		0%
Garden	444		0%		0%	90	20%
Little Bay	21,068		0%		0%		0%
Monument	172		0%		0%		0%
Mozzy Alley	3,419	2,058	60%	3,162	92%	3,287	96%

Land, Environment and Culture – Exposure	Total area (m^2) or count in the study area	Tidal areas exposure					
		PD		2050		2100	
			%		%		%
Overnight area	2,048	2,048	100%	2,048	100%	2,048	100%
Parking area lawn	1,418		0%	32	2%	491	35%
Power site pad	259	80	31%	91	35%	259	100%
Powered sites	2,025	492	24%	789	39%	1,991	98%
Regeneration area	8,798	1,356	15%	2,040	23%	2,196	25%
Sunrise Hill	2,275		0%		0%		0%
Terrace Campground	4,815	9	0%		0%	1,684	35%
Vehicle Parking Area	3,759	458	12%	756	20%	1,152	31%
Vegetation communities							
Dry Sclerophyll Forest & Woodland	184,276	20,297	11%	30,999	17%	37,809	21%
Dry Sclerophyll Forest & Woodland/Graminoid Clay	74,169		0%		0%		0%
Dry Sclerophyll Shrubland	13,366	2,793	21%	7,936	59%	8,967	67%
Graminoid Clay Heathland	129,519	30	0%	30	0%	350	0%
Littoral Rainforest	26,408	1,435	5%	3,138	12%	4,924	19%
Planted Pine	3,033	131	4%	274	9%	847	28%
Sod Grassland	1,746	363	21%	387	22%	783	45%
Swamp Sclerophyll Forest & Woodland	110,983	30,235	27%	47,474	43%	49,898	45%
Wet Sclerophyll Forest	39537		0%	1,109	3%	1,814	5%

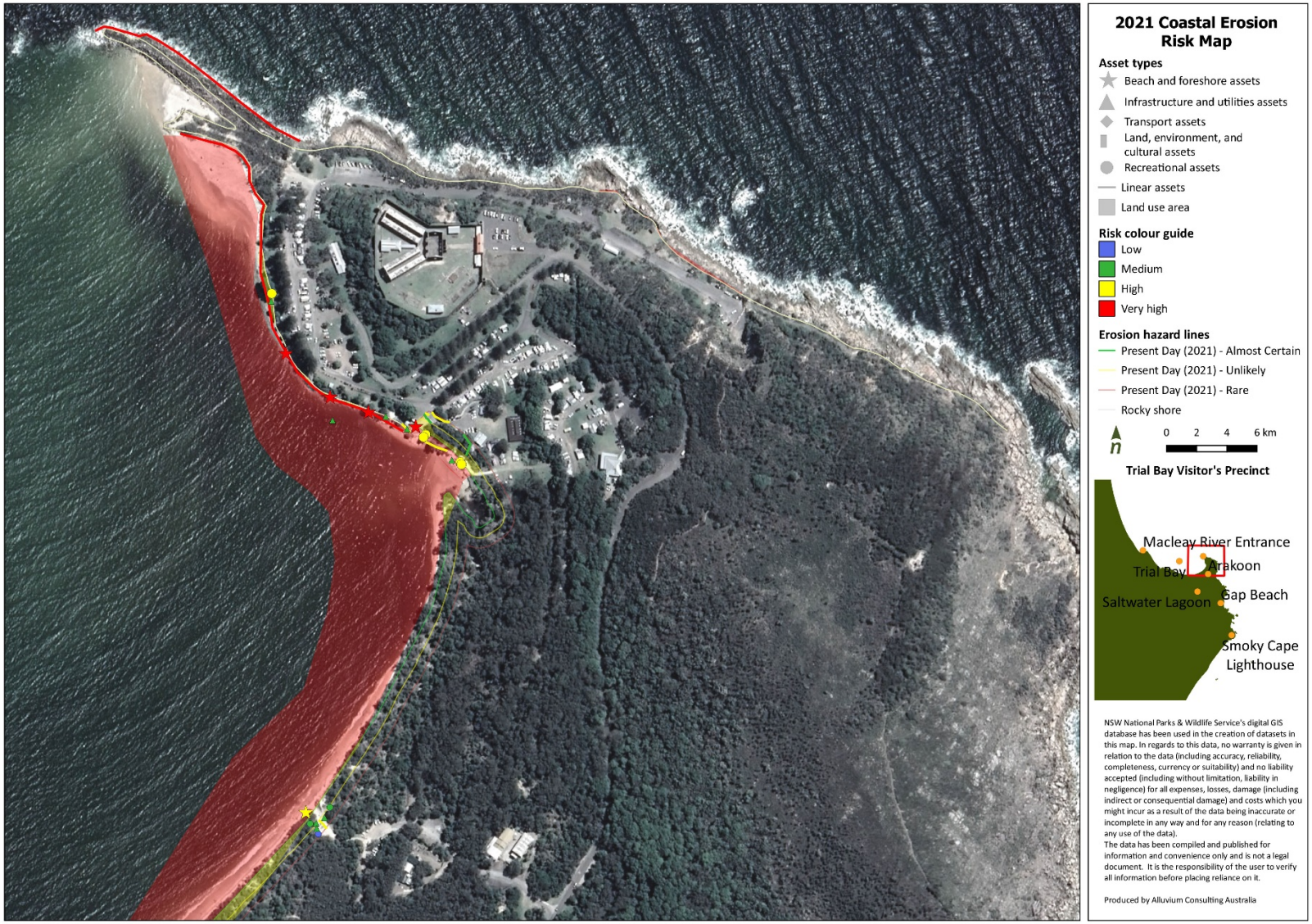
Table 40 Tidal area risk assessment results – Land, environment and culture

