Clarence Valley Coastline and Estuaries Coastal Management Program

Stage 2: Vulnerabilities and Opportunities

Final Report

November 2023

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Clarence Valley Council and Hydrosphere Consulting acknowledge the Yaegl peoples, Traditional Custodians of the lands discussed in this Scoping Study and pay tribute and respect to the Elders both past and present and emerging of the Yaegl nations.

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JOB 22-009: CLARENCE VALLEY COASTLINE AND ESTUARIES COASTAL MANAGEMENT PROGRAM
STAGE 2: VULNERABILITIES AND OPPORTUNITIES

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EXECUTIVE SUMMARY

Clarence Valley Council (CVC) will prepare a Coastal Management Program (CMP) for the Clarence Valley coastline and estuaries (CMP for the Clarence Coastline and Estuaries) to provide a long-term coordinated strategy for managing the coastal zone. Stage 1 of the CMP development (the Scoping Study) provided a review of progress of actions in the existing management plans for the coastal areas and identified the scope of the new CMP. This report addresses Stage 2 of the CMP process for the Clarence Valley coastline.

Stage 2 of the CMP development involved undertaking detailed studies that help to identify, analyse and evaluate risks, vulnerabilities and opportunities. Studies prepared in Stage 2 provide information to support decision-making in later stages of the planning process, to better understand coastal management issues and to analyse and evaluate coastal risks and opportunities. The work undertaken in Stages 1 and 2 of the CMP development has been used to identify the issues and assess the threats affecting the CVC coastal zone.

The study area for the CMP includes the open beaches, foreshores and coastal waters of the Clarence Valley Local Government Area including Woody Head, Iluka, Yamba, Angourie, Brooms Head, Sandon, Minnie Water, Diggers Camp and Wooli. The study area also includes the estuaries and lagoons of Lake Cakora, Lake Arragan, Sandon River and Wooli Wooli River including three mapped coastal management areas defined in the *Coastal Management Act 2016* (Coastal Use Area, Coastal Environment Area and Coastal Wetlands and Littoral Rainforest Area).

An assessment of coastal hazard risks to Council infrastructure and Council-managed land was prepared for the CMP study area. The assessment considered the location and criticality of Council's assets, the likelihood and extent of beach erosion/ shoreline recession and tidal/ coastal inundation over time and the consequence of the hazards to identify the risk to these assets. This assessment found that Council managed reserves along the coast are vulnerable to inundation and erosion/ recession although the majority of impacted areas at present is limited to the beaches and foreshores which are periodically impacted by higher tides and coastal erosion events caused by storms, with resulting impacts on beach amenity, safety, access and coastal infrastructure. Water, sewer and stormwater infrastructure, pathways, roads, carparks and tracks along the foreshores are also expected to be impacted over time. Higher tides and storm surges are expected to enter urban stormwater systems and increase localised flood risk along the coast more frequently in future, particularly in Yamba and Wooli. The potential impacts range from flooding, salt water intrusion, undermining and collapse depending on the type of assets and extent of protection available.

The first- pass risk assessment undertaken during Stage 1 (covering all threats across the study area) was also updated with new information available from the Stage 2 studies (coastal hazard assessments and any new management approaches) and the outcomes of the asset/ infrastructure risk assessment. The next stage (Stage 3) will involve the identification and evaluation of management options. The level of risk for each threat determined in Stage 2 has determined the options assessment process that will be followed in Stage 3 and the focus of the CMP.

A coordinated and consistent approach to strategic planning and an appropriate level of protection of environmental, cultural, built and commercial assets in the coastal zone will ensure adequate planning for and protection from coastal hazards, future development pressures and emerging threats associated with a changing climate. Due to the large geographical area, environmental and social values of the study area,

there are several key management threats to be considered in the CMP. The threats with a moderate or high risk in the current timeframe will be the focus of the CMP. Stage 3 will include potential strategic approaches to reduce the identified risks and create opportunities to manage any unacceptable risks, identification of management options, development of adaptation pathways over time and evaluation of potential actions. Potential management options to address the highest risk threats are discussed in this report including actions from previous management plans that have not yet been implemented. Other options will also be developed and assessed in Stage 3.

In addition to on-ground management options, there is a need for inclusion of current coastal hazard information into Council's planning framework through the appropriate processes offered through the NSW coastal management framework, local planning provisions and through Council's planning instruments. Council's preferred approach will be developed during Stage 3.

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1. INTRODUCTION

1.1 Background

Clarence Valley Council (CVC) is currently preparing a Coastal Management Program (CMP) for the Clarence Valley coastline and estuaries (CMP for the Clarence Coastline and Estuaries) to provide a long-term coordinated strategy for managing the coastal zone. The CMP is being prepared in consultation with government and community stakeholders to provide an integrated approach to coastal zone management.

The *NSW Coastal Management Manual* (OEH, 2018a, the Manual) provides guidance for developing a CMP and assists councils in addressing the requirements of the *Coastal Management Act, 2016*. The manual outlines the mandatory requirements and provides guidance on the preparation, development, adoption and content of a CMP. It includes a process for councils to follow when identifying and assessing the vulnerability of coastal environmental, social and economic values and evaluating management actions.

The manual outlines a five-stage process for developing and implementing a CMP (Figure 1). Stage 1 of the CMP development, the Scoping Study (Hydrosphere Consulting, 2021) was completed in March 2021. The Scoping Study provided a review of progress of actions in the existing management plans for the coastal areas and identified the scope of the new CMP. This report addresses Stage 2 of the CMP process for the Clarence Valley coastline.

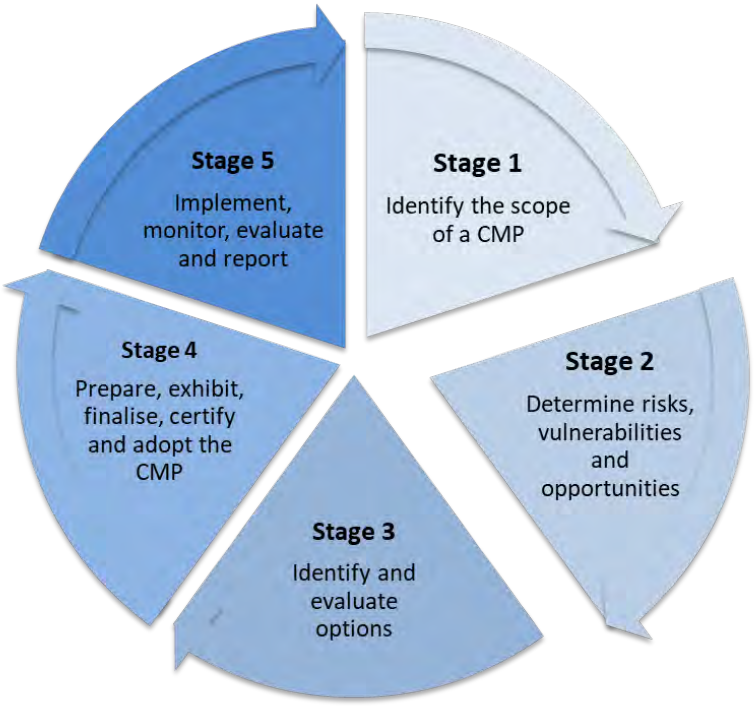


Figure 1: The five-stage process for developing a coastal management program

Source: Adapted from OEH (2018a)

1.2 Study Area

The study area for the CMP includes the open beaches, foreshores and coastal waters of the Clarence Valley Local Government Area (LGA) including the townships of Woody Head, Iluka, Yamba, Angourie, Brooms Head, Sandon, Minnie Water, Diggers Camp and Wooli. The study area also includes the estuaries and lagoons of Lake Cakora, Lake Arragan, Sandon River and Wooli Wooli River. The three currently mapped coastal management areas defined in the *Coastal Management Act 2016* (Coastal Use Area - CUA, Coastal Environment Area - CEA and Coastal Wetlands and Littoral Rainforest Area - CWLRA) within the study area are shown in Figure 2.

CVC is preparing a separate CMP for the Clarence River estuary (including Wooloweyah Lagoon) which will provide the long-term coordinated strategy for managing the remainder of the coastal zone within the LGA.

The Clarence Valley coastline lies spans over two primary coastal sediment compartments, Clarence River to Point Danger (Tweed Heads) and Yamba Heads to Bare Bluff (Sapphire Beach). The secondary sediment compartments within the study area are Bundjalung (shared with Richmond Valley Council), Yuraygir and Woolgoolga (shared with Coffs Harbour City Council) illustrated in Figure 3.

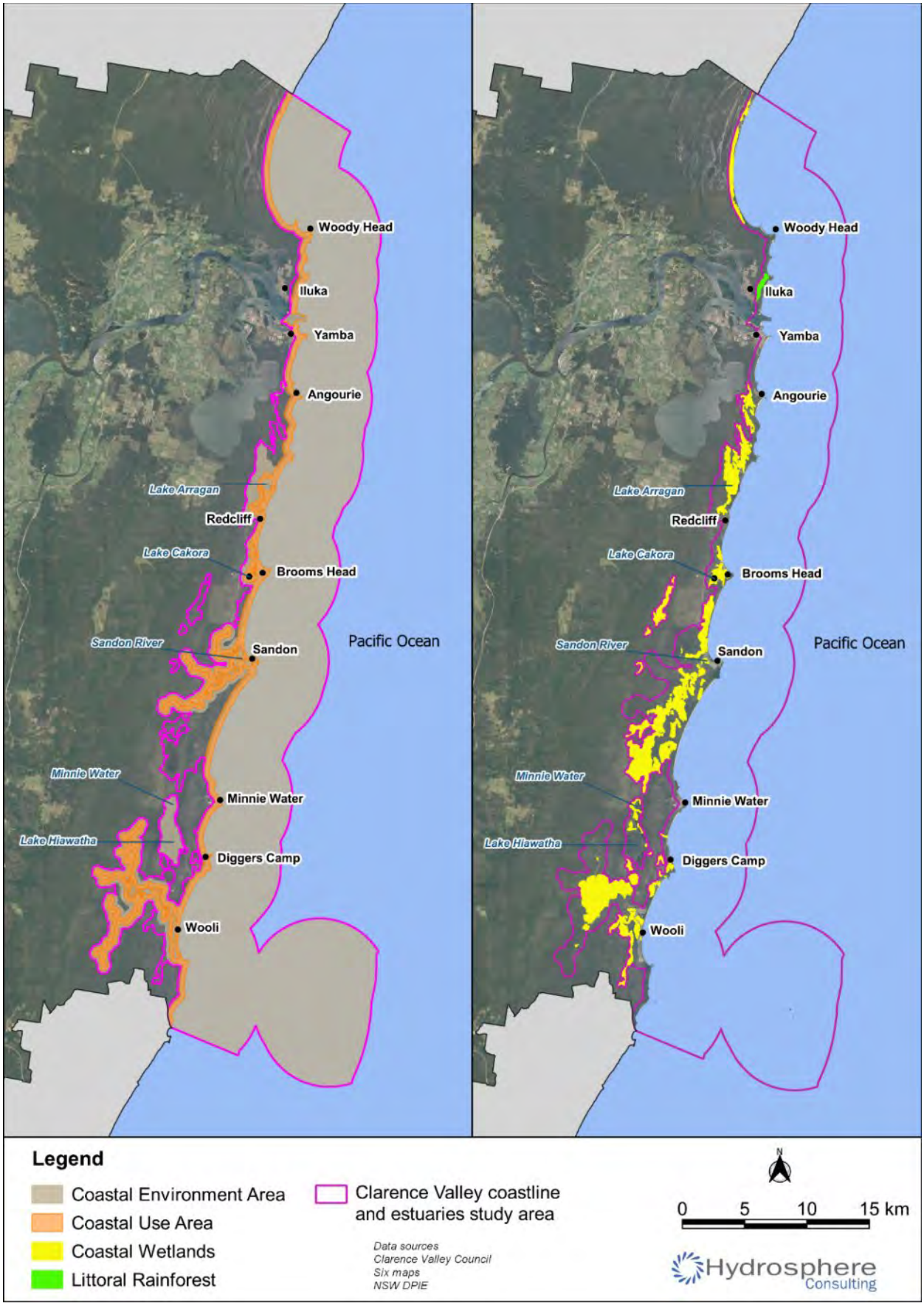


Figure 2: Coastal management areas to be addressed in the CMP for the Clarence Valley coastline and estuaries

Source: Hydrosphere Consulting (2021)

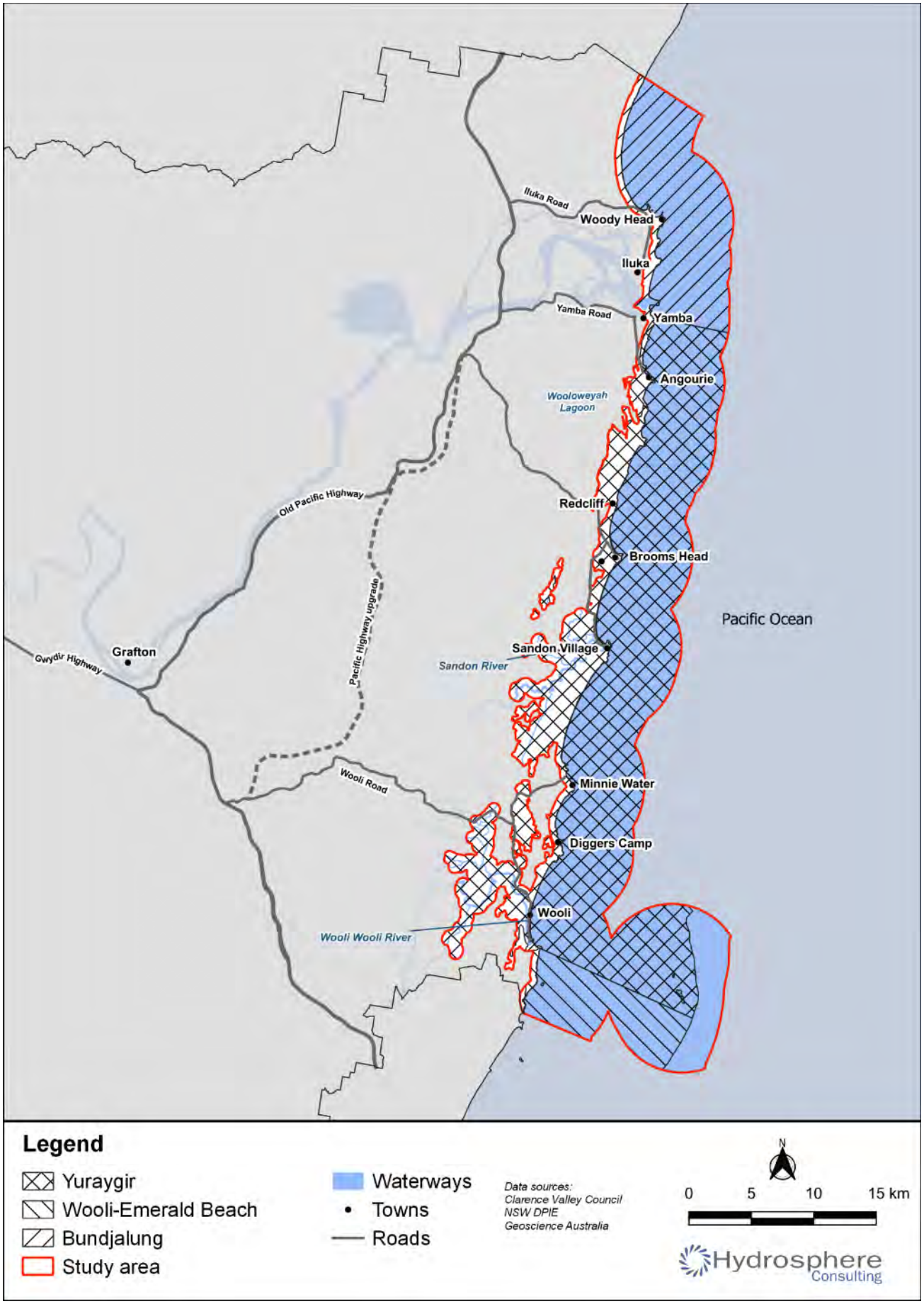


Figure 3: Secondary coastal sediment compartments within the CMP study area

1.3 Scope of Stage 2

Part A of the *Coastal Management Manual* (OEH, 2018a) outlines the mandatory requirements for a CMP. The mandatory requirements that are relevant to Stage 2 have been addressed in this report:

- MR2: A CMP is to consider a range of timeframes and planning horizons including immediate, 20 years, 50 years, 100 years and (if council considers it relevant based on expert advice) beyond.
- MR3: A CMP is to consider a broad range of coastal management issues and management actions with a focus on achieving the objects and objectives of the *Coastal Management Act 2016*.
- MR 4. A CMP must include the rationale for selecting the area to be covered by a CMP and identify whether it applies to:
    - o all or part of the coastal zone of one local government area; or
    - o all or part of the coastal zone of adjoining local government areas that share a coastal sediment compartment or estuary (where adjoining local government areas share a coastal sediment compartment or estuary, a CMP that addresses an area comprising that coastal sediment compartment or estuary must reflect this regional context).
- MR5. A CMP must identify:
    - i. any proposed amendments to mapping of the relevant coastal management areas.
    - ii. evidence to support any proposed amendments or additions to the area of the four coastal management areas in the relevant area.
    - iii. information about these proposed amendments that can support the preparation of a planning proposal and, in particular, that could be forwarded along with a planning proposal to the Minister to inform a Gateway determination under section 3.34 of the *Environmental Planning and Assessment Act 1979*.
- MR 6. During preparation of a CMP, a council is to:
    - i. identify the scope of the CMP.
    - ii. determine and assess coastal risks, vulnerabilities and opportunities (including without limitation risks to environmental, social and economic values and benefits).
    - iii. evaluate and select coastal management options.
- MR 7. A council may choose not to repeat steps (or parts of steps) in subparagraphs (ii) or (iii) of mandatory requirement 6 for the area the subject of the proposed CMP (or parts of that area) if those tasks have already been undertaken for the coastal management of that area, provided that council first considers:
    - i. whether the existing assessment of coastal risks, vulnerabilities and opportunities, or the existing evaluation of coastal management options, that council proposes to NSW Coastal Management Manual Part A 22 rely on enables council to prepare the CMP in accordance with mandatory requirement 8 below and sections 14 and 15 of the *Coastal Management Act, 2016*.

ii. the effectiveness of the existing coastal management of that area.

iii. whether any circumstances concerning the coastal management of that area have changed.

Stage 2 of the CMP development involves undertaking detailed studies that help to identify, analyse and evaluate risks, vulnerabilities and opportunities. Studies prepared in Stage 2 provide information to support decision-making in later stages of the planning process. The additional information assists communities to better understand coastal management issues and to analyse and evaluate coastal risks and opportunities.

Stage 2 of the CMP for the Clarence Valley coastline and estuaries included:

- Refining understanding of key management issues (where there are knowledge gaps) as described in the Scoping Study (Hydrosphere Consulting, 2021).
- Analysing and evaluating current and future risks (detailed risk assessment) building on the first-pass risk assessment from the Scoping Study and outcomes of Stage 2 detailed studies.
- Identification of opportunities to reduce risks and enhance the environmental, social and economic values.
- Continuing engagement with the community and stakeholders.

The Scoping Study (Hydrosphere Consulting, 2021) identified the following detailed assessments required in Stage 2 which are discussed in this report:

- Coastal hazard assessment - Section 2.4:
    - Continuous hazard mapping along the entire coastline for each planning timeframe (current, 2050 and 2100) with reference to the state-wide exposure assessment, supplemented with local scale assessment where required.
    - Detailed probabilistic analysis of beach erosion, coastal recession and coastal inundation hazards for current and emerging high-risk locations and areas not yet assessed (Shark Bay, Woody Bay, Whiting Beach, Brooms Head, Sandon area and Wooli). The detailed probabilistic analysis of beach erosion/ coastal recession was expanded to include Minnie Water, Diggers Camp, Pippi Beach and Spooky Beach.
- Review of existing slope instability assessments and monitoring data - Section 2.7:
    - Analysis of previous hazard assessments and recent instability monitoring data to provide a contemporary understanding of the instability risk at Pilot Hill (Yamba Main Beach) and Cakora Point. This assessment was expanded to include Convent Beach.
    - Identification of potential management options including ongoing monitoring, additional assessment or remediation.
- Assessment of assets and infrastructure at risk - Section 6.1:
    - Development of asset register and mapping of assets on Council land and Council-managed Crown Land.
    - Assessment of risks to public assets due to coastal hazards.

- Assessment of cultural heritage sites at risk - Section 4:
    - Identify cultural heritage sites potentially affected by coastal hazards (through cultural heritage mapping where appropriate).
- Detailed risk assessment - Section 6.2:
    - Analysis and evaluation of current and future risks (updated first-pass risk assessment).
- Review of planning controls related to coastal hazards - Section 9.
- Stakeholder engagement - the Stakeholder Engagement Strategy (Appendix D in Hydrosphere Consulting, 2021)) identified stakeholders, the level of engagement proposed and engagement tools - Section 11.

Additional information was reviewed as part of Stage 2 including:

- Coastal hazards - review of entrance instability (Section 2.2) and erosion and inundation of foreshores (Section 2.3).
- Water quality - review of water quality data and existing monitoring programs - Section 3.
- Identification of opportunities - review of actions from previous management plans and other emerging opportunities - Section 7.
- Management of National Parks and Reserves including coastal hazard response plans for National Parks campgrounds - Section 9.
- Emergency response arrangements - Section 10.
- Presentation of information required to address the intended outcomes of Stage 2 as described in Section 1.4.

Recommendations have also been provided for Stage 3 of the CMP development (Section 12).

1.4 Outcomes of Stage 2

The *Coastal Management Manual* (OEH, 2019a) describes the intended outcomes from Stage 2. Table 1 outlines the intended outcomes and the outcomes achieved for the CMP for the Clarence Coastline and Estuaries.

Table 1: Outcomes of Stage 2

Potential Stage 2 outcomes[1]	Stage 2 outcomes: CMP for the Clarence Coastline and Estuaries
Refined mapping of coastal management areas	Potential Coastal Vulnerability Area (CVA) mapping developed during Stage 2 includes the coastal hazards of beach erosion, shoreline recession, coastal inundation and tidal inundation. Further work is recommended to develop refined mapping of coastal cliff/ slope instability areas. Further work is recommended to confirm the suitability of the Coastal Wetlands and Littoral Rainforest Area (CWLRA) mapping.

Potential Stage 2 outcomes[1]	Stage 2 outcomes: CMP for the Clarence Coastline and Estuaries
Detailed information necessary for a planning proposal to amend the mapping of coastal management areas for planning purposes in council's Local Environmental Plan (LEP)	Potential amendments to planning controls are identified in this report. Council will confirm the preferred planning controls as part of Stage 3.
Context and data provided to support the identification and evaluation of management options in Stage 3	This report provides detailed information on threats and risks and identifies potential management opportunities to be considered further in Stage 3.
Improve understanding of the complexity of issues and community perspectives	This report provides detailed information on threats and risks which will be presented to the community and other stakeholders to obtain feedback on the potential management opportunities to be considered further in Stage 3.
Nature and extent of exposure to coastal hazards and threats to public and private assets (both natural and built)	Detailed information is available on the risks to public assets from coastal hazards over various timeframes. The updated risk assessment provides information on the extent of private assets potentially impacted by coastal hazards over various timeframes.
Understanding of the factors that contribute to vulnerability and to current and future risks	The detailed coastal hazard studies undertaken as part of Stage 2 provide detailed information on the factors that contribute to vulnerability and to current and future risks along the coastline.
Socioeconomic characteristics such as demographics, coast-dependent economic activity, land use patterns and future development scenarios which influence vulnerability and capacity to respond now, and in the future	Information on socioeconomic characteristics was provided in the Stage 1 Scoping Study and updated in this report.
Understanding of the range of potential future scenarios for climate change, population growth, development and use of the coast	Information on potential future scenarios was provided in the Stage 1 Scoping Study and updated in this report.
Understanding of the local community's attitude to risk in terms of what may be acceptable, tolerable or unacceptable	Development of the Stage 1 Scoping Study included detailed stakeholder engagement activities. Feedback from the community has been considered in the detailed risk assessment presented in this report. The outcomes of Stage 2 will be presented to stakeholders and any feedback will be considered during Stages 3 and 4 of the CMP development.
Opportunities to reduce risks and enhance the environmental, social and economic values	Potential management opportunities to be considered in Stage 3 are presented in this report.

1. OEH (2019a)

2. COASTAL HAZARDS

The seven coastal hazards defined in the Manual (OEH, 2019a) are:

- Hazard 1: Beach erosion - discussed in Section 2.5.
- Hazard 2: Shoreline recession - discussed in Section 2.5.
- Hazard 3: Coastal lake or watercourse entrance instability - discussed in Section 2.2.
- Hazard 4: Coastal inundation - discussed in Section 2.4.
- Hazard 5: Cliff/slope instability - discussed in Section 2.7.
- Hazard 6: Tidal inundation - discussed in Section 2.4.
- Hazard 7: Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters - discussed in Section 2.3.

2.1 Coastal Processes

The ocean conditions and wave climate along the Clarence Valley coastline is influenced by short-term weather and longer-term climatic conditions. Coastal processes and influences on coastal processes occurring along the Clarence Valley coastline include (Hydrosphere Consulting, 2021, further detail is provided in JBP, 2022 and JBP, 2023):

- Wave direction - the dominant swell direction along the Clarence Valley coastline is from the east to south-east. There is a seasonal trend in wave direction with swells predominantly east-south-east during summer, shifting further south in autumn with dominant south-east to south-south-east during winter. The spectrum expands in spring with some winds coming from the north-east sector but is still predominately south-east. During summer, east to south-east swells are dominant. Typically, the largest swells come from the south-south-east with a small portion of larger swells from the north-east east during summer.
- Wave height - wave heights peak between March and April. Periodic weather events can result in large wave conditions that impact on shorelines.
- Wind - morning winds are typically light and from the west with stronger winds from the south occasionally. Afternoon winds are typified by stronger north-east and south-east winds. Winds influence aeolian transport of sand and local wave conditions.
- Sediment movement - the Clarence Valley coastline is a longshore drift coastline. Overall sediment movement (in a northerly direction) is influenced by the predominant swell direction (south-easterly). Longshore drift occurs within and between sediment compartments. There are other localised sediment movement, including on and offshore movements under different conditions and other localised anomalies.
- Weather patterns - the El Niño Southern Oscillation (ENSO) is responsible for influencing weather patterns on the east coast and subsequently is major driver of wave climate and associated coastal processes and conditions. The ENSO drives the El Niño/ La Niña weather cycles. Typically, El Niño events are associated with reduced storminess, weaker easterly trade winds and a generally more

southerly wave climate. La Niña events are typified by the reverse characteristics, increased storminess, stronger trade winds and a more easterly wave.

The Clarence Valley coastline lies within the temperate province, south-east division and central eastern region and spans over two primary coastal sediment compartments, Clarence River to Point Danger (Tweed Heads) and Yamba Heads to Bare Bluff (Sapphire Beach). The secondary sediment compartments within the study area are Bundjalung, Yuraygir and Woolgoolga. Based on the sediment compartment framework the majority of the Clarence coastline is dominated by sediment compartments that are characterised by rocky headlands, zeta form bays and sandy beaches and the majority of the coast consists of shorelines that do not show evidence of long-term recession but are likely to begin receding with continuing sea-level rise. However, there are several sections where shoreline recession is currently occurring and is likely to continue.

The Clarence Valley coastline has a moderate tidal influence and moderate to high wave energy climate which has formed multiple crenulate shaped embayments such as at Woody Head and Sandon. Sand is supplied to the beaches by longshore drift, with sand pulses around headlands a key mechanism for the longshore transport, which generate large migratory updrift rips that erode the beach and transport sand to the north through sand waves. North of the Calrence River, the region is part of the Clarence-Moreton Basin, where softer sedimentary rocks have been eroded to form broader valleys, typically with longer beaches and fewer headlands than experienced along the south of the Clarence LGA. The southern section of the study area is part of the New England Fold Belt whose resilient sedimentary and metasedimentary rocks dominate the rocky sections of coast between Yamba to South West Rocks. This coastline is characterised by its moderately long sandy beaches, separated by rocky outcrops and headlands, most notably at Yamba, and Minnie Water. Throughout the coastline, the presence of exposed Pleistocene dunes suggests a slowly receding coast.

2.2 Coastal Lake or Watercourse Entrance Instability

The CMP study area includes five lakes/ water courses as discussed in the following sections.

2.2.1 Clarence River entrance

The Clarence River entrance is stabilised with a southern breakwater from Yamba headland and another breakwater on the northern side at Iluka. The lower estuary is further stabilised with a number of other training and protection walls including along the foreshore at Yamba and Iluka, Middle Wall, Moriarty's Wall, Iluka, Freeburn and Goodwood Island training walls. These breakwaters and entrance training walls are managed by Transport for NSW Marine Infrastructure Delivery Office (TfNSW - MIDO).

Sand accumulates to the east of the breakwaters forming an ebb tide ring bar at the entrance, with its position determined by the equilibrium between off-shore transport of sand by the ebb tide and on-shire transport by wave action. A rock reef, recognised as a significant cultural site to the Yaegl Aboriginal community, consisting of hard sandstone, limits water depths in the river downstream of Moriarty's Wall. The river mouth is subject to a net northerly littoral sand drift which is driven at variable rates by the combination of waves, tides and ocean currents. Floods continue to play a major role in the exchange of sediment between the river and coast (Hydrosphere Consulting, 2021).

The construction of breakwaters and training walls in the Clarence River entrance does not eliminate the formation of entrance bars and accretion of sand in the navigation channels. Depending on the height of the bar, it can cause a navigation hazard which was identified as an issue in the *Clarence River Estuary Management Plan* (Umwelt, 2003) and the Stage 1 Scoping Study. Historically, dredging has occurred in the Clarence River entrance to improve navigation, most recently in 2016, and for sand and gravel supply to the construction industry. Sand also accumulates inside the entrance in the Yamba Harbour approach channel, creating a navigation issue. Sand from within the approach channel has previously been dredged to a navigable depth when required with dredging activities managed by TfNSW - MIDO. Sedimentation and navigation impacts within the Clarence River entrance are an ongoing concern raised by stakeholders (Hydrosphere Consulting, 2021).

The *Clarence River Estuary Management Plan* (Umwelt, 2003) contained actions for the NSW government, led by DPE - Crown Lands, to coordinate studies of sedimentation in the estuary. To date those assessments have not been completed and hence there is limited understanding of sedimentation processes and related impacts affecting the estuary and entrance.

2.2.2 Lake Cakora

Lake Cakora, located at Brooms Head, is an intermittently closed and open lake or lagoon (ICOLL) with an untrained entrance. Breakout events are a function of rainfall and coastal conditions. During entrance breakouts, sediment from the entrance foreshore is transported into the nearshore area. Sediment is then reworked by coastal processes and transported back onshore by waves to reform the entrance berm. Informal opening of the entrance is undertaken periodically, typically when the water level is perceived to be too high within the lake or the water quality is perceived to be poor, usually after it has not been open to the ocean for a period of time and particularly when this coincides with the summer holiday period (Hydrosphere Consulting, 2021).

An entrance management regime was proposed in the certified CZMP for Brooms Head and Lake Cakora (CVC, 2017) involving artificial breakout of Lake Cakora entrance during swimming season for recreational purposes if the lake water level has reached 1.6 mAHD without breaking out naturally. Fixed gauges were to be installed adjacent to Ocean Road Bridge to monitor lake water levels. The entrance management strategy has not been formalised for Lake Cakora.

2.2.3 Lake Arragan and Mara Creek

Lake Arragan and Mara Creek are ICOLLs with untrained and unmanaged entrances within Yuraygir National Park. NPWS estimates that Lake Arragan naturally opens 3-4 times per year, depending on conditions. The state of the entrance varies naturally in response to prevailing catchment runoff and coastal conditions. Breakout events typically occur during summer-autumn coinciding with periods of high rainfall and often high tides and large seas. Stakeholders (e.g. NPWS) have not raised any issues related to the entrance opening regime of either ICOLL and there is no desire to artificially manage these entrances (Hydrosphere Consulting, 2021).

2.2.4 Sandon River

The Sandon River flows through Yuraygir National Park into the sea at Sandon. The entrance is flanked by two rocky headlands which act as natural training walls. The Sandon River estuary has a net upstream movement of marine sands by tidal currents resulting in the formation of shoals in the lower estuary. Sedimentation due to upstream sources is not greatly affecting the estuary and sand movement within the estuary is deemed to be predominantly natural (Hydrosphere Consulting, 2021).

2.2.5 Wooli Wooli River

The Wooli Wooli River flows through Yuraygir National Park and enters the sea near the Wooli. The entrance to Wooli Wooli River estuary has trained walls which ensure the estuary remains open to the sea. These breakwaters and entrance navigation channel are managed by TfNSW - MIDO.

Within the lower estuary, the shoal pattern has remained relatively stable over the past 50 years, with the exception of the shoals around Mangrove Island. In the vicinity of Mangrove Island, shoals appear to have moved downstream by episodic flood events and then slowly reworked back into upstream positions by inflowing (flood) tides. Sand build-up and entrance condition/ safety are an ongoing concern raised by stakeholders (Hydrosphere Consulting, 2021).

2.3 Erosion and Inundation of Foreshores

Hazard 7 (Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters) has been considered as two separate issues for the CMP development:

1. Erosion of foreshores.
2. Inundation of foreshores under tides, waves, and catchment flood waters.

2.3.1 Erosion of foreshores

The available information on bank erosion can be summarised as (Hydrosphere Consulting, 2021):

- Clarence River entrance - the majority of the banks within lower estuary within the study area are protected with rock revetment/ training walls.
- Lake Cakora - bank erosion assessments have not been undertaken although no significant bank erosion sites have been noted in previous studies. The first-pass risk assessment in the Scoping Study found that the risk of bank erosion was moderate at the Lake Cakora bridge (also considered in the Stage 2 beach erosion assessment, Section 2.5).
- Sandon River - the most recent assessment of bank condition was undertaken in 2010. Bank erosion was found to be occurring throughout the estuary on outside bends along 30 - 100 m of river bank, ranging from minor to severe. The majority of the Sandon River catchment is located within Yuraygir National Park and the tidal reaches are part of the Solitary Islands Marine Park. Due to high vegetation cover on banks and the undeveloped nature of the catchment, all erosion is considered to be natural and due to the ongoing lateral adjustment of the waterway. Some minor ad hoc erosion control works have been undertaken on the southern bank of the entrance adjacent to the residential

properties at Sandon Village and along Sandon River Road near the entrance to the campground. No other works have been undertaken to address the other identified erosion sites in Sandon River estuary (Hydrosphere Consulting, 2021).

- Wooli Wooli River - the most recent assessment of bank condition was undertaken in 2006. The majority of the catchment is located within Yuraygir National Park and the tidal reaches are part of the Solitary Islands Marine Park. Erosion hot spots at the South Terrace boat ramp and the banks adjoining the Solitary Islands Marine Park Resort Caravan Park (noted in the first-pass risk assessment) have since been remediated. Other erosion hot spots were noted on the southern bank approaching “The Forks” and isolated areas along Bookram Creek. Bank erosion was attributed to a variety of causes but mostly related to removal of riparian vegetation combined with tidal and flood flows or boat wake and wind waves. The first-pass risk assessment found that the risk of bank erosion was moderate in parts of the Wooli Wooli River.

2.3.2 Inundation of foreshores under tides, waves and catchment flood waters

CVC is undertaking a flood study for Wooli Wooli River which will include assessment of tidal (sunny day) inundation expected to be completed in 2023. Outputs will include updated flood mapping to support land use planning. There are no flood studies undertaken for Sandon River or Lake Cakora. Foreshore inundation for the Clarence River entrance will be addressed in the CMP for the Clarence River Estuary (currently being developed by CVC).

There is limited guidance regarding the assessment of this hazard for CMPs but available flood risk mapping that includes catchment and marine/ tidal inundation would meet the objective of this hazard for the purposes of CVA mapping.

2.4 Tidal and Coastal Inundation

Tidal inundation is generally related to elevated tidal water levels under average meteorological conditions. Tidal inundation may include shorter-term incursion of seawater onto low-lying land during an elevated water level event such as a high tide or more permanent inundation due to land subsidence, changes in tidal range or sea level rise. Coastal inundation is generally related to storm events and occurs when a combination of marine and atmospheric processes raises ocean water levels above normal elevations and inundates low-lying areas or overtops dunes, structures and barriers (Figure 4). Wave overtopping and storm surge can also be associated with tsunami events. Any changes in mean sea level will directly affect the extent and severity of tidal/ coastal inundation hazards.

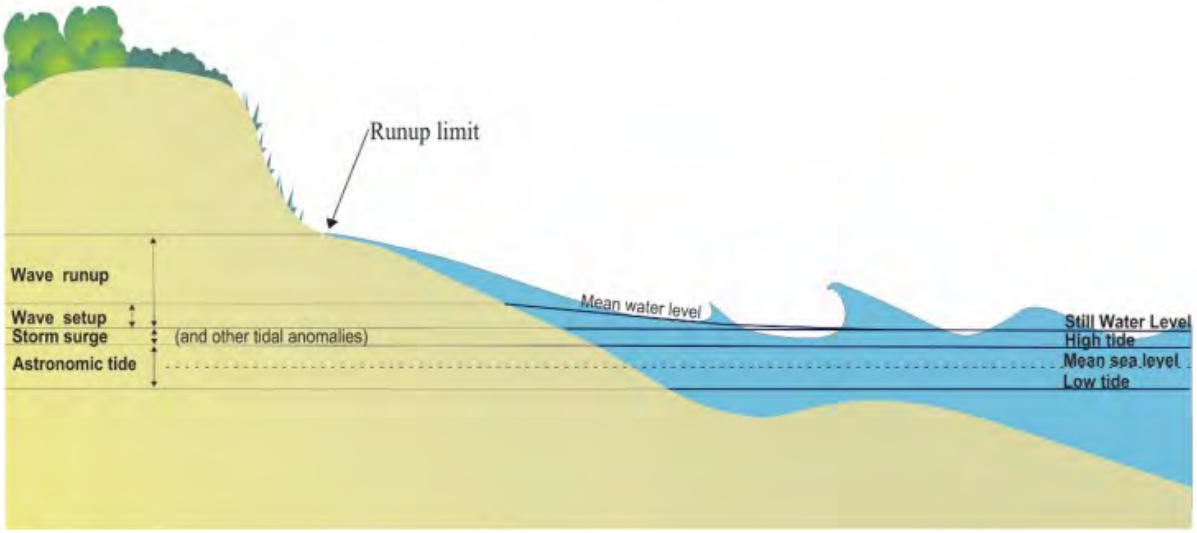


Figure 4: Elevated water levels on the open coast

Source: OEH (2019a)

The detailed assessment of tidal and coastal inundation undertaken for the Clarence coastline (JBP, 2022 attached in Appendix 2) provides information on the likelihood of occurrence and the resultant spatial extent of inundation over time. Tidal and coastal inundation hazard mapping has been produced for the Clarence River and coastline areas using hydrodynamic modelling and spatial projection methods. The assessment was undertaken for each planning horizon, event frequency and climate pathway (Table 3). Further detail and mapping are provided in JBP (2022).

2.5 Beach Erosion and Shoreline Recession

Beach erosion refers to the removal of beach materials by wave action, tidal currents, littoral currents or wind. It is usually associated with storms or with elevated water levels and can occur on the open coast and in estuaries. Beach erosion events are often interspersed with a beach recovery phase when sediment moves back onshore to rebuild the beach and dunes. The sediment budget is maintained in a closed sediment compartment (Figure 5). Changes in the distribution of sediment between the nearshore, alongshore, beach face, foredune and estuaries are considered in the assessment of potential beach erosion. Short-term fluctuations of the shoreline are often quite dramatic and may mask long-term accretion or recession that occurs at much slower rates (Figure 5). Shoreline recession refers to continuing landward movement of the shoreline or a net landward movement of the shoreline over a specified time. As shoreline recession occurs, the beach fluctuation zone is translated landward (Figure 6). Whether long term recession occurs depends primarily on the state of the sediment budget for a particular part of the coast. Coastal sediment compartments can gain and/or lose sediment from several sources. If the losses persistently exceed the gains, then the depositional shorelines within that compartment will recede.