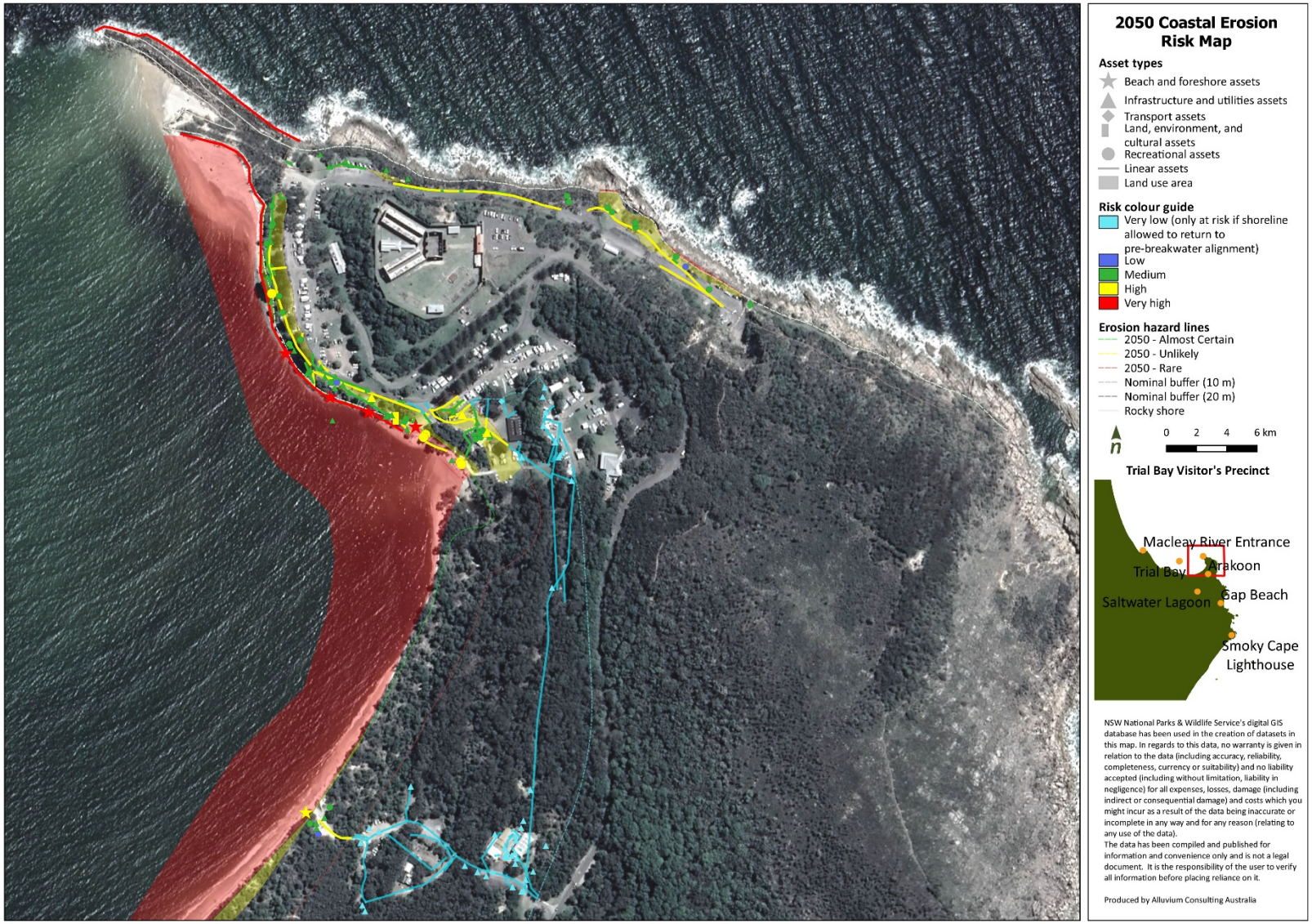
Land, Environment and Culture – Risk	Total area (m^2) or count in the study area	Tidal areas risk															
		PD					2050					2100					
		Low		Medium		High		Very high		Low		Medium		High		Very high	
		%		%		%		%		%		%		%		%	
Point assets	**Count**																
Heritage																	
Historic Ruin	9	0%		0%		0%	1	11%		0%		0%		0%	1	11%	
Monument/Plaque	1	0%		0%		0%		0%		0%		0%		0%		0%	
Historic Site																	
Gravesite	4	0%		0%		0%		0%		0%		0%		0%		0%	
Landuse																	
Quarry	1	0%		0%		0%		0%		0%		0%		0%		0%	
Polygon assets	**Area (m^2)**																
Beach																	
Front Beach	173,985	0%		0%		0%	162,523	93%		0%		0%		0%	168,405	97%	
Landuse																	
BBQ/Picnic area	6,087	0%		0%		0%	2,604	43%		0%		0%		0%	2,862	47%	
Beachfront campsites	5,490	0%		0%		0%	31	1%		0%		0%		0%	560	10%	
Depot yard	246	0%		0%		0%		0%		0%		0%		0%		0%	
Gaol visitor area	4,441	0%		0%		0%		0%		0%		0%		0%		0%	
Garden	444	0%		0%		0%		0%		0%		0%		0%		0%	
Little Bay	21,068	0%		0%		0%		0%		0%		0%		0%		0%	
Monument	172	0%		0%		0%		0%		0%		0%		0%		0%	
Mozzy Alley	3,419	0%		0%	2,058	60%		0%		0%		0%	3,162	92%		0%	
Overnight area	2,048	0%		0%		0%	2,048	100%		0%		0%		0%	2,048	100%	
Parking area lawn	1,418	0%		0%		0%		0%		0%		0%	32	2%		0%	
Power site pad	259	0%		0%		0%	80	31%		0%		0%		0%	91	35%	
Powered sites	2,025	0%		0%		0%	492	24%		0%		0%		0%	789	39%	