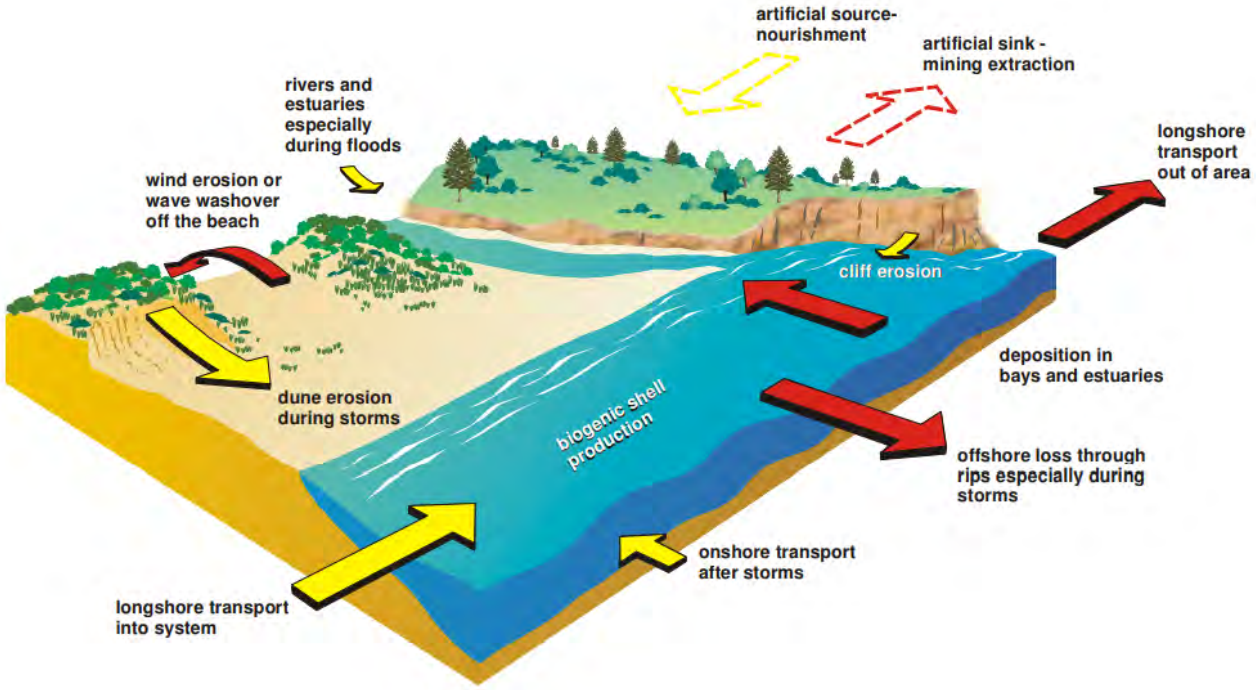


Figure 5: Components of the coastal sediment budget

Source: DLWC (2001)

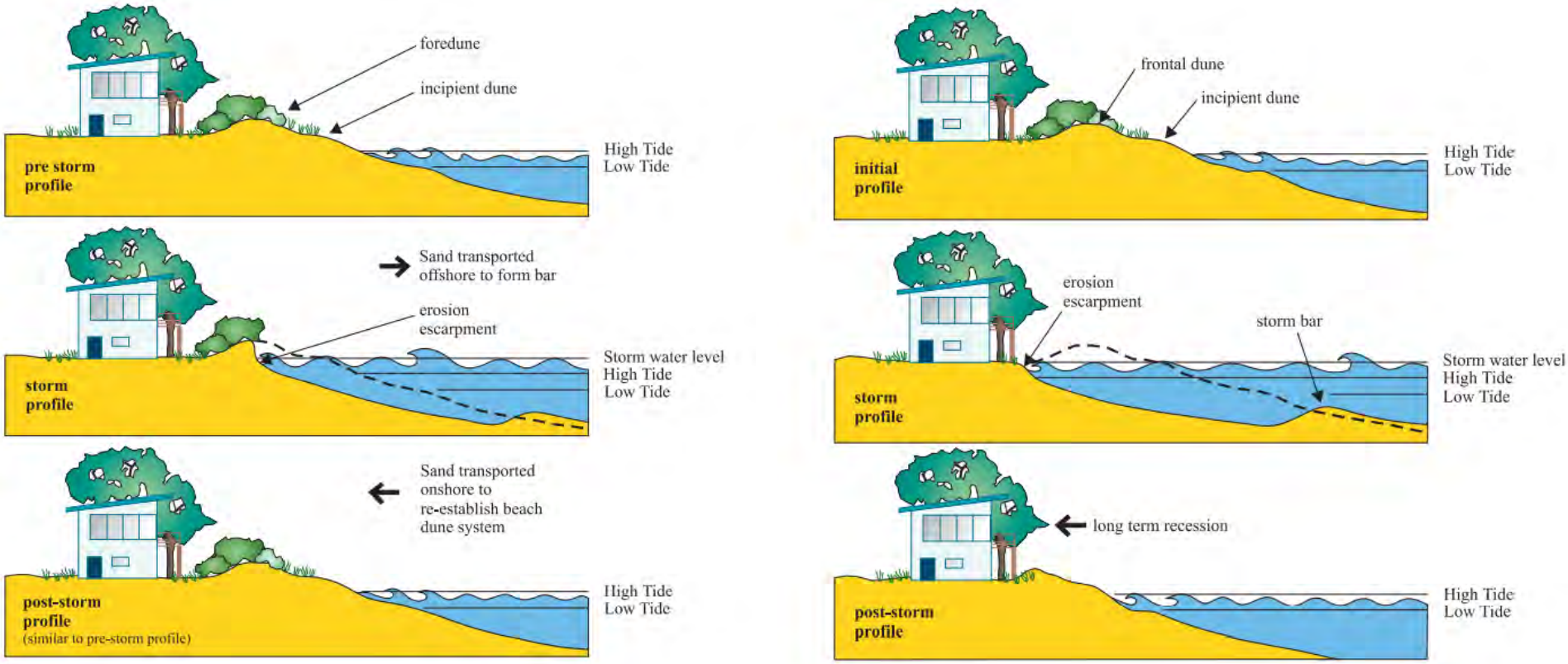


Figure 6: Beach erosion/accretion cycle with no permanent sand loss or shoreline retreat, left; Long-term beach recession - landward displacement due to permanent sand loss, right

Source: DLWC (2001)

2.6 Stage 2 Coastal Hazard Assessments

Due to the lack of contemporary and detailed information, coastal hazard assessments have been undertaken for the hazards of coastal erosion, recession and inundation as defined by OEH (2019a):

- Beach erosion - refers to the removal of beach materials by wave action, tidal currents, littoral currents or wind. It is usually associated with storms or with elevated water levels and can occur on the open coast and in estuaries.
- Shoreline recession - refers to continuing landward movement of the shoreline or a net landward movement of the shoreline over a specified time. As shoreline recession occurs, the beach is translated landward.
- Tidal inundation - inundation of land by tidal action under average meteorological conditions. Tidal inundation may include shorter-term incursion of seawater onto low-lying land during an elevated water level event such as a king tide or more permanent inundation due to land subsidence, changes in tidal range or sea level rise.
- Coastal inundation related to storm events - the temporary flooding of a portion of land within the coastal zone which is generally related to storm events. Coastal inundation occurs when a combination of marine and atmospheric processes raises ocean water levels above normal elevations and inundates low-lying areas or overtop dunes, structures and barriers. It is often associated with storms resulting in elevated water levels (storm surge), wave setup, wave run-up and over-wash flows.

The coastal hazard assessment and associated maps (JBP, 2022; JBP, 2023) were prepared to support the development of the CMP as part of Stage 2. Hazard mapping has been produced for present day (2023), +20 years (2043), +50 years (2073) and +100 years (2123) planning timeframes.

Coastal hazards have been defined in terms of an event frequency based on terminology used in flood management planning, specifically the terminology used in *Australian Rainfall and Runoff* (Commonwealth of Australia (Geoscience Australia, 2019) in order to apply consistent natural hazard risk assessment nomenclature.

Table 2: Australian Rainfall and Runoff Preferred Terminology

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

Source: Figure 1.2.1, Geoscience Australia (2019)

Annual Exceedance Probability (AEP) - the probability of an event being equalled or exceeded within a year. Average Recurrence Interval (ARI) - the average time period between occurrences equalling or exceeding a given value. Events more frequent than 50% AEP should be expressed as X Exceedances per Year (EY). For example, 2 EY is equivalent to a design event with a six month recurrence interval when there is no seasonality in flood occurrence. PMP = probable maximum precipitation.

For inundation, the event frequency is described using an annual exceedance probability (AEP, the probability that a particular inundation event will be exceeded in a given year). However, future erosion and recession hazard projections are a combination of short-term and long-term probabilistic components, therefore scenarios are described in terms of likely exceedance probability (EP). For a given planning horizon, erosion/ recession maps indicate the probability (e.g. 1%) that the hazard extent will be exceeded. The frequency (Table 3) has been presented as a qualitative description, useful to aid community and stakeholder understanding of risk.

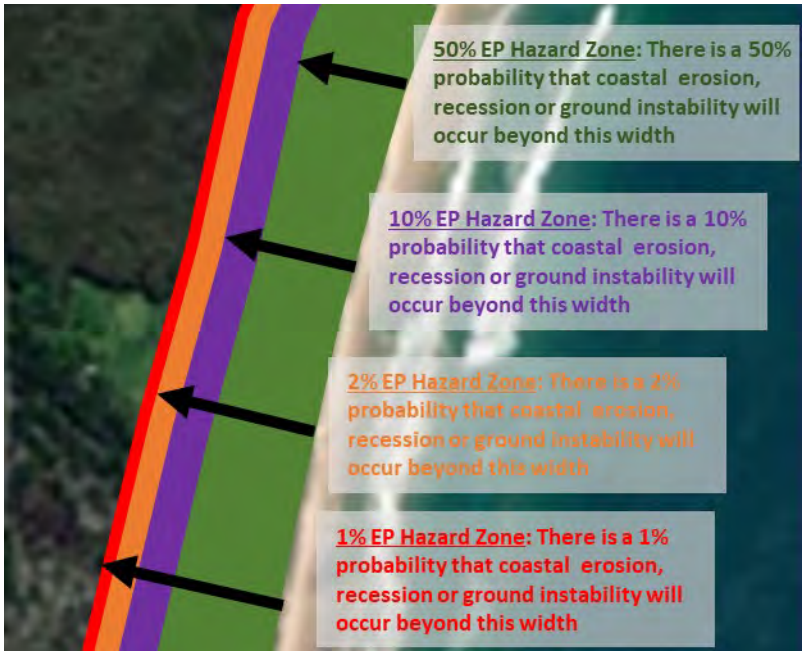


Figure 7: Width of hazard zone (coastal erosion, recession or ground instability) for each event frequency

Future time horizons include allowances for sea level rise. These were presented as two scenarios based on Shared Socio-economic Pathways (SSPs), where SSP2 represents the previous Representative Concentration Pathway (RCP) RCP4.5 and SSP5 represents the previous RCP8.5. The SSPs consider how socio-economic factors may change over the next century including potential changes to population, economic growth, education, urbanisation and the rate of technological development. SSP2 represents a pathway where the world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. It considers intermediate greenhouse gas emissions, with carbon dioxide (CO_2) emissions maintaining current levels until 2050, then falling, but not reaching net zero by 2100. SSP5 represents the highest level of fossil fuel use, food demand, energy use and greenhouse gas emissions. It includes very high greenhouse gas emissions, where CO_2 emissions tripled by 2075. However, it also includes a socio-economic pathway where competitive markets, innovation and participatory societies are able to produce rapid technological progress to achieve sustainable development over the long-term. Further information is available in the Intergovernmental Pael on Climate Change (IPCC) Sixth Assessment Report (IPCC, 2023).

In 2021 CVC commissioned consultants Risk Frontiers (2021) to undertake a climate risk assessment. The highest greenhouse gas scenario is RCP8.5 (SSP5) and represents a worst-case scenario where GHG emissions continue to increase, and global mean temperature increase exceeds 4°C. RCP4.5 (SSP2) is a middle-of-the road GHG emission scenario where some mitigation of GHG emissions occurs, and global mean temperature increase is between 2 - 3ºC. RCP8.5 translates into greater sea level rise compared to RCP4.5. RCP8.5 is currently considered to be less likely whereas RCP4.5 is considered to be a more realistic future scenario. RCP8.5 is a worst-case scenario and is considered to be less likely than RCP4.5. The Risk Frontiers (2021) report was adopted by Council in April 2022.

The coastal hazard scenarios considered in the assessment are shown in Table 3.

Table 3: Coastal hazard assessment scenarios

Hazard	Planning timeframes	Event frequency (AEP)	Event frequency (EP)	Frequency descriptor	Future climate
Tidal inundation (High High Water Solstice Spring, HHWSS)	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	> 1 per year	-	Very Frequent	SSP2 and SSP5
Coastal inundation (extreme sea level)	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	10% AEP	-	Frequent to Rare	SSP2 and SSP5
		2% AEP		Rare	
		1% AEP		Rare to Very Rare	
Beach erosion and shoreline recession	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	-	50% EP	Frequent	SSP2 and SSP5
			10% EP	Frequent to Rare	
			2% EP	Rare	
			1% EP	Rare to Very Rare	

2.6.1 Topographic Surveys

A LiDAR survey was undertaken in Pilot Hill and Convent Beach in February 2022 with slope sections provided at four locations to assist with the assessment of slope instability (Section 2.7). Further detail is provided in FSG (2022) and survey outputs are provided in Appendix 1.

Additional LiDAR survey was undertaken at Brooms Head and Wooli in June 2022 to assist with the assessment of beach erosion and shoreline recession (Section 2.5). Three slope sections are presented for Brooms Head beach with sections selected to capture the main areas of erosion and the rock seawall. Similarly at Wooli beach selected sections are presented where erosion/recession was more evident. Survey outputs are provided in Appendix 1.

2.6.2 Detailed Probabilistic Assessment

The detailed assessment provides information on the likelihood of beach erosion/ shoreline recession over time. The erosion and recession assessment (JBP, 2023 attached in Appendix 3) was undertaken for each planning horizon, event frequency and climate pathway (Table 3) and considered five factors:

- Historic recession rate.
- Future variability in wave climate.
- Potential sea level rise impacts.
- Storm (event-based) erosion.
- Other site-specific geomorphological features.

The future extent of erosion and shoreline recession will depend on the occurrence and severity of storms, future variability in wave climate and impacts due to sea level rise. Each parameter has been applied within a probabilistic framework, which considers the statistical distribution of each factor to account for expected variation within the analysis. The study applies a stochastic simulation to repeatedly and randomly combine these variable parameters to provide consolidated predictions of potential impacts which are mapped for various statistical frequencies (exceedance probabilities).

JBP (2023) provides maps over different time horizons for the potential 'undefended' shoreline erosion zone (i.e. assuming there are no effective protection works). These maps combine the long-term recession rate, variability in offshore waves, sea level rise impacts and an extreme storm (the average rate of recession observed at the site is not used, rather it is a value that is larger than 50%, 90%, 98% or 99% of the combined data). The mapping therefore shows the erosion/ recession that would have occurred without any protection works (including existing works) or underlying bedrock which may inhibit beach erosion. This enables consideration of the effectiveness of existing coastal protection works and bedrock in reducing risks. The potential effectiveness of the coastal protection works and bedrock in minimising the hazards are considered in the risk assessment (Section 6). Further detail and mapping are provided in JBP (2023).

2.6.3 Regional Scale Mapping

For the remainder of the coastline not considered in the detailed assessment of erosion and recession, regional scale mapping is available from spatial data developed by Hanslow *et al.* (2016) derived from a volumetric coastal response model applied with a statistical approach to forecast immediate and future coastal erosion and recession based on the approach by Kinsela *et al.* (2016). The First Pass (Proximity analysis) and Second Pass (Regional-scale modelling) assessments have been completed for the NSW coastline, with the latter moving towards a probabilistic framework. The First Pass assessment used a simple proximity analysis to consider potentially erodible sandy coast featuring properties that may be affected by coastal erosion at present or in the future. This used proximity buffers extending 55, 110 and 220 metres landward from open-coast sandy shorelines. The Second Pass assessment used a sediment-compartment templating approach to characterise the morphology and sediment budgets of NSW beaches. This was applied through a probabilistic framework to consider uncertainty in model inputs. It used a volumetric beach response model, where the long-term erosion was calculated based on a sediment budget imbalance between sources and sinks.

Mapping is available for the 2015, 2050 and 2100 timeframes and 50%, 10%, 1% and 0.1% exceedance levels. The approach is intended to provide a consistent analysis suitable for application to all NSW beaches. Regional scale mapping for the remainder of the Clarence coastline is provided in Appendix 4. The mapping is a broad-scale assessment and does not consider all potential local-scale influences and should not be used to assess erosion risk to individual properties and assets. Detailed assessment for urban areas, where the risk of erosion has been identified for planning purposes is provided in JBP (2023) and discussed above.

DPE is currently in the process of updating this regional scale mapping and any changes to planning layers/ CVA mapping will reflect the latest mapping data available.

2.6.4 Vulnerability to Inundation and Erosion/ Recession

Areas within close proximity to estuary entrances are most vulnerable to inundation with oceanic inundation of lesser concern along the Clarence Valley coastline. Areas vulnerable to inundation are:

- North of Clarence River - Inundation is predicted to impact on the Bundjalung National Park north of the Clarence River with inundation extents increasing over time towards Iluka Road at Shark Bay. More frequent inundation (from the Clarence River) of management trails including Saltwater Inlet management trail and the NPWS depot is expected over the next 20 years. By 2043, inundation from the Clarence River is predicted to impact parts of the Iluka foreshore. These inundation extents originate outside the study area (inland to the west), expanding to the study area over the long term.
- Yamba - Similarly, Hickey Island is vulnerable to inundation at present with inundation extents increasing over time.
- Brooms Head - The village of Brooms Head (south of Lake Cakora entrance) is vulnerable to coastal inundation with inundation extents increasing over time within the northern and eastern boundaries of the residential areas. North of the entrance, inundation may potentially impact Ocean Road and residential areas at present with inundation becoming more frequent over time. By 2073, inundation of large parts of the village north and south of the entrance is expected to be frequent with inundation extents increasing over time.
- Sandon - Periodic inundation is predicted to impact on the campground, access road and surrounding Yuraygir National Park in the current timeframe with extents increasing over time. More frequent inundation of Sandon River Road is expected over the next 20 years. Periodic storm surge from the ocean could extend into the campground areas including the boat ramp and southern campsite areas over the next 20 years. Campsites in the northern section are expected to be periodically inundated by 2073. In Sandon Village, inundation of the Back Trail at the entrance to the village may become more frequent over the next 20 years and properties on the western side of the village may be impacted by inundation by 2123.
- Wooli - Lower lying parts of North Street/ Riverside Drive and South Terrace and nearby residential areas may be periodically impacted by inundation at present with parts of Wooli Road and nearby residential areas also periodically inundated by 2073.

Along the Clarence coastline many beaches are vulnerable to coastal erosion/ recession. Assuming no foreshore protection, the predicted impacts include:

- Shark Bay is expected to recede further within Bundjalung National Park with erosion threatening Iluka Road (near Shark Bay picnic area) in 20 years with rare events (2% EP) and becoming more likely in the longer-term with more frequent events (50% EP in 2073).
- Woody Bay is expected to recede further within Bundjalung National Park with erosion threatening the Woody Head campground access road at present with frequent to rare events (at least 10% EP) with the risk of further recession increasing in future and impacting on additional campground infrastructure. Iluka Road in this area is predicted to be impacted in 20 years with rare events (2% EP) and becoming more likely in the longer-term with more frequent events (50% EP in 2073)
- Whiting Beach is vulnerable to erosion with the car park at risk within 50 years (50% EP) and the whole of the island at risk by 2073.

- Erosion along Pippi Beach is predicted to reach Pacific Parade within 50 years during rare events (2% EP) and more frequent events in the longer-term (2123).
- The shoreline of the Brooms Head foreshore north of the existing seawall is expected to recede further through the campground towards Ocean Road and the bridge with each storm event, threatening Ocean Road and the northern bridge abutment at present in frequent to rare events (at least 10% EP) and more frequent events in future (10% EP in 2043). The residential properties along Ocean Road foreshore are at risk at present with frequent (50% EP) events. Residential properties with Brooms Head along Ocean Road are at risk in 20 years in rare to very rare events (1% EP) and more frequent events by 2073 (2% EP).
- The northern arm of Lake Cakora is predicted to breakthrough to the ocean in a rare event (2% EP) at present and more frequent events (10% EP) in future, potentially receding to Brooms Head Road within 100 years with frequent events (50% EP).
- Sandon beach is vulnerable to erosion with Sandon River Road and the Sandon River campground at risk from rare (2% EP) events at present and more frequent events in future. Coastal erosion may reach the Sandon River within 100 years.
- The north and middle sections of Minnie Water beach are vulnerable to erosion with the surf club at risk at present in frequent to rare (10% EP) events and more frequent events in future. Sandon Road and Banksia Street and residential properties are at risk within 50 years in rare events (2% EP) and more frequent events by 2123.
- Diggers Camp is vulnerable to erosion with Nugget Street at risk at present from frequent to rare (10% EP) events and more frequent events in future.
- Wooli Beach is vulnerable to erosion with Wooli Village at risk from frequent to rare (10% EP) events at present with coastal erosion potentially reaching the Wooli Wooli River within 100 years. The northern section of Wooli is vulnerable to erosion in frequent to rare (10% EP) events within 100 years.

While the hazard mapping shows a threat of erosion along the majority of the coastline, the presence of coastal protection works, underlying or exposed bedrock is expected to mitigate some of the risk. However, there is limited information on the condition and suitability of the coastal protection works and the presence and condition of the coastal protection works cannot be guaranteed across all planning time horizons without appropriate engineering assessments. While fit-for-purpose structures may reduce the erosion/ recession hazard, they may not limit the risk for rare or very rare events as they would be expected to fail depending on their design, or over the longer term, where structures are not maintained/ upgraded to account for sea level rise. Ongoing assessment of these structures, maintenance and adaptation to sea level rise will be required to provide longer-term protection. Similarly, the exact nature of the bedrock requires detailed geotechnical investigation in areas relying on the bedrock to reduce the erosion risk. These areas include:

- Woody Head campground where a seawall has been constructed to the eastern end of Woody Bay. There is no protection provided along Woody Bay and seawall end effects are resulting in increased erosion at the western end of the seawall.
- Whiting Beach adjacent to the Clarence River entrance breakwall where a geotextile sand container wall has been constructed. Sand nourishment campaigns at Whiting Beach (2008 and 2016)

provided short-term restoration of the beach following erosion events and built up the incipient dune to provide protection against future storm events.

- The southern end of Diggers Beach which may be protected by bedrock extending from Diggers Headland.
- The southern end of Minnie Water which may be protected by bedrock extending from the southern headland.
- Brooms Head foreshore where a seawall has been constructed along the southern foreshore of the campground. There is no protection provided along the northern section of the foreshore and seawall end effects are resulting in increased erosion in this section near the Lake Cakora entrance.
- Ocean Road foreshore where coastal protection works have been constructed.
- Sandon Village foreshore where various seawalls have been constructed by private property owners. The eastern part of the village may be protected by bedrock extending from the headland.
- Spooky Beach which may be protected by bedrock extending from Spooky Point and Green Point.

The regional scale mapping indicates the non-urban areas of the coastline (mainly Bundjalung and Yuraygir National Parks including the smaller coastal campgrounds at Black Rocks and Illaroo) are also vulnerable to erosion.

Following an initial assessment, Yamba Main Beach and Convent Beach were not modelled using the probabilistic erosion assessment methodology described in JBP (2023) as the primary coastal hazard at these locations is the stability of high-crested cliffs (discussed in Section 2.7). While beach erosion may occur with sea level rise and/or extreme wave events at the base of the cliffs, there is limited geotechnical information to enable assessment of these hazards. Additional geotechnical assessment is recommended to assess the hazard in these locations.

The impacts and threats of inundation and erosion/ recession individually are exacerbated if combined. This could occur if severe erosion and inundation occurred simultaneously or incrementally over time as recession progresses and inundation heights and frequency increases. The Sandon and Wooli ‘peninsulas’ are threatened by coastal erosion/ recession from the east and from the west by inundation from the estuary. Similarly, Hickey Island is threatened by erosion/recession from the north and inundation from the estuary to the south. Mapping (JBP, 2022; JBP, 2023) indicates that there are locations where erosion risk and inundation risk overlap, where there is a further risk of potentially broader scale, more permanent implications, if the two hazards occur simultaneously. This could result in a ‘break through’ where longer-term or permanent estuary-ocean exchange would occur leading to the complete loss of land and assets within the area.

A less drastic outcome of erosion/ recession combining with inundation is an area or zone of increased intermittent inundation or wave overtopping during coastal storm events. Historic aerial photography of Sandon shows the area where the campground is located was detached from the peninsula from approximately 1942 - 1958 (Figure 8), separated by a low sandy area where water would have intermittently overtopped the dune. It is possible similar conditions could occur again in the future due to the combination of erosion and inundation.

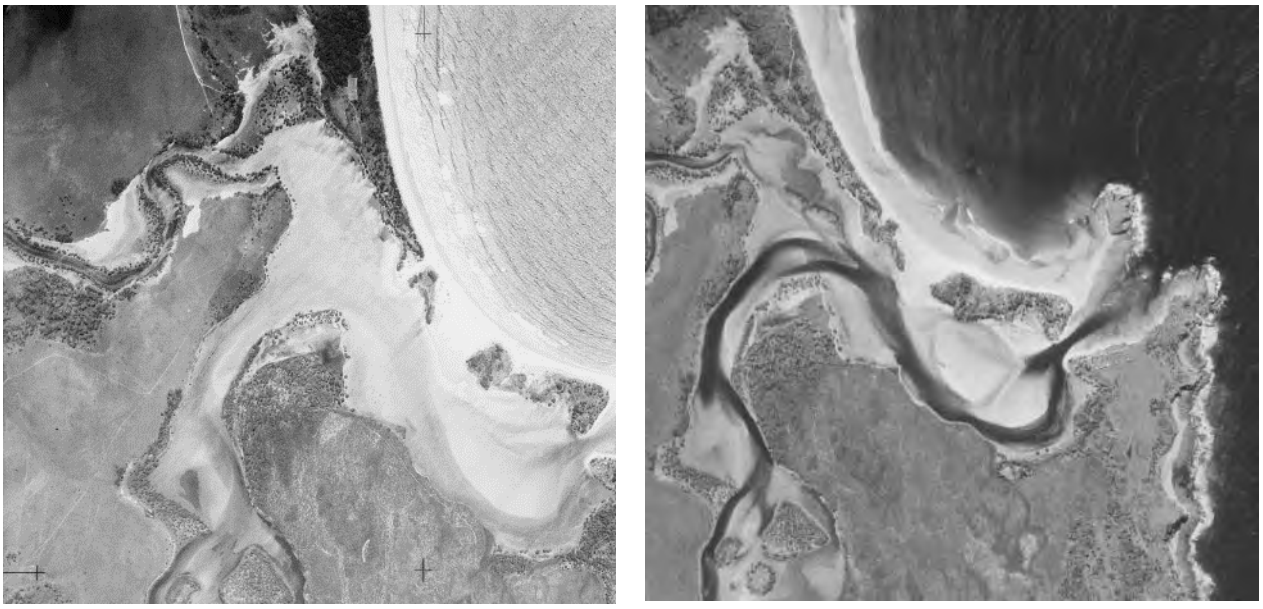


Figure 8: Aerial photography from 1942 (left) and 1958 (right) showing river break-out to the ocean and substantial sand accretion along Sandon Beach and within the river

Source: N. Johnston (left), *Historical Imagery Viewer* Historical Imagery (nsw.gov.au) (right)

2.7 Slope Instability

2.7.1 Background

Geotechnical or slope instability hazard occurs on the headlands and bluffs along the coastline within and separating coastal sediment compartments (sections of the coastline with similar characteristics and processes which share a common sediment resource with clearly defined physical boundaries). The differing degree of instability often relates to the interaction of weathering and erosion processes on different geological formations and rock types along with changes to the types of vegetation on the slope. Geotechnical hazards present risks both to property and to life, such as rock falling from headlands and cliff faces, collapse of unconsolidated materials (such as high dune escarpments), reduced foundation capacity and the collapse of cliffs under houses and development (OEH, 2019a).

The Scoping Study (Hydrosphere Consulting,2021) summarised the existing information relating to slope instability available at that time as:

- Slope instability is the critical issue for the Yamba coastline particularly the areas backing Main Beach and Convent Beach. The majority of the geotechnical landslide hazards in this area result from the effects of coastal actions on the beach and dunes. The exceptions are the risks associated with instability of the moderately steep headland slopes on the northern side of Yamba Point and the potential for rock falls from underneath the path on the southern side of Yamba Point. Slope instability in these areas has been studied both on a broader area basis and site/ development basis.
- Slope instability and associated risks in relation to CVC infrastructure and individuals at Cakora Point (Brooms Head) has been identified including rock falls and tumbling from jointed greywacke, crest fretting causing receding crests and rock falls from overhangs.

Pilot Hill, Pippi Beach and Cakora Point were the areas considered to be at highest risk of slope instability/ landslip in the first-pass risk assessment (Hydrosphere Consulting, 2021). During Stage 2, FSG Geotechnics and Foundations (2022) undertook a desktop study to collate the available information relating to land instability issues for sites located at Pilot Hill and Convent Beach in Yamba and Cakora Point in Brooms Head (attached in Appendix 5) including:

- Analysis of previous hazard assessments and recent available instability monitoring data to provide a contemporary understanding of the instability risk at Pilot Hill and Cakora Point, including:
    - Review of existing geotechnical reports and risk assessments.
    - Review of geological maps.
    - Review of aerial photography and geomorphology.
    - Development of geological and geomorphological models for cliff/slope instability.
    - Review of existing monitoring data including rainfall, groundwater and inclinometer data.
    - Identification of key geotechnical and geological hazards and processes and confirmation landslide risk zones and mechanisms identified in previous reports.
- Identification of potential management options including ongoing monitoring, additional assessment, or remediation:
    - High level review of previous slope risk assessments.
    - Review of existing slope stability management strategies and whether current mitigation measures are adequate and/or whether alternative options can be considered.
    - Recommendations for further studies or investigations.

The information and recommendations from FSG Geotechnics and Foundations (2022) are summarised in the following sections.

2.7.2 Pilot Hill

Infrastructure at Pilot Hill includes the Pacific Hotel, neighbouring buildings along Pilot Street, the Yamba Surf Life Saving Club (SLSC) and vehicle access, zig zag walkway, public and private walkways, Marine Parade and drainage infrastructure. The site is subject to ongoing geological processes and in the long term it is expected that the slope would continue to regress. Any rise in sea level is likely to accelerate this regression, particularly if waves are able to break directly onto the toe of the dune sand slope (FSG Geotechnics and Foundations, 2022).

Based on the site geology at Pilot Hill, slope instability failures would be expected to result from (Figure 9, FSG Geotechnics and Foundations, 2022):

- Minor failure at the toe of the slope which may be caused by localised scour, a tree falling over or other loss of vegetation and/or elevated streaming groundwater and/or retreat of the wave cut platform.
- Material above this minor slip would calve off in small sections in durations of hours to weeks. The failure may also spread laterally from the initiation point.

- The basal plane of failures would comprise the angle of repose for the sand material and is expected to be between 24° and 27°. The failed slope will settle with a batter within this range.

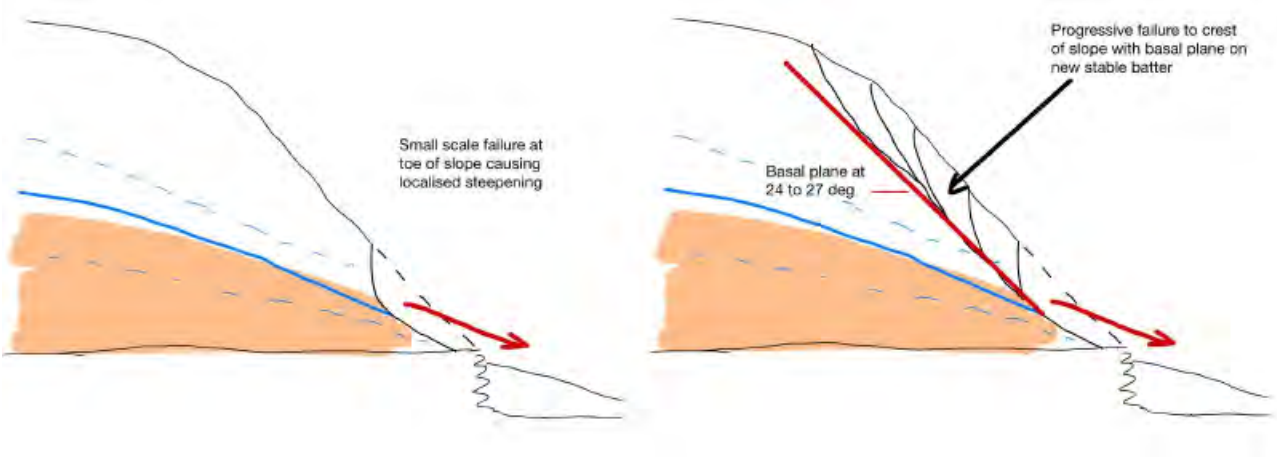


Figure 9: Schematic of expected slope failure for beach facing dunes

Source: FSG Geotechnics and Foundations (2022)

Historical landslide events have been recorded around the Pacific Hotel since May 1921. The Pacific Hotel suffered extensive damage due to a historical landslide in 1950, with additional damage occurring on the slope below the building over the ensuing years. These failures are indicative of the failure modes described in Figure 9.

Previous monitoring, data analysis and investigations at Pilot Hill is documented in FSG Geotechnics and Foundations (2022):

- Rainfall data collection and analysis.
- Instrument monitoring (11 piezometers and 6 inclinometers).
- LiDAR survey (February 2022, Appendix 1).
- Penetrative site investigations (boreholes).
- Numerical modelling - rainfall return period, groundwater modelling, stormwater modelling and slope stability modelling.
- Slope risk assessment.

Analysis of the rainfall data and groundwater levels indicates that groundwater levels were at about peak historical levels when previous landslides had occurred.

In accordance with recommendations from the above assessments, Council currently implements an Emergency Management Plan to respond to the risks associated with rainfall events, which is aimed at identifying possible rainfall conditions that may trigger a landslide event. Rainfall is monitored to identify conditions that may give rise to an emergency as follows:

1. A period of prolonged high rainfall, up to periods of 90 days.
2. A period of high daily rainfall after previous wet periods.
3. High intensity rainfall over short periods of say 1 day or less.

Emergency rainfall warning levels were set up based on analysis of historic rainfall data. Two warning levels are assigned - an Orange Alert Level which was based on a 1 in 3-year rainfall event, and a Red Alert Level which is based on a 1 in 10-year rainfall. The levels are revised based on actual rainfall. At its meeting of 26 April 2022 Council adopted (Resolution 07.22.084) revised “orange” and “red” alert antecedent rainfall levels as recommended in the JK Geotechnics (2021) review of the Interim Emergency Management Plan. The current warning levels are shown in Table 4. The warning levels apply to land within Landslide Risk Zones (LRZ) 1a, 1b, 2 and 3 shown in Figure 10 extending from 2 Pilot Street south to the Pacific Hotel.

Table 4: Rainfall warning levels

Antecedent Rainfall Period (days)	Orange Alert Level (mm)	Red Alert Level (mm)
1	180	200
2	200	280
5	215	325
8	250	370
15	310	425
30	425	560
45	500	675
60	600	800
90	740	955

Source: JK Geotechnics (2021)

Council monitors the rainfall and alerts landowners and occupants if rainfall levels meeting the orange or red levels are experienced or expected. It is the landowners’ responsibility to monitor their premises for any evidence of movement once an alert advice has been notified and based on those observations and their own assessment of their building’s structural design, make their own assessments as to whether further action is necessary. Council also advises emergency service representatives who are responsible for evacuation advice. If the orange or red levels are reached, Council will inspect drainage infrastructure to ensure that it is functioning properly. If the red alert level is reached, Marine Parade will be closed to vehicular traffic, the zig zag path will be closed to pedestrians and the Yamba SLSC will also be closed.

In March 2022 a landslip affected the zig zag walking path located on the slope above the SLSC and extending into the area below the Pacific Hotel affected by historical land sliding. In response to this event, access to the SLSC and Marine Parade, the boardwalk construction and the walking path below the Pacific Hotel was closed for several weeks. The closure was to reduce the risk to the public and allow time for the groundwater levels to dissipate.

Some Pilot Hill landowners have raised concerns at the appropriateness of restrictions imposed by the current landslip hazard management, which date back to the adoption of the *Yamba Coastline Management Study* in 1999, given that Yamba recorded its most significant period of rainfall in 145 years of record in March 2022, with only minor slips occurring. The last formal review of geotechnical risk at Pilot Hill was undertaken in 2018.

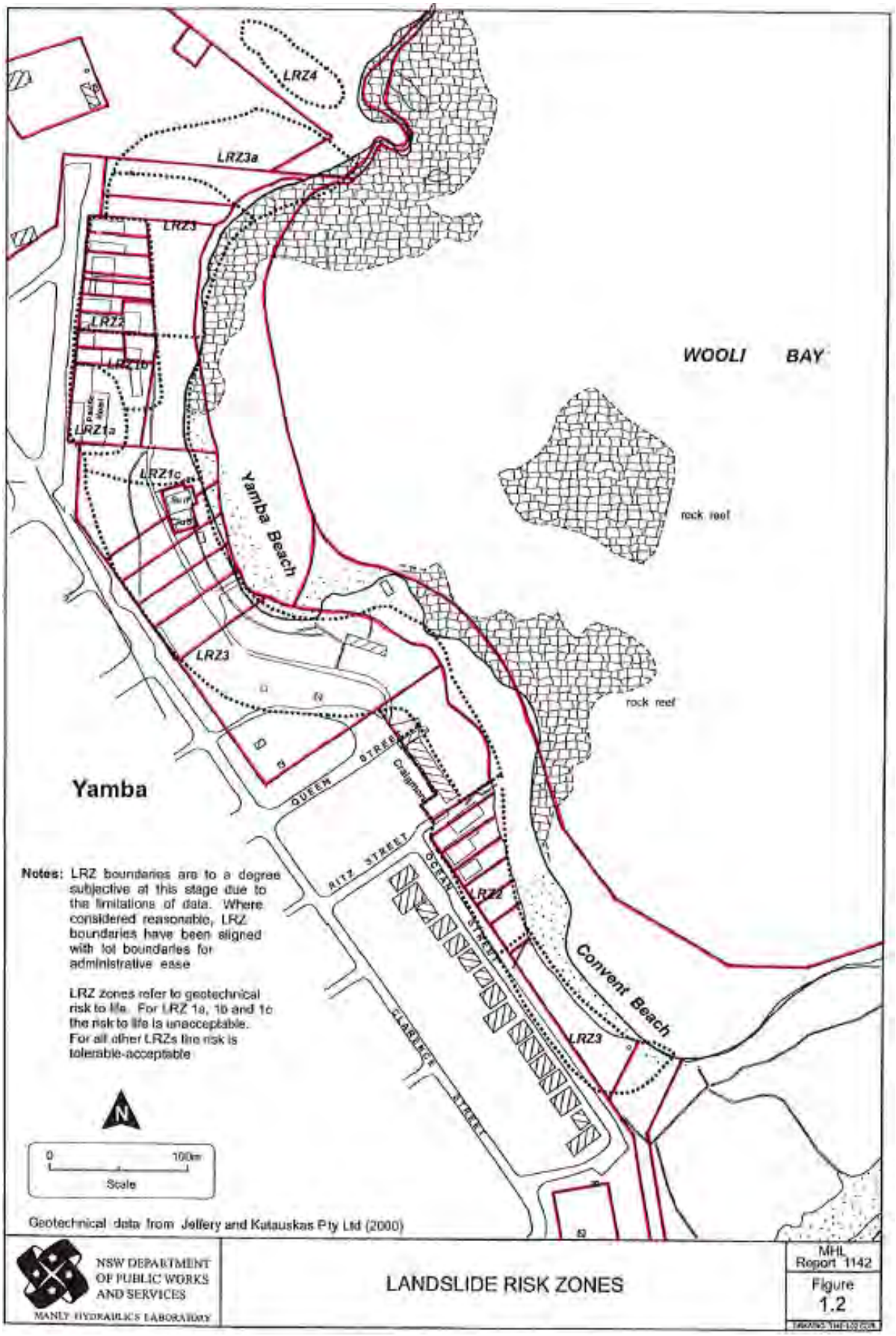


Figure 10: Landslide risk zones subject to emergency levels

Source: CVC (2015)

The ongoing failures or movement that is being observed at Pilot Hill is a combination of superficial scouring and oversteepening due to concentrated stormwater flows, saturation, and failure of the upper sand materials due to perched water tables and slow creep movement of the entire sand dune mass, most likely on the interface with either the silty sand or sandy clay layer. The more recent failures appear to be due to the first two mechanisms. The failure mechanisms are expected to be ongoing, and while the current slope stability management strategy (rainfall monitoring) provides prior warning of slope failures (albeit not in real time), it does not provide resolution for CVC or stakeholders on how the slope can ultimately be stabilised or managed. FSG Geotechnics and Foundations (2022) recommends that the following short term (< 1 year) and long-term (> 1 year) management strategies are weighted equally towards minimising the slope risk and while determining the long-term stabilisation requirements:

- Short-term recommendations (< 1 year) - the focus of the short-term recommendations should be ensuring that the geotechnical information and monitoring data is sufficient and suitable to allow further review of the slope stability analysis and AGS 2007 Risk Assessment. The following is recommended:
    - Emergency management strategy: Continue the existing emergency management strategy involving rainfall monitoring and alerts until other short-term recommendations are completed. Based on the results of the monitoring program review, additional geotechnical investigations, updated slope stability analysis and risk assessment and the status of remediation measures described below, the emergency management strategy (alert levels and application area) should be reviewed and updated to reflect the revised risk information.
    - Review and repair existing instrumentation.
    - Review monitoring program
    - Plan and undertake additional geotechnical investigations.
    - Update slope stability analysis and risk assessment.
    - Undertake short term slope remediation measures to manage stormwater flows.
    - Review landscaping on dunes to improve surface stability.
- Long-term recommendations (> 1 year): Following completion of the short-term recommendations (within 1 year) the following long-term strategies should be considered:
    - Undertake periodic drone photography and LiDAR survey.
    - Review and update planning and development controls.

The recommended short-term options were considered by the CVC Coast and Estuary Management Committee (CEMC) at its meeting of 9 September 2022 and adopted by Council at its subsequent meeting. As over 20 years have elapsed since the Emergency Management Plan was adopted, and as noted above, the most significant rainfall event on record occurred earlier this year, it is considered appropriate that as part of Stage 3 of the CMP development an independent review of geotechnical hazards be undertaken (particularly the short-term recommendations). The short-term recommendations not undertaken in Stage 3 and longer-term recommendations should also be considered as CMP actions.

2.7.3 Convent Beach

Infrastructure at Convent Beach includes houses/ apartments, pathways and Ocean Street. Slope stability failures are expected to result from similar mechanisms as Pilot Hill as described in Section 2.7.2 and Figure 9. JK Geotechnics (2021) noted a large historical landslide occurred in the slope in front of the Craigmore Apartments in 1999 and the entire section of the slope would be subject to ongoing hillside erosion processes that may lead to localised or more significant instability.

No instrumentation, monitoring data or investigation data is available for Convent Beach. The rainfall trigger levels and emergency response at Pilot Hill does not apply to homes along Convent Beach.

FSG Geotechnics and Foundations (2022) recommends the following long-term (> 1 year) management strategies for Convent Beach:

- Drone photography and survey.
- Slope risk assessment.
- Review and update planning and development controls.

These longer-term recommendations should be considered as CMP actions.

2.7.4 Cakora Point

Cakora Point headland is exposed to ongoing geological processes from direct wave attack. This has resulted in the development of an extensive wave cut platform with cliffs and coves through the erosion of the headland. This method of erosion is the result of wave action on the rock that is concentrated on the tidal range resulting in undercutting of the slope which subsequently results in toppling failures and rock falls that develop along natural fractures (FSG Geotechnics and Foundations, 2022). Infrastructure at Cakora Point includes public pathways and a carpark with the nearest private property located 140 m from the headland.

A previous study (SMEC, 2012) reported that previous rockfall events have occurred at the site as evidenced by scree material accumulated at the toe of the slope, but no specific landslide events have been identified. Mechanisms of failure were documented as (SMEC, 2012):

- Mechanism 1 - receding cove: consisted of a cove in the northern part of the headland. Failures comprised rock falls and toppling of blocks from intersecting joint sets in siltstone and sandstone. It was noted that a 3 m high build-up of debris was present at the toe of the slope.
- Mechanism 2 - undermining: consisted of an overhanging slope in the northern part of the site with bedding and orthogonal joint sets resulting in toppling and rock fall events in siltstone and sandstone with failed material present on the beach below. Groundwater seepage appears within the slope and it is postulated that this is caused by rainfall and site drainage.
- Mechanism 3 - crest fretting and block toppling: Weathered siltstone material is fretting away from the crest of the slope aided by informal public access tracks. This slope is mainly siltstone and sandstone with a sandstone wave cut platform at the toe of the slope. Rock falls from blocks and toppling rocks occur from orthogonal joints and the bedding planes, fallen blocks are strewn across the wave cut platform. This mechanism was reported at three locations (refer SMEC, 2012).

No instrumentation, monitoring data or investigation data is available for Cakora Point. A slope risk assessment was undertaken by SMEC (2012). Some recommendations from SMEC (2012) have been implemented including warning signs and walkway barriers. The rainfall trigger levels and emergency response at Pilot Hill does not apply to Cakora Point.