Land, Environment and Culture – Risk	2100					
	Low		Medium		High	Very high
	%		%		%	%
Point assets						
Heritage						
Historic Ruin	0%		0%		0%	1 11%
Monument/Plaque	0%		0%		0%	0%
Historic Site						
Gravesite	0%		0%		0%	0%
Landuse						
Quarry	0%		0%		0%	0%
Polygon assets						
Beach						
Front Beach	0%		0%		0%	170,144 98%
Landuse						
BBQ/Picnic area	0%		0%		0%	3,133 51%
Beachfront campsites	0%		0%		0%	3,030 55%
Depot yard	0%		0%		0%	246 100%
Gaol visitor area	0%		0%		0%	0%
Garden	0%		0%	90	20%	0%
Little Bay	0%		0%		0%	0%
Monument	0%		0%		0%	0%
Mozzy Alley	0%		0%	3,287	96%	0%
Overnight area	0%		0%		0%	2,048 100%
Parking area lawn	0%		0%	491	35%	0%
Power site pad	0%		0%		0%	259 100%
Powered sites	0%		0%		0%	1,991 98%

Land, Environment and Culture – Risk	Total area (m^2) or count in the study area	Tidal areas risk															
		PD					2050					2100					
		Low		Medium		High		Very high		Low		Medium		High		Very high	
		%		%		%		%		%		%		%		%	
Regeneration area	8,798	0%		0%	1,356	15%		0%		0%		0%	2,040	23%		0%		0%	2,196	25%		0%
Sunrise Hill	2,275	0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Terrace Campground	4,815	0%		0%		0%	9	0%		0%		0%		0%		0%		0%		0%	1,684	35%
Vehicle Parking Area	3,759	0%		0%		0%	458	12%		0%		0%		0%	756	20%		0%		0%	1,152	31%
Vegetation communities																						
Dry Sclerophyll Forest & Woodland	184,276	0%		0%	20,297	11%		0%		0%		0%	30,999	17%		0%		0%	37,809	21%		0%
Dry Sclerophyll Forest & Woodland /Graminoid Clay	74,169	0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%
Dry Sclerophyll Shrubland	13,366	0%		0%	2,793	21%		0%		0%		0%	7,936	59%		0%		0%	8,967	67%		0%
Graminoid Clay Heathland	129,519	0%		0%	30	0%		0%		0%		0%	30	0%		0%		0%	350	0%		0%
Littoral Rainforest	26,408	0%		0%	1,435	5%		0%		0%		0%	3,138	12%		0%		0%	4,924	19%		0%
Planted Pine	3,033	0%		0%	131	4%		0%		0%		0%	274	9%		0%		0%	847	28%		0%
Sod Grassland	1,746	0%		0%	363	21%		0%		0%		0%	387	22%		0%		0%	783	45%		0%
Swamp Sclerophyll Forest & Woodland	110,983	0%		0%	30,235	27%		0%		0%		0%	47,474	43%		0%		0%	49,898	45%		0%
Wet Sclerophyll Forest	39537	0%		0%		0%		0%		0%		0%	1,109	3%		0%		0%	1,814	5%		0%

Appendix 7: Risk maps


2021 Coastal Erosion Risk Map
Asset types
Beach and foreshore assets
Infrastructure and utilities assets
Transport assets
Land, environment, and cultural assets
Recreational assets
Linear assets
Land use area
Risk colour guide
Low
Medium
High
Very high
Erosion hazard lines
Present Day (2021) - Almost Certain
Present Day (2021) - Unlikely
Present Day (2021) - Rare
Rocky shore
n
0 2 4 6 km
Trial Bay Visitor's Precinct
Macleay River Entrance
Arakoon
Trial Bay
Saltwater Lagoon
Gap Beach
Smoky Cape Lighthouse
NSW National Parks & Wildlife Service's digital GIS database has been used in the creation of datasets in this map. In regards to this data, no warranty is given in relation to the data (including accuracy, reliability, completeness, currency or suitability) and no liability accepted (including without limitation, liability in negligence) for all expenses, losses, damage (including indirect or consequential damage) and costs which you might incur as a result of the data being inaccurate or incomplete in any way and for any reason (relating to any use of the data).
The data has been compiled and published for information and convenience only and is not a legal document. It is the responsibility of the user to verify all information before placing reliance on it.
Produced by Alluvium Consulting Australia