FSG Geotechnics and Foundations (2022) recommends the following long-term (> 1 year) management strategies for Cakora Point:

- Undertake a desktop study using geo-located historical aerial photographs to assess and estimate the rate of slope regression, rock falls, and erosion of scree material at the toe of the slope when exposed to wave action. This will provide a better estimation of the probability of these events.
- Undertake detailed mapping of the site and the creation of a catalogue of specific hazards on the site. Once specific hazards are identified any progression towards failure can be tracked through periodic inspections so that a proactive approach can be made towards management of hazards.
- Undertake regular periodic inspections of the site to assess the progression of any previously identified slope hazards and to identify any new hazards. Inspections should be undertaken on an interval of between 2 and 5 years based on the results of the slope regression analysis. If the slope is regressing quickly with scree rapidly eroded from the toe of the slope then a shorter inspection period would be warranted.
- Undertake drone survey initially 3 monthly and following a peak rainfall event to catalogue changes in the slope geometry and also potentially identify areas that may not be immediately noticeable by manual/visual means. The use of drones with set flight paths and photo locations (with the same orientation) for each flight would allow detailed assessment of the coastal processes and historical rock fall that has occurred between flights. A drone-based survey methodology may need to be developed that captures the undercut areas of the cliff in a repeatable and quantifiable way.
- Revise the slope risk assessment with actual failure rates identified through the regression analysis and site inspections. This may either increase or decrease the consequences of any slope failures.

These longer-term recommendations should be considered as CMP actions.

3. WATER QUALITY

The CMP Scoping Study (Hydrosphere Consulting, 2021) reported the water quality data available at that time. Since the preparation of the CMP Scoping Study, new water quality data has been made available from the NSW DPE estuary health monitoring program including raw water quality datasets (2009 - 2019) and online Estuary Report Cards (2021/22 program). The program monitors and reports on the health of NSW estuaries to assess the condition of estuarine ecosystems and inform management decisions. The available data are discussed for each waterway in the following sections. A review of actions to address issues related to water quality from previous management plans is provided in Section 7.1.

A targeted water quality program to assess identified risks (urban stormwater and wastewater management systems) and progress of management actions should also be considered for implementation. This could include a short -term microbial source tracking program to identify the extent and sources of faecal pollution (e.g. human, dog, cattle, wildlife etc.) and assist in directing management action.

3.1 Wooli Wooli River

The CMP Scoping Study (Hydrosphere Consulting, 2021) reported that the collection of water quality data in the study area has been sporadic, site/ project specific and there has been little or no integration between sampling efforts, or of data storage and analysis. From the limited data available for the Wooli Wooli River, there were some indications of poor water quality in the lower estuary including elevated nutrient levels (total nitrogen, TN and total phosphorous, TP), elevated Chlorophyll *a* and turbidity. Low pH values were identified in the mid and upper estuary sites (WBM, 2006; Ryder *et al.*, 2014). The Scoping Study identified the following potential causes of poor water quality at Wooli:

- Overflow from on-site wastewater management systems.
- Urban stormwater runoff.

The DPE estuary health monitoring program included sampling within the Wooli Wooli River from 2009 - 2019 at a range of sites throughout the estuary, most (90%) of which are upstream of Wooli urban areas (Figure 11).

The most recent sampling in the Wooli Wooli River was completed over the 2021/22 summer when two sites were sampled on a monthly basis. The Wooli Wooli River Estuary Report Card (DPE, 2023a, Figure 12a) showed the condition of the estuary was ‘good’ during the 2021/2022 summer for algae abundance and water clarity with an overall estuary health grade of B (good). Historical water quality results from 2009 - 2019 (Figure 12b) show overall grades of water quality as ‘excellent (A)’ from 2012 to 2016 and ‘good (B)’ in 2009/2010 and 2018/2019. A review of other parameters available as part of the DPE estuary health water quality dataset indicates that pH and nutrient levels (TN and TP) were within guidelines for healthy aquatic ecosystem function for the periods assessed. Dissolved oxygen levels (median value of 84% saturation) were slightly below the recommended guideline level (85% saturation).

The grades indicate that water quality recorded from sites throughout the estuary and predominantly in the mid and upper estuary, upstream of Wooli urban areas has been consistently good throughout the monitoring periods from 2009 - 2021. This is expected of a largely undisturbed catchment area within a National Park. The DPE estuary health water quality program is not considered to have sufficient replication

of sites in proximity to the urban areas of Wooli to adequately assess potential water quality pollution from urban sources (only 6 samples in the lower estuary from 2009 - 2019).

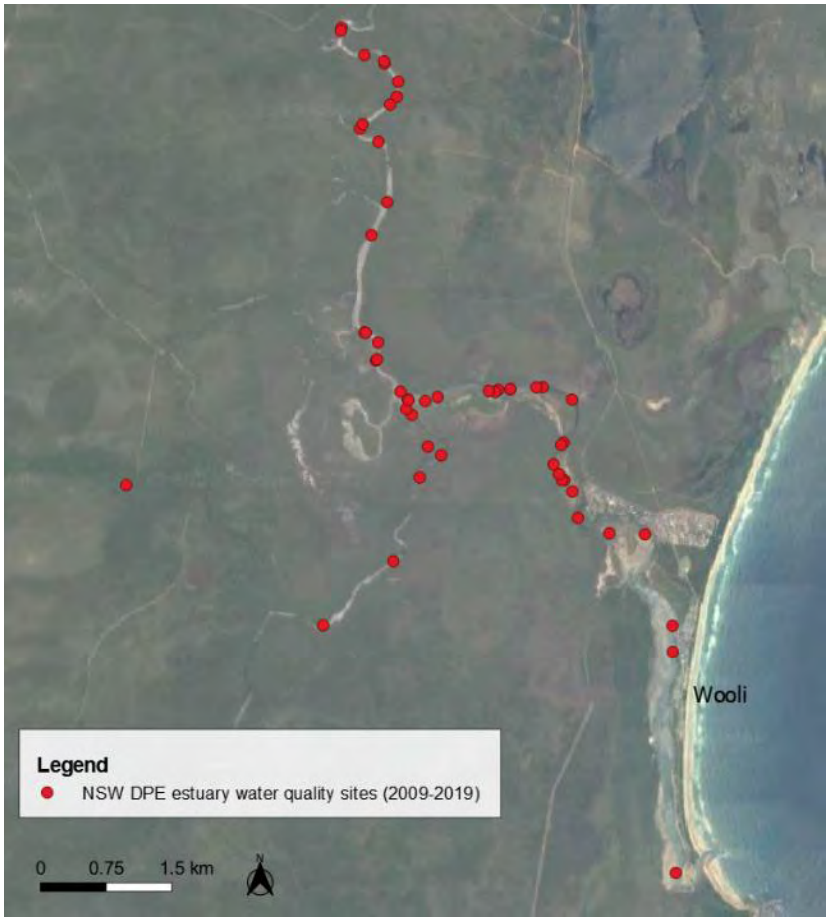
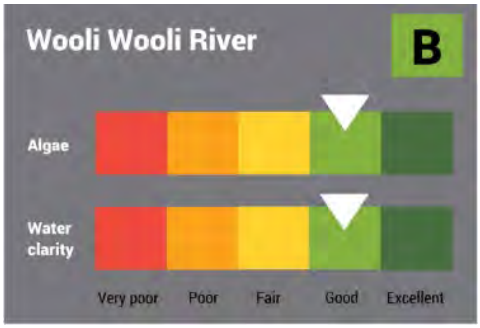


Figure 11: NSW DPE estuary water quality monitoring sites (2009 - 2019) - Wooli Wooli River

Source: Data from SEED (2023a)



Year	Algae	Water clarity	Overall grade
2009–10	B	B	B
2012–13	A	B	A
2015–16	B	A	A
2018–19	B	B	B

Figure 12: Wooli Wooli River estuary: Report card 2021/22 summer (left); Historical grades 2009 - 2019 (right)

Source: DPE (2023a)

3.2 Sandon River

The CMP Scoping Study (Hydrosphere Consulting, 2021) reported water quality conditions for Sandon River from a limited number of studies available from 1997, 1999/2000 and 2010. There were some indications of poor water quality at times including elevated nutrient levels (TN and TP), faecal coliforms and low dissolved oxygen levels. Septic systems were identified as a possible source of poor water quality. Water quality was

not expected to deteriorate further into the future given the relatively natural condition of the majority of the catchment. The Scoping Study identified the following potential causes of poor water quality at Sandon River:

- On-site wastewater management systems (within the village and/or the campground and cottages).
- Urban stormwater runoff.

The DPE estuary health monitoring program included sampling within Sandon River from 2007 - 2022 at a range of sites throughout the estuary, most of which are upstream of potential pollution sources in the lower estuary (e.g. Sandon River campground and Sandon Village, Figure 13).

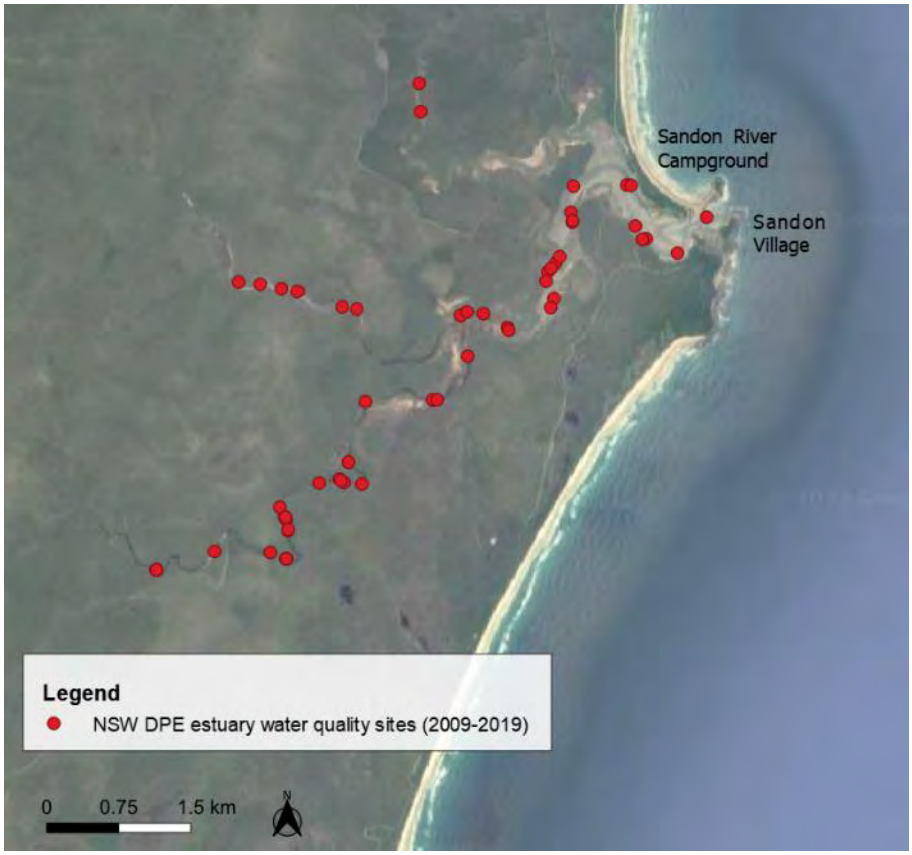


Figure 13: NSW DPE estuary water quality monitoring sites (2009 - 2019)

Source: Data from SEED (2023a)

The most recent sampling in the Sandon River was completed over the 2021/22 summer when two sites were sampled on a monthly basis (Figure 14a). The Sandon River Estuary Report Card (DPE, 2023b) showed the overall condition of the estuary was 'good' during the 2021/2022 summer for algae abundance and water clarity with an overall estuary health grade of B (good).

Historical water quality results from 2007 - 2019 (Figure 14b) show overall grades of water quality as 'excellent (A)' in 2015/2016 and 'good (B)' for all other years assessed. A review of other parameters available as part of the DPE estuary health water quality dataset indicates that pH and nutrient levels (TN and TP) were within guidelines for health aquatic ecosystem function for the periods assessed. Dissolved oxygen levels (median value of 84% saturation) were slightly below the recommended guideline level (85% saturation).

The grades indicate that water quality recorded from sites throughout the estuary has been consistently good or excellent throughout the monitoring periods from 2009 - 2021, except for water clarity in 2012/2013 receiving a 'Fair (C)' grade during this period which coincided with high rainfall. This is expected of a largely undisturbed catchment area within a National Park. The DPE estuary health water quality program is not considered to have sufficient replication of sites in proximity to the potential pollution sources in the lower estuary to adequately assess water quality risk from these areas.

Year	Algae	Water clarity	Overall grade
2007–08	A	B	B
2009–10	B	B	B
2012–13	B	C	B
2015–16	A	B	A
2018–19	B	B	B

Figure 14: Sandon River estuary: Report Card 2021/22 summer (left); Historical grades 2007 - 2019 (right)

Source: DPE (2023b)

3.3 Lake Cakora

The CMP Scoping Study (Hydrosphere Consulting, 2021) reported that the community considers poor water quality to be a significant issue within the lake (CVC, 2009). From the limited data available for Lake Cakora, there were indications of poor water quality in the lagoon including elevated nutrient levels (TN, bioavailable nitrogen and bioavailable phosphorus) (Ryder *et al.,* 2014). Water quality is influenced by catchment runoff, water depth, entrance conditions and the degree of tidal mixing (CVC, 2017). The Scoping Study identified the following potential causes of poor water quality at Lake Cakora:

- Overflow from on-site wastewater management systems exacerbated by intermittent flooding of disposal fields adjacent to the lagoon.
- Urban stormwater runoff.
- Amplification of the effects of poor flushing. When the entrance to Lake Cakora is closed, higher water levels and reduced flushing times leads to poor water quality in the estuary. Entrance management is discussed in Section 2.2.2.

The DPE estuary health monitoring program included sampling within the northern arm of Lake Cakora in 2009/2010 (Figure 15) and again in 2021/2022, although the location of these more recent samples was not documented.

The most recent sampling was completed over the 2021/2022 summer when two sites were sampled on a monthly basis. The Cakora Lagoon Estuary Report Card (DPE, 2023c) showed the condition of the estuary was 'good (B)' during the 2021/2022 summer with algae abundance graded excellent (A), water clarity graded fair (C) and an overall estuary health grade of B (good).

Historical water quality results from 2009/2010 (Figure 16b) show the overall grade for water quality was 'poor (D)' with water clarity graded 'very poor (E)' and algae abundance graded 'fair (C)'. A review of other

parameters available for 2009/2010 as part of the DPE estuary health water quality dataset indicates that TN, Chlorophyll *a* and Turbidity levels all exceeded the recommended guidelines for healthy aquatic ecosystem function.

Figure 15: NSW DPE estuary water quality monitoring sites (2009 - 2010)

Source: Data from SEED (2023)

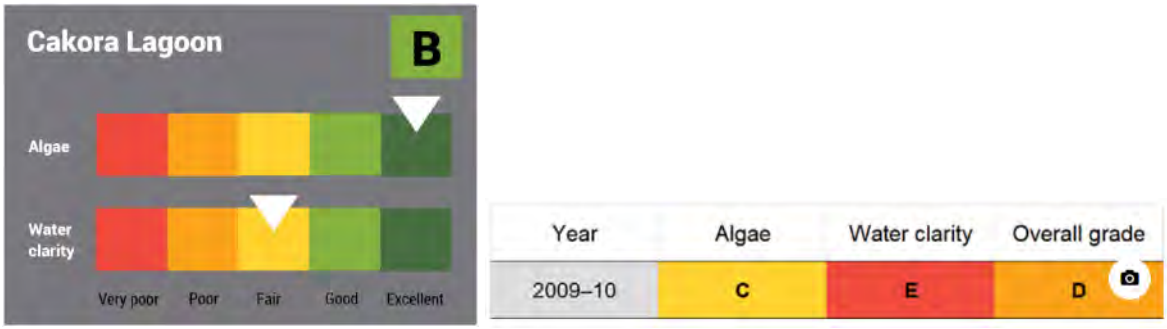


Figure 16: Lake Cakora: Report Card 2021-22 summer (left); Historical grades 2009/2010 (right)

Source: DPE (2023c)

3.4 Lake Arragan and Mara Creek

Lake Arragan and Mara Creek are ICOLLs with untrained and unmanaged entrances. The entire Lake Arragan catchment lies within Yuraygir National Park. The catchment is generally in a natural, vegetated condition with minimal sources of disturbance from fire trails/ access roads and the Lake Arragan National Parks Camping Ground in the lower extent of the estuary near the entrance (Figure 17). The majority of the Mara Creek catchment is also within Yuraygir National Park with some roads and urban residential areas (Angourie) in the north east portion of the catchment. The DPE estuary health monitoring program included sampling within Lake Arragan in 2009/2010, 2012/2013 (Figure 17) and 2021/2022. Sampling was typically

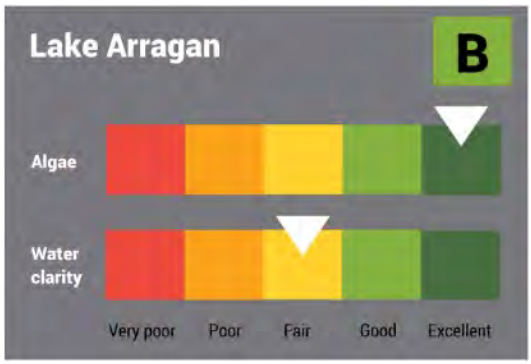
completed over the spring and summer months when two sites were sampled on a monthly basis. Mara Creek has not been sampled by DPE to date.

Figure 17: NSW DPE estuary water quality monitoring sites (2009/2010 and 2012/2013)

Source: Data from SEED (2023a)

The Lake Arragan Estuary Report Card (DPE, 2023d) showed the overall condition of the estuary was 'good (B)' during the 2021/2022 summer with algae abundance graded excellent (A), and water clarity graded fair (C).

Historical water quality results from 2009/2010 and 2012/2013 (Figure 18b) show the overall grade for water quality ranges from 'fair (C)' in 2009/2010 to 'excellent (A)' in 2012/2013. A review of other parameters available for these years as part of the DPE estuary health water quality dataset indicates that TN levels assessed during each sampling event exceeded the recommended guidelines for healthy aquatic ecosystem function, and in some instances was over four times the recommended level. Poor water quality is associated with extended entrance closure.



Year	Algae	Water clarity	Overall grade
2009–10	B	D	C
2012–13	A	A	A

Figure 18: Lake Arragan: Report Card 2021-22 summer (left); Historical grades 2009/2010 and 2012/2013 (right)

Source: DPE (2023d)

Potential causes of poor water quality at Lake Arragan are:

- On-site wastewater management systems (within the campground).
- Amplification of the effects of poor flushing. When the entrance to Lake Arragan is closed, higher water levels and reduced flushing times leads to poor water quality in the lower estuary. Entrance management is discussed in Section 2.2.2.

There is no water quality information available for Mara Creek to assess water quality condition however the following potential sources of pollutants exist in the catchment area:

- Urban stormwater runoff.
- Sewer infrastructure failures (e.g. sewer overflows / discharge to the environment).
- Amplification of the effects of poor flushing. When the entrance to Mara Creek is closed, higher water levels and reduced flushing times may lead to poor water quality in the lower estuary. Entrance management is discussed in Section 2.2.2.

4. CULTURAL HERITAGE

The Clarence Valley coastline is the traditional land of the Yaegl People. Yaegl Country centres around the lower Clarence River extending south along the coastline to Red Rock and north to Black Rocks (Jerusalem Creek).

Prior to European arrival, the Yaegl People occupied the coastline and surrounding areas for thousands of years. Yaegl People have a deep and abiding connection to the lands and waters of their traditional country and attribute particular cultural significance to the waterways, coastline and seas. The coastal areas continue to play a significant role in the daily lives of the Yaegl People, providing an abundance of natural resources for survival, ceremonial rituals and a deep social, cultural and spiritual connection. Numerous significant sites, areas and landscapes are located along the coastline. The estuaries and their forested catchments include ceremonial sites (carved trees, stone arrangements, natural mythological ceremonial sites, initiation grounds and waterholes), extractive sites (stone and ochre quarries, axe grinding grooves and scarred trees), open campsites, middens, fish traps, contact sites, rock shelters and art sites (Hydrosphere Consulting, 2021).

The Yaegl Traditional Owners Aboriginal Corporation (Yaegl TOAC) are the traditional owners and custodians of Yaegl Country which is bordered by Gumbayngirr Country to the south and south-west and Bundjalung country to the north and north-west. The Yaegl people's ongoing use and relationship to country is recognised with the successful Native Title determinations over lands and coastal waters along the coastline:

- NCD2015/002 - Yaegl People #1 - covers the tidal waters within the lower Clarence River estuary, Whiting Beach and Clarence River entrance within the study area.
- NCD2015/003 - Yaegl People #2 - covers areas of Crown land within the lower Clarence Valley from Shark Bay in the north to Wooli in the south including areas of National Park.
- NCD2017/003 - Yaegl People #2 (Part B) - covers the majority of the Clarence Valley coastline. It covers all the land and waters, including the tidal waters, from the mean high-water mark 200 m offshore extending from Wooli Wooli River north to the Shark Bay tombolo.

In 2019, representatives of Yaegl TOAC, the Office of Environment and Heritage (OEH) and CVC signed a memorandum of understanding for a cultural mapping project of the Clarence Valley. The project aims to identify and map known and "high potential" areas of Aboriginal heritage to ensure culturally appropriate information is used to inform conservation and local plans.

The project included cultural heritage management initiatives including assessment of the Aboriginal Heritage Information Management System data and extensive field surveys with nominated cultural representatives to validate and record data. The project aimed to produce 1:25,000 scale topographic maps for the Yaegl Native Title areas, annotated with "known" and "high potential" areas of Aboriginal cultural heritage, within and immediately adjacent to the Clarence Valley LGA. Once complete, a training program was planned for Yaegl site officers, CVC staff and other appropriate agencies.

The Yaegl cultural heritage mapping was originally coordinated by NPWS on behalf of OEH with a working group including representatives of the local Yaegl Aboriginal community, NPWS, CVC and consultants. A change of management of Aboriginal cultural heritage in NSW government agencies resulted in the overall

carriage of responsibility transferred from NPWS to Heritage NSW. Draft cultural mapping has been completed although the project has not progressed since then.

Yaegl representatives provided information on the Yaegl cultural mapping project during consultation for Stage 2 of the CMP. The aim is to develop procedures for database management and use in development/ activity approvals once funding is available to progress this component.

All Crown land is considered to be subject to native title rights unless native title is considered to be extinguished (i.e. through granting of freehold estate, construction of public infrastructure prior to 1996, mining leases etc.). Any activity that impacts on native title is considered to be a 'future act' (specific proposals to deal with land in a way that affects native title and interests) under the *Native Title Act 1993*. Future act activities require a notice to be forwarded to the native title holders' representative body for consultation and feedback. Where actions are proposed on Crown land, consideration of Aboriginal Land Claims lodged under the *Aboriginal Land Rights Act 1983* (NSW) will need to be undertaken. Any works will need to be compliant with the *Native Title Act 1993*.

Indigenous Land Use Agreements (ILUAs) are voluntary agreements between native title holders and other people or bodies about the use and management of areas of land and/or waters and act as a contract between the parties. The Yaegl Interim Licences ILUA (between Yaegl TOAC and the Crown Lands Minister) is registered for all land and waters covered by the above Native Title determination areas (until November 2023). The appropriate mechanisms for protection of Native Title rights in CMP development and implementation will need to be identified and developed.

The outcomes of Stage 2 of the CMP development will be presented to Yaegl TOAC. Any CMP management actions in response to coastal hazards will be determined in consultation with Yaegl TOAC, along with other stakeholders including NPWS.

5. LAND USE AND SOCIO-ECONOMIC CHARACTERISTICS OF THE STUDY AREA

Approximately 80% of land in the study area (12,486 ha out of 15,460 ha) is managed as National Park/ Reserve within Yuraygir National Park, Bundjalung National Park and Iluka Nature Reserve. Virtually the entire Lake Arragan, Lake Cakora, Sandon River and Wooli Wooli River catchments is National Park/ Reserve. Along the coastline, 96% of the coastline north of the Clarence River estuary, 94% of the Yamba-Sandon and 84% of the Sandon-Wooli coastline areas are managed as National Park/ Reserve. The Solitary Islands Marine Park in conjunction with the adjacent Yuraygir National Park, is one of the few areas in Australia, where a full combination of estuaries, beaches, headlands, islands and offshore waters as well as a significant proportion of the catchments of those estuaries are protected. Only 1.7% (262 ha) of the study area is urban or rural residential and grazing is undertaken in 2.4% of the study area.

North of the Clarence River, CVC manages land adjoining Iluka Main Beach including the northern carpark and hind dune area. The northern break wall and adjacent carpark is managed by the Department of Planning and Environment - Crown Lands (DPE - Crown Lands). Iluka Road and associated assets and services are located immediately behind the beach at Shark Bay and the road reserve is managed by CVC. South of the Clarence River, the coastline around Yamba including Whiting Beach is managed by CVC. Green Point, Spooky Beach and the Blue and Green Pools area are also managed by CVC. The majority of Angourie Point is National Park however parking and access to the point is through Council and Crown managed reserves. South of Angourie the majority of the coastline is managed by NPWS except for relatively small areas around each of the villages which are managed by CVC and DPE - Crown Lands (Hydrosphere Consulting, 2021). Land use within the study area is summarised in Figure 19.

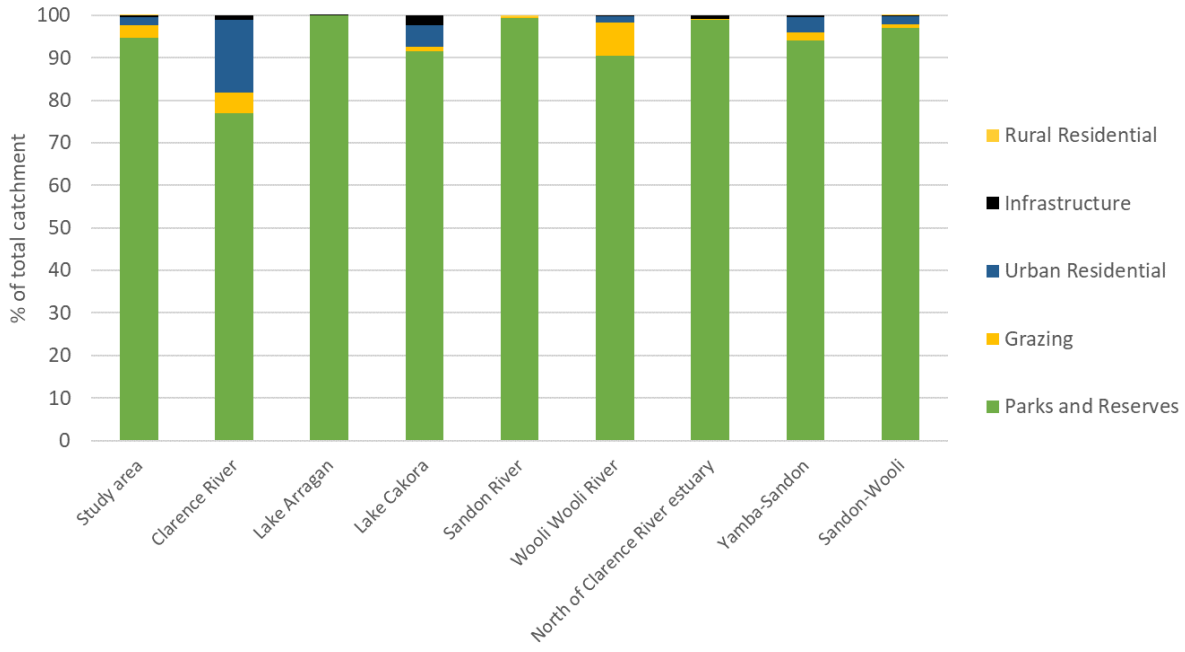


Figure 19: Land use percentages within the study area

Source: DPIE (2020), adapted from Hydrosphere Consulting (2021)

For many community members, interaction with the coast and estuaries is a highly valued part of life. The beaches and waterways provide a place for social interaction, recreation, relaxation, nature appreciation, connection, exercise and commercial activities. The coastal community of Yamba fulfils the local service needs of residents on the coast and visitors. The Clarence Valley has several favourable characteristics

related to economic opportunities in the coastal zone including coastal, riverine and hinterland amenity, arable soils, favourable climate and access to Sydney and Brisbane via the Pacific Highway.

Estuary general fishery activities occur in Sandon River and Wooli Wooli River estuaries. Ocean hauling occurs along the length of the Clarence Valley coastline with the exception of Woody Bay, Turners Beach to Pippi Beach and Angourie Point south to Lake Arragan entrance. The main species targeted in the area is Sea mullet (*M. cephalus)* which are typically targeted between April and September each year. Priority Oyster Aquaculture Areas (POAA) are located in Sandon River (4.5 ha) and Wooli Wooli River (18.3 ha) estuaries (Hydrosphere Consulting, 2021). A regional seaport at Yamba is situated at the mouth of the Clarence River which is one of five internationally recognised ports in NSW. The loading wharf of the Port of Yamba is located on Goodwood Island (outside the study area) however the jurisdictional extent of the Port extends throughout the lower Clarence River estuary including the river entrance and channels in the lower estuary.

The Clarence Valley coastline is a popular tourist destination for activities such as fishing, water sports, whale watching, coastal walks, wildlife appreciation with many camping and accommodation options. Accommodation for visitors includes motels, holiday cottages and caravan parks in the adjoining coastal villages. Within the parks and reserves, Woody Head camping area (Bundjalung National Park) and various small camping areas cater for low-key, short-term camping (Black Rocks camping area in Bundjalung National Park and Station Creek, Pebbly Beach, Sandon River, Illaroo, Boorkoom, Red Cliff and Lake Arragan camping areas in Yuraygir National Park). A range of National Park picnic areas and day walks is also provided in these coastal parks.

Future economic growth areas include tourism, aquaculture, forestry and marine manufacturing. No major housing development has been identified in the study area. Some residential growth is expected to occur in the existing urban growth centres (focused on existing major towns).

The Clarence Valley coastline will experience broadscale climate change impacts as well as interrelated localised impacts into the future due to sea level rise, an increase in extreme rainfall events and storms, increase in estuary water temperature and acidity, increase in fire weather and associated impacts on biodiversity and other values of the coastline and estuaries (Hydrosphere Consulting, 2021). The impacts of climate change have been considered in the coastal hazard assessments and detailed risk assessment.

6. DETAILED RISK ASSESSMENT

6.1 Asset Risk and Exposure

An assessment of risks to Council infrastructure and Council-managed land was prepared for the CMP study area. The assessment considered the location and criticality of assets, the likelihood and extent of beach erosion/ shoreline recession and tidal/ coastal inundation over time and the consequence of the hazards to identify the risk to these assets. The risk assessment methodology and results are provided in Appendix 6.

The predicted impacts to Council assets with the urban areas that are vulnerable to inundation, recession/ erosion and potentially the combined hazards (Section 2.6.4) range from flooding, salt water intrusion, undermining and collapse depending on the type of assets and extent of protection available. The assets at highest risk are:

- Council managed reserves along the coast are vulnerable to erosion, recession and inundation although the majority of impacted areas at present is limited to the beaches and foreshores which are periodically impacted by higher tides and storm surge (e.g. Iluka, Whiting Beach and Brooms Head foreshores).
- Brooms Head sports ground, Brooms Head Reserve west of the village, Sandon Public Reserve along the foreshore of Sandon River, Wooli Coastal Reserve and Wooli Public Recreation Reserve are expected to be periodically impacted by inundation from Lake Cakora, Sandon River and Wooli Wooli River respectively (during at least present day 10% EP scenarios) with inundation extents increasing over time and with higher intensity storm surge.
- In future, the reserves most at risk of inundation are in Whiting Beach, Wooli and Brooms Head. Pathways, roads, carparks and tracks along the foreshores within these areas are expected to be similarly impacted.
- Higher tides and storm surges are expected to enter urban stormwater systems along the coast more frequently in future, particularly in Yamba and Wooli.
- Some Council managed reserves along the coast (e.g. at Hickey Island, Brooms Head, Sandon village) are also vulnerable to erosion/ recession at present with the extents of potentially impacted areas increasing over time and with more severe (rarer) events.
- The Clarence Coastal Zone Parks reserve at Hickey Island is predicted to be completely lost to erosion by 2073 with frequent to rare events and by 2123 with frequent events.
- Large sections of Brooms Head Caravan Park reserve fronting the ocean are predicted to be impacted with frequent to rare events at present and by 2043 with frequent events.
- Water, sewer and stormwater infrastructure, pathways, roads, carparks and tracks along the ocean foreshores are also expected to be impacted.

6.2 Detailed Threat and Risk Assessment

Following the identification of the current threats and issues within the study area, a first - pass (or preliminary) risk assessment and gap analysis were completed as part of Stage 1 to prioritise risks and identify those that should be further investigated in subsequent stages of the CMP. The first-pass risk assessment included the following components with further detail provided in the Scoping Study (Hydrosphere Consulting, 2021):

- Assessment of community uses and values.
- Identification of threats and stressors.
- Analysis of the level of risk presented by those threats. The analysis was separated into geographic areas (e.g. beaches, towns) based on the land tenure, level of risk and knowledge.

The first- pass risk assessment has been updated with new information available from Stage 2. The methodology adopted for the detailed threat and risk assessment is detailed in Appendix 7. The process identifies credible risks, the likelihood of the risk event occurring, the consequences should the event occur and applies a risk rating. For each of the identified threats, the following factors have been considered for each part of the study area:

- How is the threat currently being managed? Have previous management actions addressed this threat?
- How effective are the current management measures and what is the residual risk?
- In the future, how is the risk level likely to change (over 20, 50 and 100 years)? Specifically, how will climate change, increasing development pressures and population growth increase these risks?

The risk assessment outcomes identify the key threats to be addressed in the CMP (Section 12.1).

6.3 Risks to Coastal Wetlands and Littoral Rainforest Areas

Areas mapped as CWLRA (Resilience and Hazards SEPP) within the study area have been assessed against the coastal hazard mapping (inundation and erosion/ recession) from JBP (2022), JBP (2023) and the regional scale mapping (Appendix 4). The littoral rainforest at Iluka Nature Reserve is not located within mapped coastal hazard areas. The following coastal wetland areas are vulnerable to coastal hazards within the next 100 years:

- Coastal wetlands within Bundjalung National Park along Ten Mile Beach
- Coastal wetlands on Hickey Island
- Coastal wetlands within and bordering Yuraygir National Park:
    - Brooms Head north and Lake Cakora entrance
    - Lake Cakora
    - Sandon and Sandon Beach
    - Sandon River
    - Minnie Water Beach
    - Wooli Wooli River

Any erosion extending to the coastal wetland areas is expected to cause die-off of existing freshwater vegetation species and also alter the surrounding local hydrology with increased intrusion of saline water and associated vegetation modifications. Within the estuary areas, future inundation of fringing coastal wetland areas is expected to be more frequent with increasing depth over time, potentially altering the vegetation composition. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, rock walls, retaining walls, altered drainage, urban development, grazing and lawn mowing on the landward side. While the risk to coastal wetlands with coastal hazards is evident, additional investigation into the extent, condition and vulnerability of wetland areas is required as discussed in Section 8.5.2.

7. POTENTIAL MANAGEMENT OPTIONS

A coordinated and consistent approach to strategic planning and an appropriate level of protection of environmental, cultural, built and commercial assets in the coastal zone will ensure adequate protection from coastal hazards, future development pressures and emerging threats associated with a changing climate. Potential management options to address the highest risk threats are discussed in the following sections. In addition, other options will also be developed and assessed in Stage 3 to address the highest risk threats.

7.1 Review of Actions from Previous Management Plans

The coastline management plans prepared by CVC for the study area include:

- *Brooms Head and Lake Cakora Coastal Zone Management Plan* (CVC, 2017).
- Draft *Coastal Zone Management Plan for the Sandon River Estuary* (GHD, 2012).
- Draft *Wooli Beach Coastal Zone Management Plan* (Royal HaskoningDHV, 2018).
- *Wooli Wooli River Estuary Management Plan* (BMT WBM, 2009).
- *Yamba Coastline Management Plan* (MHL, 2003) and *Implementation Strategy* (Maclean Shire Council, 2004).

Related studies include:

- *Options to Manage Recession of Whiting Beach, Yamba* (Royal HaskoningDHV, 2015).
- *Technical Report 3 Risk Assessment and Stabilisation for Pilot Hill Yamba, NSW* (JK Geotechnics, 2017).

Appendix E of the Scoping Study outlined the status of management actions from these management plans in 2021. Since the preparation of the Scoping Study, progress on some actions has been undertaken.

Previous actions that should be considered for inclusion in Stage 3 of the CMP development are listed in Table 5. Some actions from these plans have been progressed as described in the following sections.

Table 5: Actions from previous management plans/ studies that should be considered in Stage 3

Location	Action	Management plan source	Current status	Recommendations for CMP
All beaches	Dune management including fencing, formalise and maintain walking tracks/ pathways, cultural heritage and educational signage	Strategy D - MHL (2003) and Maclean Shire Council (2004), Action 4.1, 4.2, 4.3 - CVC (2017), Strategy MS9 - Royal HaskoningDHV (2018)	Some dune management works have been undertaken with ongoing maintenance. Council is preparing updated plans of management for community land, Crown reserves and other public places addressing issues such as public access and use, protection of biodiversity, maintenance of facilities and infrastructure (Section 8.2).	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.
All beaches	Investigate beach nourishment options and sand sources (e.g. dredging projects)	Strategy E, F - MHL (2003) and Maclean Shire Council (2004), Action 13.2 - CVC (2017), Strategy MS9 - Royal HaskoningDHV (2018), Royal HaskoningDHV (2015)	Dredging opportunities include the Lower Clarence River, including the entrance channels to Iluka and Yamba boat harbours, which is identified as a 'key investment location' in the *NSW Coastal Dredging Strategy* (DPIE, 2019), implemented by Transport for NSW Maritime Infrastructure Delivery Office (MIDO).	Priorities for sand nourishment including potential sources of sand should be identified as a potential coastal protection option for the highest risk beaches identified in the Stage 2 coastal hazard assessment.

Location	Action	Management plan source	Current status	Recommendations for CMP
All areas	Review of planning advice provided on S149 certificates (now called Planning certificates) and planning controls, update LEP with coastal risk mapping and DCP with additional planning controls	Action 5.1, 5.2, 5.3,5.4, 5.5, 8.3, 12.3 - CVC (2017), Strategy MS7 - Royal HaskoningDHV (2018), Strategy C - MHL (2003) and Maclean Shire Council (2004), Action R4 - GHD (2012)	Existing planning controls are discussed in Section 8.1. Recommendations for revised planning controls to address slope instability were provided by FSG Geotechnics and Foundations (2022).	Inclusion of CVA in SEPP mapping or local controls should be considered (Section 8).
All areas	Regular monitoring of beach profile including pre- and post-storms	Action 10.2 - CVC (2017), Strategy MS4 - Royal HaskoningDHV (2018), Royal HaskoningDHV (2015), Action S5 - GHD (2012)	Beach profile data is collected periodically. Topographical surveys were undertaken for some beaches (Section 2.6.1).	Monitoring should continue on a regular basis for areas at risk from coastal storms.
All areas	Emergency response including community education	Strategy B - MHL (2003) and Maclean Shire Council (2004), Action 3.2, 8.1 - CVC (2017), Strategy MS5 - Royal HaskoningDHV (2018)	Council has prepared Emergency Action Subplans for Wooli and Brooms Head/ Lake Cakora (Section 10).	Coastal Zone Emergency Action Subplans (CZEAS) will be developed as part of Stage 3 (Section 10).

Location	Action	Management plan source	Current status	Recommendations for CMP
All areas	Cultural heritage management	Action H1 - GHD (2012), Strategy MS11 - Royal HaskoningDHV (2018)	Three successful native title determinations exist over large parts of the study area (Yaegl People). The Yaegl cultural heritage mapping project has provided draft maps of known and "high potential" areas of Aboriginal heritage to ensure culturally appropriate information is used to inform conservation and local plans (Section 4). CVC is establishing mechanisms for liaison with Native Title holders to ensure council actions are compatible with cultural heritage requirements. Consultation with Native Title representatives is ongoing (Section 11).	Cultural heritage management actions should be developed in consultation with YTOAC within the Native Title areas and Local Aboriginal Land Councils and other Aboriginal Groups in other parts of the study area. This may include finalisation of the cultural heritage mapping project with consideration of coastal hazards, incorporation of cultural heritage management requirements into the design of coastal protection options, development of procedures for development/ activity approvals. The appropriate mechanisms for protection of Native Title rights in CMP development and implementation will need to be identified and developed.
Yamba - Pilot Hill	Additional investigation of slope instability and potential stabilisation actions	Strategy A - MHL (2003) and Maclean Shire Council (2004), JK Geotechnics (2017)	Recommendations for additional investigations were provided by FSG Geotechnics and Foundations (2022).	Short-term recommendations from FSG Geotechnics and Foundations (2022) for Pilot Hill will be undertaken during Stage 3 or as CMP actions. Other recommendations should be considered as CMP actions.
Yamba - Pilot Hill, Wooli	Advise energy and communications utilities of coastal hazards to enable ongoing utilities management	MHL (2003) and Maclean Shire Council (2004), Strategy MS8 - Royal HaskoningDHV (2018)	No progress.	Ongoing consultation is recommended.

Location	Action	Management plan source	Current status	Recommendations for CMP
Yamba - Main Beach	Investigate options for relocation of Yamba SLSC	Strategy B - MHL (2003) and Maclean Shire Council (2004)	Yamba SLSC has prepared plans for a surf club at Turners Beach.	Additional slope stability investigations being undertaken will provide more information on slope instability risks in the Main Beach precinct. Replacement of the seawall and/ or relocation of the SLSC should be considered. Ongoing consultation with the SLSC is recommended.
Yamba - Main Beach	Maintenance of sea wall	Strategy B - MHL (2003) and Maclean Shire Council (2004)	A concept design has been prepared for replacement of the seawall (Section 7.4). Significant expenditure may not be warranted if the Yamba SLSC is relocated.	Additional slope stability investigations being undertaken will provide more information on slope instability risks in this precinct. Replacement of the seawall and/ or relocation of the SLSC should be considered.
Yamba - Main Beach	Master Plan project planned for Yamba Main Beach, plan to consider improved access and seek funding to complete improvements	Strategy D - MHL (2003) and Maclean Shire Council (2004)	Council is preparing updated plans of management for community land, Crown reserves and other public places addressing issues such as public access and use, protection of biodiversity, maintenance of facilities and infrastructure.	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.
Clarence River entrance	Improved access arrangements including disabled access along breakwaters and safety fencing	MHL (2003) and Maclean Shire Council (2004)	Some access management works have been undertaken.	Potential CMP actions should consider the recommendations for multi-use and eco features identified in the DPI - Fisheries breakwater audit (Section 7.7.3 and Appendix 8).

Location	Action	Management plan source	Current status	Recommendations for CMP
Brooms Head	Extension of foreshore revetment, provision of access to northern foreshore reserve	Action 2.1, 9.5 - CVC (2017)	A concept design for extension of the revetment has been prepared (Section 7.3).	Physical modelling of the proposed revetment extension is being undertaken during Stage 3/4. The outcomes of this work should be considered in the assessment of potential coastal protection works.
Brooms Head	Retention of existing Ocean Road revetment	Action 2.3 - CVC (2017)	No change. The coastal hazard assessments indicate that the Ocean Road foreshore is vulnerable to inundation and erosion.	Planning controls and coastal management actions should consider the outcomes of the coastal hazard assessments.
Brooms Head	Monitoring of revetment wall condition pre- and post-storms and maintenance of existing foreshore reserve revetment	Action 2.2, 10.1 - CVC (2017)	No progress. The coastal hazard assessments indicate that the rock revetment is providing protection to the foreshore reserve from coastal erosion, although end effect erosion has occurred at the northern end.	Ongoing assessment of coastal protection structures, maintenance and adaptation to sea level rise will be required to provide longer-term protection.
Brooms Head	Review/ maintain beach access ways	Action 9.2 - CVC (2017)	Some access management works have been undertaken. The concept design for the extension of the rock revetment includes pedestrian access to the beach (Section 7.3). Council is preparing an updated plan of management for the foreshore reserve addressing issues such as public access and use, protection of biodiversity, maintenance of facilities and infrastructure.	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.