2050 Coastal Erosion Risk Map
Asset types
Beach and foreshore assets
Infrastructure and utilities assets
Transport assets
Land, environment, and cultural assets
Recreational assets
Linear assets
Land use area
Risk colour guide
Very low (only at risk if shoreline allowed to return to pre-breakwater alignment)
Low
Medium
High
Very high
Erosion hazard lines
2050 - Almost Certain
2050 - Unlikely
2050 - Rare
Nominal buffer (10 m)
Nominal buffer (20 m)
Rocky shore
n
0 2 4 6 km
Trial Bay Visitor's Precinct
Macleay River Entrance
Arakoon
Trial Bay
Saltwater Lagoon
Gap Beach
Smoky Cape Lighthouse
NSW National Parks & Wildlife Service's digital GIS database has been used in the creation of datasets in this map. In regards to this data, no warranty is given in relation to the data (including accuracy, reliability, completeness, currency or suitability) and no liability accepted (including without limitation, liability in negligence) for all expenses, losses, damage (including indirect or consequential damage) and costs which you might incur as a result of the data being inaccurate or incomplete in any way and for any reason (relating to any use of the data).
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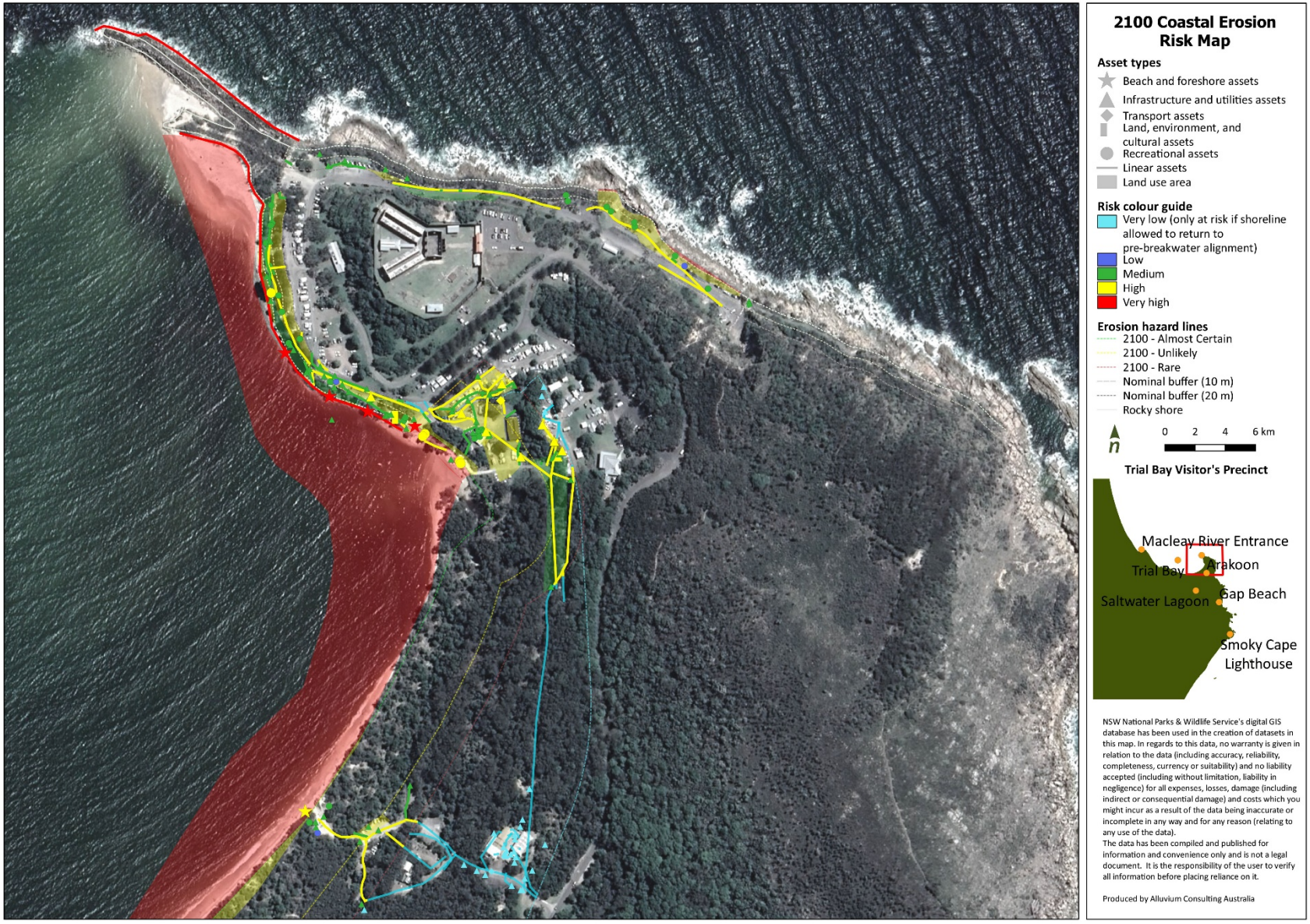
Produced by Alluvium Consulting Australia


2100 Coastal Erosion Risk Map
Asset types
Beach and foreshore assets
Infrastructure and utilities assets
Transport assets
Land, environment, and cultural assets
Recreational assets
Linear assets
Land use area
Risk colour guide
Very low (only at risk if shoreline allowed to return to pre-breakwater alignment)
Low
Medium
High
Very high
Erosion hazard lines
2100 - Almost Certain
2100 - Unlikely
2100 - Rare
Nominal buffer (10 m)
Nominal buffer (20 m)
Rocky shore
n
0 2 4 6 km
Trial Bay Visitor's Precinct
Macleay River Entrance
Trial Bay
Arakoon
Saltwater Lagoon
Gap Beach
Smoky Cape Lighthouse
NSW National Parks & Wildlife Service's digital GIS database has been used in the creation of datasets in this map. In regards to this data, no warranty is given in relation to the data (including accuracy, reliability, completeness, currency or suitability) and no liability accepted (including without limitation, liability in negligence) for all expenses, losses, damage (including indirect or consequential damage) and costs which you might incur as a result of the data being inaccurate or incomplete in any way and for any reason (relating to any use of the data).
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