Location	Action	Management plan source	Current status	Recommendations for CMP
Brooms Head	Maintain track markers along Yuraygir coastal walk	Action 9.6 - CVC (2017)	Recreational actions are consistent with the NPWS Plans of Management (Section 9).	Improvements to existing recreational features should be considered.
Brooms Head	Improve compliance/ enforce penalties for unauthorised vehicle access around Lake Cakora	Action 11.1 - CVC (2017)	Council has adopted a policy regarding beach access and vehicles on beaches.	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.
Brooms Head	Public facilities management, relocation or reconstruction in accordance with coastal risk	Action 12.1 - CVC (2017)	Some campsites were removed following 2022 coastal storms. Council is preparing an updated plan of management for the foreshore reserve addressing issues such as public access and use, protection of biodiversity, maintenance of facilities and infrastructure.	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.
Brooms Head	Periodically remove debris (kelp & other) from beach and lagoon area to reduce odour, impact on beach amenity and maintain public safety.	Action 13.1 - CVC (2017)	The accumulation of beach-cast seaweed on beaches is a natural process and plays an important role in a beach ecosystem. Beach-cast seaweed provides food and habitat for a wide range of fauna species and plays an important role in the cycling of nutrients on beaches. The deposition of large amounts of seaweed can also play a role in stabilising beaches by promoting the accretion of sand.	The majority of the material either disappears naturally, decomposes, dries out, or is moved by wave/currents or covered by sand therefore removal is not usually cost-effective. Community preference for active management of beach debris should be considered in the CMP.

Location	Action	Management plan source	Current status	Recommendations for CMP
Brooms Head, Wooli	Beach scraping to restore beach access following storms	Action 9.2 - CVC (2017), Strategy MS10 - Royal HaskoningDHV (2018)	Recontouring of beach is undertaken. Trial beach scraping has been undertaken at Wooli. CVC is planning to undertake another round of beach scraping when conditions are appropriate.	Access restoration should be considered as part of emergency planning (CZEAS).
Lake Cakora	Upgrade beach access/ pedestrian access bridge east of prawn farm site	Action 9.3 - CVC (2017)	No progress	Potential CMP actions should consider the coastal hazards in prioritisation of future works including the potential for inundation and erosion over the longer term.
Lake Cakora entrance	Maintain, replace and improve foreshore facilities	Action 12.2 - CVC (2017)	Foreshore facilities include the boat ramp, fish cleaning tables, picnic and recreation facilities. Council is preparing an updated plan of management for the foreshore reserve addressing issues such as public access and use, protection of biodiversity, maintenance of facilities and infrastructure.	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.
Lake Cakora entrance	Implement artificial breakout for recreational purposes	Action 7.1 - CVC (2017)	There is no formal entrance management policy for the entrance however anecdotally, members of the public informally open the entrance periodically when the water level is perceived to be too high within the lake or the water quality is perceived to be poor (Hydrosphere Consulting, 2021).	It is recommended that an entrance management strategy is developed based on best-practice management of ICOLLs that protects the environmental values of Lake Cakora.

Location	Action	Management plan source	Current status	Recommendations for CMP
Lake Cakora entrance	Maintain current access to Ocean Road reserve adjacent to northern bridge abutment.	Action 9.4 - CVC (2017)	The reserve is accessible from the bridge.	Potential CMP actions should consider the coastal hazards in prioritisation of future works including the potential for inundation and erosion over the longer term.
Cakora Point	Slope instability investigations and access management	Action 9.1 - CVC (2017)	Recommendations for additional investigations were provided by FSG Geotechnics and Foundations (2022)	The FSG Geotechnics and Foundations (2022) recommendations should be considered as CMP actions.
Sandon River estuary	Address entrance erosion	Action S2 - GHD (2012)	Informal coastal protection works have been undertaken at the Sandon campground and Sandon Village. A section of Sandon River Road along the estuary has been armoured with rock revetment to prevent further bank erosion. NPWS has prepared a coastal hazard response plan for the campground (Section 9.1)	Recommended actions from the coastal hazard response plan should be considered. Planning controls and coastal management actions should consider the outcomes of the coastal hazard assessments.
Sandon River estuary	Management of domestic and feral animals	Action E4 - GHD (2012)	Management of domestic and feral animals is consistent with NPWS Plans of Management (Section 9) and Marine Park regulations.	Existing regulations and enforcement to address illegal activities. are considered to be appropriate.
Sandon River estuary	Litter/ rubbish control	Action E5 - GHD (2012)	Litter/ rubbish control is consistent with NPWS Plans of Management (Section 9) and Marine Park regulations.	Existing regulations and enforcement to address illegal activities. are considered to be appropriate.
Sandon River estuary	Investigation and management of landfill contamination (Sandon Village)	Action E9 - GHD (2012)	There is no data available on the location, composition or impacts of these landfills.	Estuary water quality monitoring targeting contaminants of concern should be considered (Section 3).

Location	Action	Management plan source	Current status	Recommendations for CMP
Sandon River estuary	Management of development in campground	Action R4 - GHD (2012)	NPWS has prepared a coastal hazard response plan for the campground (Section 9.1).	Recommended actions from the coastal hazard response plan should be considered.
Sandon River estuary, Wooli Wooli River Estuary	Water quality monitoring	Action E6, R1 - GHD (2012), Action WQ-5 - BMT WBM (2009)	Some water quality data are available (Section 3). No ongoing water quality undertaken by CVC or DPI – Marine Parks. Some sites within the estuary were included in the Ecohealth program (Section 3).	A targeted water quality assessment to assess identified risks (urban stormwater and wastewater management systems) and progress of management actions should also be considered for implementation. This could include a short -term microbial source tracking program to identify the extent and sources of faecal pollution (e.g. human, dog, cattle, wildlife etc.) and assist in directing management action.
Sandon River estuary, Wooli Wooli River Estuary	Stormwater management	Action E8 - GHD (2012), Action WQ-1 - BMT WBM (2009)	Stormwater discharges from all urban areas within the study area with minimal treatment. Some water quality data are available (Section 3).	
Sandon River estuary, Wooli Wooli River Estuary	Education/ promotion/ signage/ materials	Action E3, S3 - GHD (2012), Action C-1, E-1, E-2, W-4 - BMT WBM (2009)	Community education is consistent with NPWS Plans of Management (Section 9) and Marine Park regulations.	Ongoing community education actions should be considered.
Wooli Wooli River Estuary	Review of Solitary Islands Marine Park (SIMP) zoning	Action W1 - BMT WBM (2009)	Ongoing review by DPI - Marine Parks.	Ongoing review of SIMP zoning with consideration of water quality data, community feedback and coastal hazard assessments is recommended.

Location	Action	Management plan source	Current status	Recommendations for CMP
Wooli Wooli River Estuary	Monitoring of bank recession, riparian vegetation management, planning controls and river access management, Protection of public infrastructure from bank erosion	Action F-1, F-2, F-3, F-4 - BMT WBM (2009)	Erosion “hot spots” were identified in 2006. Bank erosion has been attributed to removal of riparian vegetation combined with tidal and flood flows or boat wake and wind waves (Hydrosphere Consulting, 2021).	A bank condition assessment should be considered. Recommendations for erosion controls should be considered for inclusion in the CMP.
Wooli Wooli River Estuary	Aquatic and terrestrial habitat identification and protection	Action C-2 - BMT WBM (2009)	Contemporary terrestrial and aquatic vegetation mapping is now available.	A review of CWLRA mapping (Section 8.5.2), actions to support estuarine vegetation migration with climate change (Section 7.7.1) and other vegetation protection actions should be considered.
Wooli Wooli River Estuary	Prepare emergency action plan for spills	Action WQ-4 - BMT WBM (2009)	Addressed through Council and NSW Government hazardous material management plans.	Not required in CMP.
Wooli Wooli River Estuary	Dredging of navigation channels	Action W-6 - BMT WBM (2009)	Sand build-up and entrance condition/safety was also raised as an issue for the Wooli Wooli River in BMT WBM (2009) and in the community survey for the scoping study (Hydrosphere Consulting, 2021). The Wooli Wooli estuary is not identified as key investment location’ in the *NSW Coastal Dredging Strategy* (DPIE, 2019, Section 7.6).	Dredging for navigation improvements should be considered.
Wooli Beach	Beach nourishment scheme	Strategy MS1, MS2 - Royal HaskoningDHV (2018)	The Wooli Beach Management Strategy has been developed (Section 7.2).	Ongoing implementation of the Beach Management Strategy should be considered.

Location	Action	Management plan source	Current status	Recommendations for CMP
Wooli Beach	Management of vehicular and pedestrian access to beach	Strategy MS10 - Royal HaskoningDHV (2018)	Council is preparing updated plans of management for community land, Crown reserves and other public places addressing issues such as public access and use, protection of biodiversity, maintenance of facilities and infrastructure.	Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.
Wooli Beach	If Beach nourishment scheme is unsuccessful, investigate alternative coastal protection works	Strategy MS13 - Royal HaskoningDHV (2018)	No progress.	Alternative coastal protection works should be considered and compared to the Wooli Beach Management Strategy.
Whiting Beach	Raise elevation of the north-western end of the track at Hickey Island to reduce the risk of oceanic inundation	Royal HaskoningDHV (2015)	The coastal hazard assessments indicate that large parts of Hickey Island are vulnerable to inundation.	Options to manage or adapt to inundation should be considered.

7.2 Wooli Beach Management Strategy

To address coastal instability at the village of Wooli and the significant risk from storm erosion and longer-term recession, the draft *Wooli Beach Coastal Zone Management Plan* (CZMP, Royal HaskoningDHV, 2018) proposed the placement of 60,000 m^3 of sand on the beach adjacent to Wooli Village to offset forecast recession (estimated to be 4 m^3/m/year above mean sea level (MSL)) over the subsequent five years. The beach nourishment scheme in the CZMP was proposed to include sand back-passing (the process of transporting sand from a downdrift location to an updrift location) from the northern end of Wooli Beach and supplementary beach scraping (cross-shore movement of small to medium quantities of sand, generally from the intertidal zone to the upper beach and dune by mechanical means) as the primary mechanisms to mitigate current risks to built assets.

A trial beach scraping (two campaigns) was undertaken at Wooli Beach in March - May 2019 involving redistribution of approximately 13,500 m^3 (15-17 m^3/m) of sand from the intertidal zone. The first campaign was undertaken over a length of approximately 800 m in front of the southern portion of Wooli Village and the sand was placed over the incipient dune modifying the existing dune feature. The second campaign was undertaken over the southern 500 m of Wooli Village (i.e. the southern 500 m was scraped twice). Following completion of the scraping, an incipient dune profile was formed. Dune catch fencing and dune revegetation was also undertaken. The purpose of these campaigns was to build sand reserves in front of Wooli Village to reduce current erosion and recession risk and inform future sand scraping campaigns and development of a beach management strategy (BMS) to offset future erosion and recession hazards (Royal HaskoningDHV, 2021a).

A BMS has been developed for Wooli Beach comprising sand back-passing and beach scraping, vegetation management and ongoing monitoring (Royal HaskoningDHV, 2021a). The sand management plan includes a number of scenarios, depending on the beach state when the management activities are undertaken. Implementation of the BMS would be subject to Council endorsement, relevant permits and available funding.

The sand management strategy at Wooli aims to:

- Ensure sufficient sand remains available to reduce risks to public and private assets from storm erosion (from potentially up to 50-year ARI storm event based on erosion assessments undertaken by Royal HaskoningDHV (2021a).
- To ‘hold the line’ and offset long term recession.

The annual volume of sediment required for nourishment (based on the updated long-term average rate of recession of approximately 2 m^3/m/year above MSL) is 2,040 m^3 above MSL for the southern portion of Wooli Village which was deemed to be most exposed to storm erosion (Royal HaskoningDHV, 2018, Figure 20, 800m between chainage 1,350 m and chainage 2,150 m where chainage is measured from the breakwater at the southern end of Wooli Beach). Including the northern portion of Wooli Village to chainage 3,950 m (additional 1,600 m) would require an additional 2,040 m^3 of sediment (Royal HaskoningDHV, 2021a). The total volume of material required to ‘hold the line’ is the annual volume of sediment for nourishment multiplied by the time between nourishment campaigns in years. However Royal HaskoningDHV (2021a) recommends that significantly larger volumes of sand should be targeted to assist in providing a buffer to offset storm erosion.

Figure 20: Wooli Village property protection area

Source: Royal HaskoningDHV (2021a)

The preferred sand source at Wooli Beach is sand from the northern end of the beach, near Wilsons Headland as net northerly longshore sediment transport results in the accumulation of sand at the northern end of Wooli Beach. Royal HaskoningDHV (2021a) recommends that sand back-passing is only undertaken for emergency sand nourishment of Wooli Village for the following reasons:

1. Moving sand from one end of the beach to the other typically creates a planform that is in disequilibrium. The benefit of the sand movement and beach nourishment may be short lived. Longevity can be increased by placing the sand further landward, where it would not be mobilised by longshore drift processes.

2. Interannual beach rotation is observed at Wooli Beach. It is therefore preferred to let nature move sand from one end of the beach to the other, and then undertake beach scraping activities to move the sand further landward. This option would be significantly cheaper than sand back-passing.

Emergency sand nourishment was only recommended when there is an urgent need to bolster dune volumes adjacent to Wooli Village and there are limited sand reserves available at the southern (i.e. village) end of the beach. Some of the sand from the borrow zone at the northern end of the beach would otherwise be lost (northwards) out of the compartment (Royal HaskoningDHV, 2021a).

The BMS includes:

1. Frequent beach scraping directly in front of the village, preferably in late Autumn (April and May) with a focus on establishing/ building an incipient dune. If an incipient dune is present, of a suitable volume and vegetated, the sand should be placed seaward of the incipient dune to create a wide subaerial beach and encourage natural dune building processes (Figure 21).
2. Sand back-passing as required following a large storm event. As much sand as practical should be harvested from the northern end of Wooli Beach and placed near Wooli Village (Figure 21).

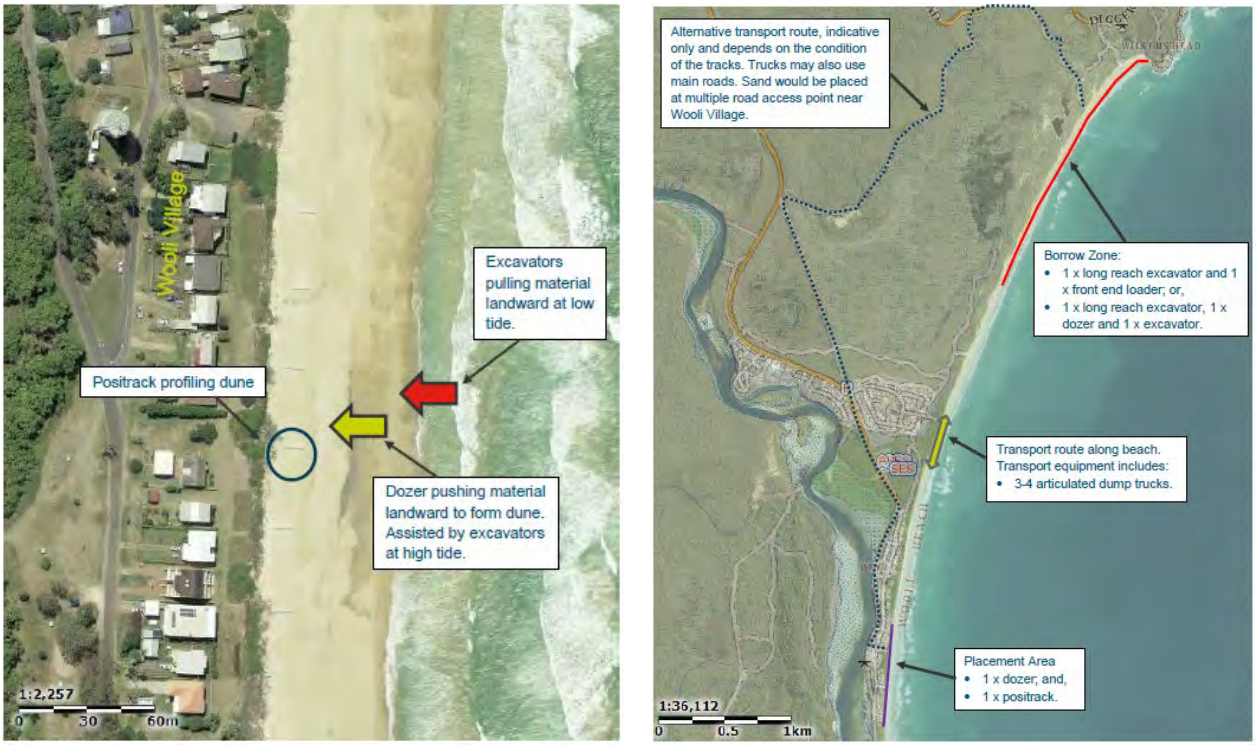


Figure 21: Beach scraping and sand back-passing at Wooli Beach

Source: Royal HaskoningDHV (2021a)

Due to uncertainties around the beach profile at the proposed time of sand management, three theoretical beach profiles (at the commencement of beach nourishment activities) were presented by Royal HaskoningDHV (2021a) as shown in Table 6 and Figure 22 to Figure 24. Dune management would be undertaken to create a natural and stable incipient profile, vegetated with native communities but would not be required for beach nourishment activities, depending on the profile at the time of the nourishment.

Table 6: Wooli Beach sand placement scenarios

Scenario	Volume of sand seaward of properties (m^3/m above MSL)[1]	Sand placement objectives	Placement profile	Sand source	Placed volume (m^3/m)	Revegetation requirements	Volume of sand seaward of properties after sand placement (m^3/m above MSL)[1]
1 - Following significant storm erosion event (a depleted beach, similar to the profile in 2006)	~110	Reinstate sand reserves with largest practical quantity of sand. Placement slope 1V:15H	Dune	Back-passing and beach scraping if suitable sand reserves are available for scraping activities	17	Nil - insufficient quantity of sand to establish incipient dune	~127
2 - Incipient dune crest <3.5m AHD and berm at 2.5m AHD (associated with initial beach recovery following an extreme storm event)	~190	Establish/rebuild incipient dune with a crest at or higher than 3.5m AHD and width of 2m. Placement slope 1V:12H.	Dune	Beach scraping	~13	Vegetate incipient dune	~200
3 - Incipient dune >3.5 mAHD and berm at 2.5 mAHD (could be associated with a number of events, including beach recovery, minor storm erosion or the post-nourishment dune profile after Scenario 2)	~200	Place sand seaward of incipient dune and above mean runup at MHW (1.65m AHD). Placement slope 1V:12H.	Dune and berm	Beach scraping	~13	Nil - placed sand to naturally nourish dune and berm	~210

1. Volume calculations assume properties are offset 12m from the crest of the foredune.

2. The beach scraping borrow zone extends above and below MSL. The volume of material scraped and placed does not directly translate to an increase in the volume of sand above MSL. However, the scraped zone would recover over time and the increase in sand reserves above MSL would be greater than the quantity of sand scraped below MSL.

Source: Royal HaskoningDHV (2021a).

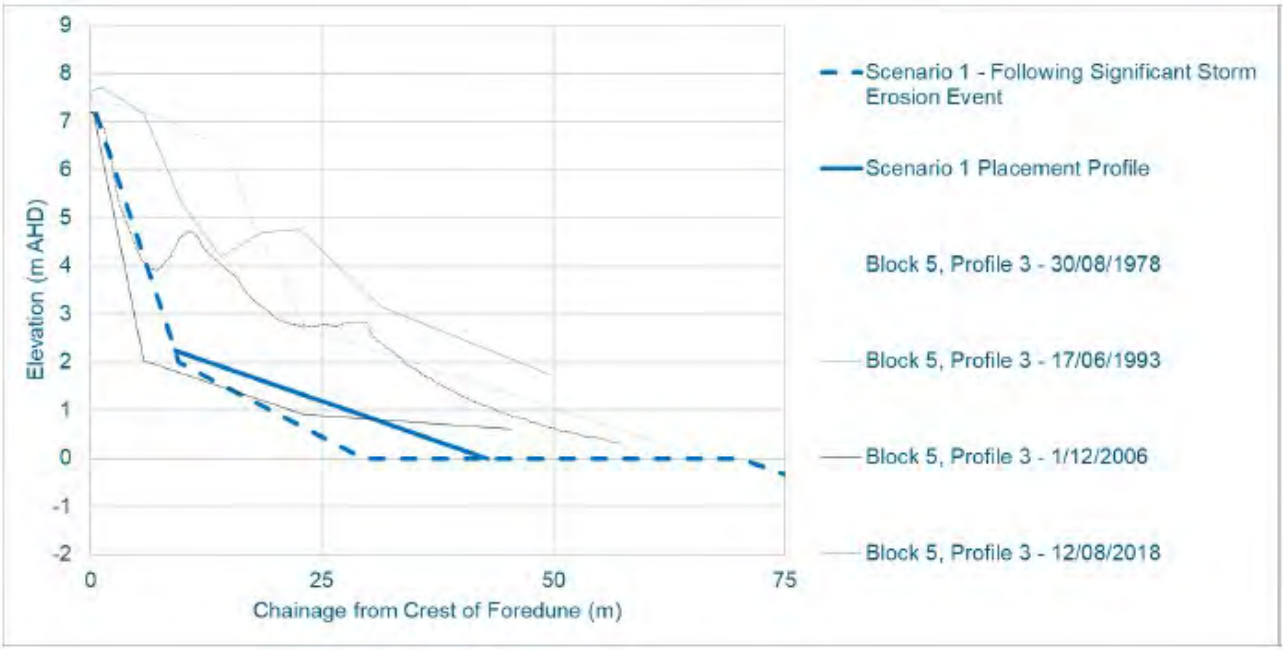


Figure 22: Typical historical photogrammetry profiles and Scenario 1 sand placement profile

Block 5, Profile 3 is located at the southern end of Wooli Village where the properties are located close to the crest of the foredune

Source: Royal HaskoningDHV (2021a).

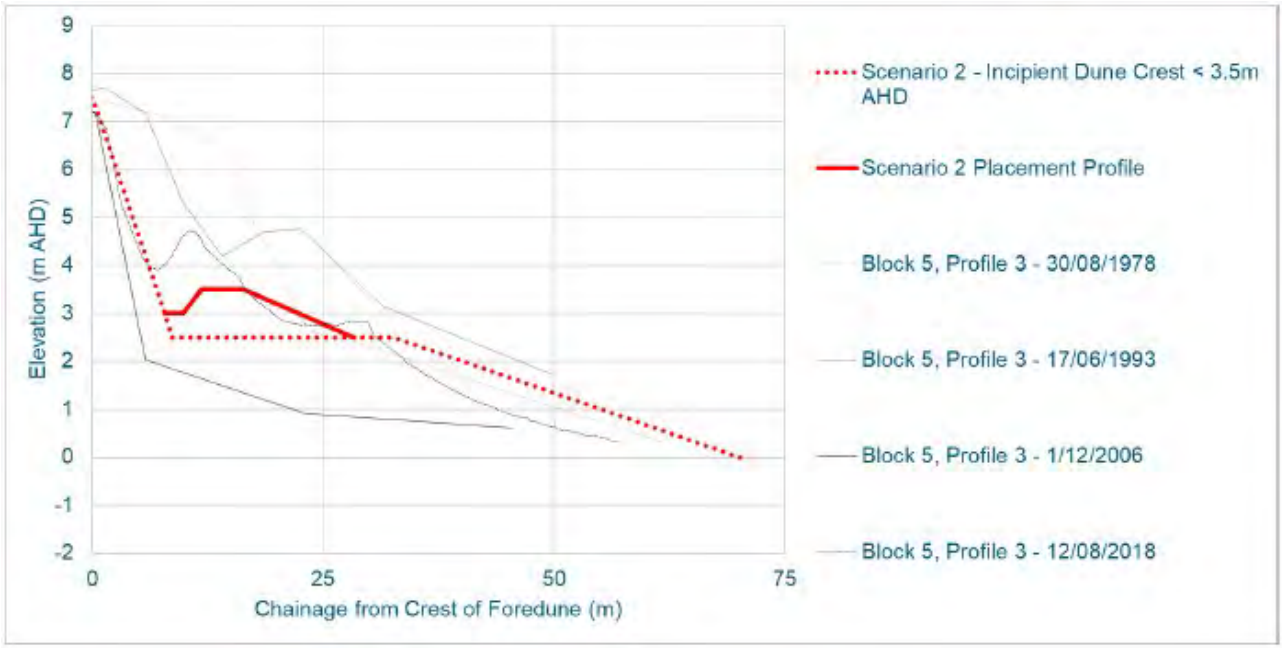


Figure 23: Typical historical photogrammetry profiles and Scenario 2 sand placement profile

Block 5, Profile 3 is located at the southern end of Wooli Village where the properties are located close to the crest of the foredune

Source: Royal HaskoningDHV (2021a)

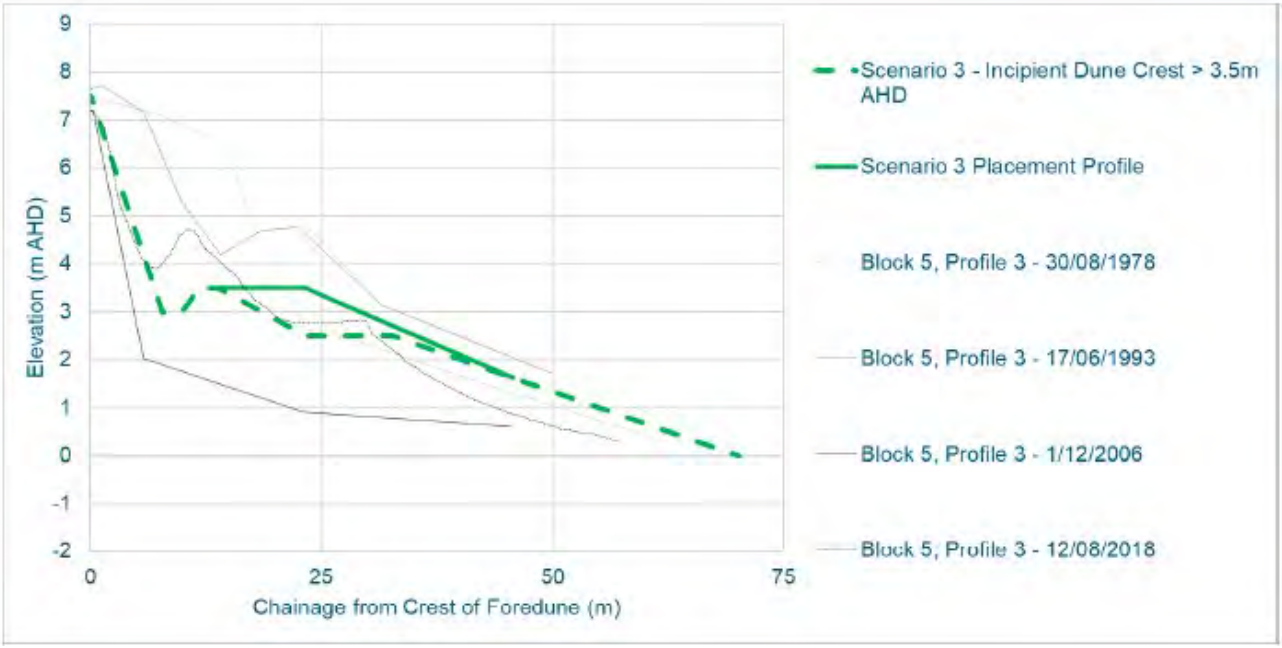


Figure 24: Typical historical photogrammetry profiles and Scenario 3 sand placement profile

Block 5, Profile 3 is located at the southern end of Wooli Village where the properties are located close to the crest of the foredune

Source: Royal HaskoningDHV (2021a)

Design drawings for the BMS are included in Royal HaskoningDHV (2021a). Cost estimates provided in Royal HaskoningDHV (2021a) are (excluding GST, including 15% contingency):

- Scenario 1: $287,500 - $402,500
- Scenario 2: $132,250
- Scenario 3: $97,750

7.3 Brooms Head Seawall Extension

The Brooms Head Reserve accommodates Brooms Head Caravan Park. The southern portion of Brooms Head Reserve is flanked by a rock revetment which has been extended in the past in response to 'end effects' where erosion is exacerbated at the end of a hard control structure. Due to the risk to public assets from storm erosion and long-term recession, the *Brooms Head and Lake Cakora Coastal Zone Management Plan* (CVC, 2017) included a priority action to extend the existing foreshore revetment at the northern end of Brooms Head Reserve to the southern bridge abutment (in the entrance compartment of Lake Cakora). Detailed design including allowance for public foreshore access and stormwater management and environmental impact assessment have been completed (Royal HaskoningDHV, 2021b).

Construction of the works is intended to be undertaken in two stages (Figure 25). Stage 1 involves extension of the rock revetment along Brooms Head Reserve along the same alignment and using similar material (rock armour). The revetment would extend to approximately 20 m beyond the northern end of the caravan park. The northern 10 m of the revetment is designed to be exposed on the landward side to ensure 'end effects' do not lead to undermining and failure of the structure. The works would include reconstruction of eroded foredunes to an elevation of approximately 4 mAHD, to match the existing profile to the south. Sand fill would therefore be required to re-create an artificial dune. The dune would require restoration after reconstruction, including vegetation planting and dune fencing activities. The foredune would be protected by

the rock revetment with a crest elevation at approximately 3.5 mAHD. Stage 1 would include construction of timber and fibre reinforced plastic beach access stairs to improve public amenity.

Stage 2 involves foreshore protection near Ocean Road bridge, construction of an end control structure and construction of a new beach accessway. The foreshore at this location is known to move in response to estuarine flows from Lake Cakora and is exposed to wave erosion when the entrance is open to the ocean. The Stage 2 revetment would mitigate the risk of the bridge abutment being undermined or outflanked by erosion within the entrance compartment.

An end control structure is also proposed near Lake Cakora entrance as part of Stage 2:

- To form a 'pocket beach' between the end control structure and the revetment to the south. This would maintain the existing beach alignment, rather than producing a new alignment as an unwanted impact of a curved revetment, or the uncontrolled end effects of a revetment terminating in the adjacent dune system. It would also ensure existing dune and foreshore vegetation is retained.
- To maintain beach amenity to the south, including the vegetated dune system in the entrance compartment, and ensuring the pedestrian and vehicle beach accessway locations are secured.
- To minimise the effects of wave reflection from the constructed works towards the properties within the Lake Cakora entrance compartment (north of the bridge).

The length and orientation of the end control structure is complex and, as such, the end control structure is intended to be a trial structure. The end control structure would be approximately 30 m long at an orientation of 45°N, constructed from KYOWA Rock Bags. This would ensure that the structure can be readily removed (and reused) or repositioned without leaving traces of rock on the beach, if unexpected detrimental impacts are observed. The crest of the end control structure would be at 1.9 mAHD. The length and height aim to ensure sand bypasses the structure and reduces or eliminates potential detrimental impacts downdrift (north) of the site. The crest level of the structures could also be raised in the future to accommodate future sea level rise if required.

Design drawings are provided in Royal HaskoningDHV (2021b). The estimated cost for Stage 1 and Stage 2 is $2.5 million (excluding GST and including a 20% contingency, Royal HaskoningDHV, 2021b).

CVC plans to undertake physical modelling of the proposed design to verify that there will be no adverse impact on downdrift areas and optimise the design. The outcomes of the physical modelling should be considered in the Stage 3 assessment of options.

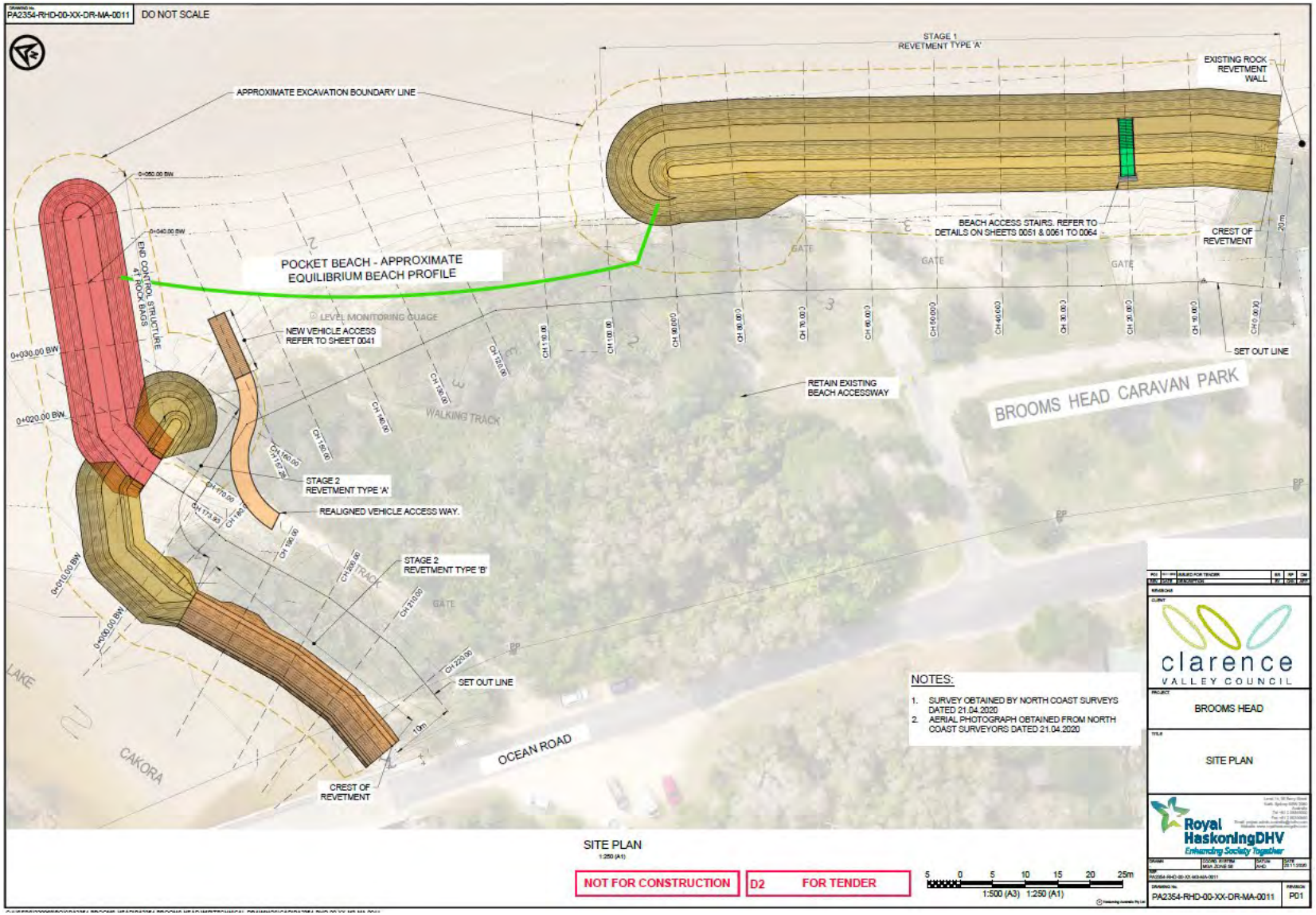


Figure 25: Brooms Head revetment extension - stage 1 and 2 site plan

Source: Royal HaskoningDHV (2021c)

7.4 Whiting Beach Nourishment

Due to significant recession of Whiting Beach since the construction of the Clarence River entrance breakwaters, potential management options were investigated by CVC (RoyalHaskoningDHV, 2015a) including:

- Do nothing.
- Structural works in the surrounding Clarence River, comprising an offshore breakwater, T-Piece extension or reinstatement of the middle training wall.
- Structural works at Whiting Beach, comprising a revetment/seawall or groyne
- Beach nourishment at Whiting Beach.

RoyalHaskoningDHV (2015a) recommended beach nourishment along Whiting Beach in order to maintain a sufficient volume of sand such that infrastructure landward of Whiting Beach was not threatened. In the short term, around 40,000 m^3 of sand would be required every 10 years to maintain Whiting Beach (in the vicinity of the car park) at its 2015 position. Sand sources investigated included previously dredged areas (e.g. Clarence River bar), a potential future dredge area west of Dart Island, other relatively shallow areas and commercial sand sources.

Approximately 10,000 m^3 of material was placed on the beach in 2016 from dredging of the navigation channel at the tip of Dart Island by DPE - Crown Lands. The material was pumped directly to Whiting Beach, dewatered on site before being reprofiled by an excavator.

Future dredging and placement of sand on Whiting Beach by DPE - Crown Lands may be limited therefore RoyalHaskoningDHV (2015a) recommended future dredging is undertaken between Hickey Island and Dart Island with placement of sand on Whiting Beach (Figure 26). A preliminary Review of Environmental Factors for these works found that this is considered to be a viable option for managing the ongoing recession of Whiting Beach and should be able to occur without any significant environmental impact, subject to some supplementary investigations being favourable (RoyalHaskoningDHV, 2015b).

RoyalHaskoningDHV (2015a) also recommended that the elevation of the north-western end of the track at Hickey Island is raised to reduce the risk of oceanic inundation propagating along the track.

Stage 3 of the CMP should consider the options proposed in RoyalHaskoningDHV (2015a), potential risks (e.g. sand depletion, seagrass impacts, recreational fishing impacts) and other potential sand sources such as the Yamba approach channel near middle wall.

Figure 26: Proposed dredging area between Dart Island and Hickey Island and White Beach nourishment area

Source: RoyalHaskoningDHV (2015b)

7.5 Yamba Main Beach seawall

Following concerns raised by the Yamba SLSC about the condition and suitability of the existing rock/ concrete revetment wall at Yamba Main Beach and damage caused to the wall during a storm event in 2009, CVC commissioned a report to investigate options for the replacement of the wall. The report (Royal HaskoningDHV, 2012) recommended a replacement rock armoured revetment with discrete banks of suspended concrete bleaches (large steps) incorporated in the face to provide for seating. A concept design is provided in Royal HaskoningDHV (2012) and the general arrangement plan is provided on Figure 27. The works are estimated to cost between $2.2 million and $2.6 million (Royal HaskoningDHV, 2012, indexed to 2023$) depending on the extent of recycling of construction materials.

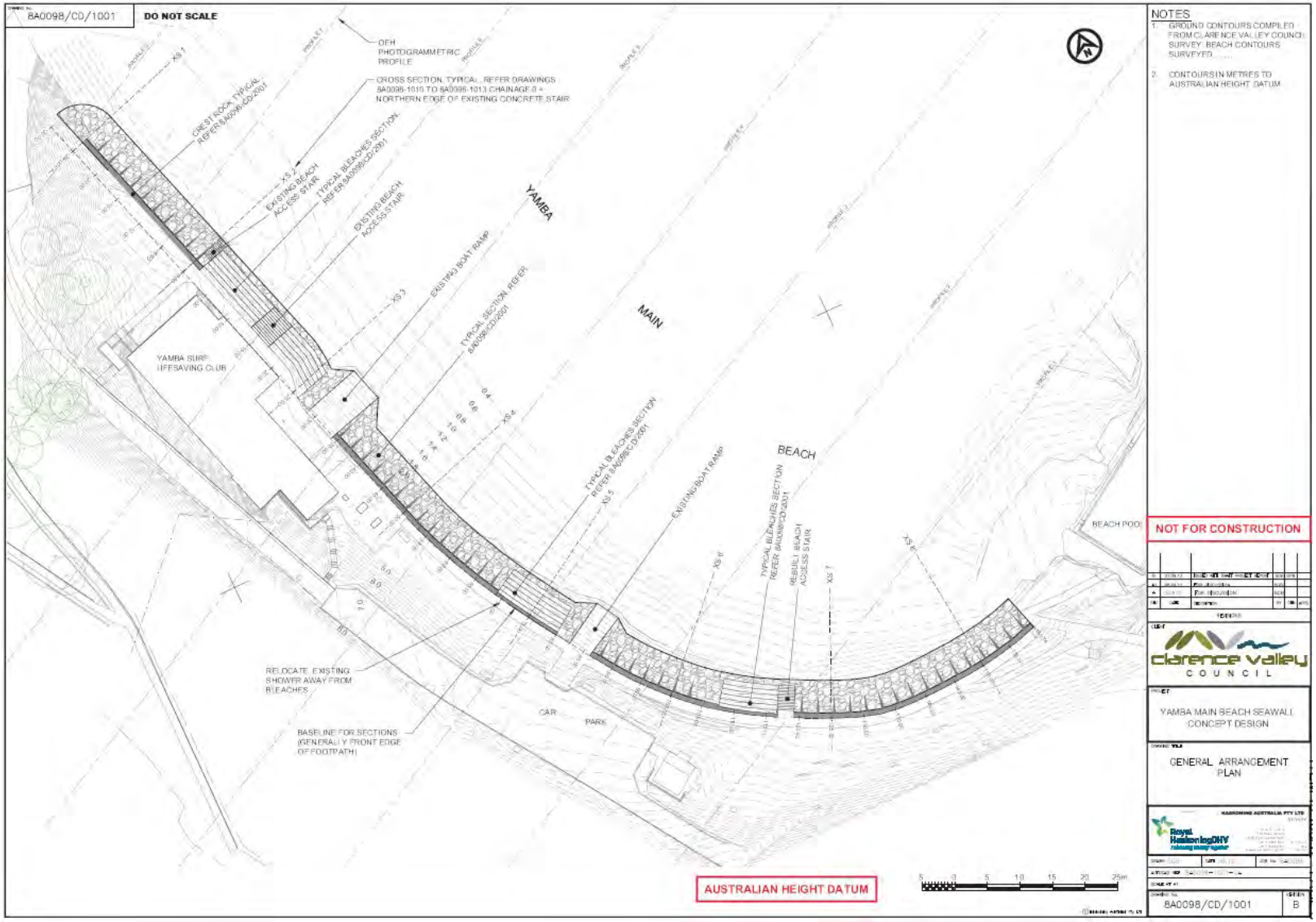


Figure 27: Yamba Main Beach seawall replacement - general arrangement plan

Source: Royal HaskoningDHV (2012)

7.6 Dredging

Dredging is a potential option to maintain navigation channels and provide access to maritime infrastructure that are otherwise restricted by natural sand shoaling. The *NSW Coastal Dredging Strategy 2019 - 2024* (DPIE, 2019) outlines statewide priority dredging locations (state government responsibilities co-ordinated by the Maritime Delivery Office (MIDO) and council maintenance of navigation channels). The Strategy identifies the lower Clarence River as a key investment location (for dredging of the entrance channels to Iluka and Yamba boat harbours) with nourishment potentially on Whiting Beach (refer Section 7.4) and Wooli Creek (Wooli Wooli River) as a priority regional location (dredging of the river entrance channel to the town wharf) with nourishment potentially on Wooli Beach. The NSW Government is currently reviewing priorities for dredging with an updated strategy and priorities expected to be released in 2023/24.

7.7 Marine Estate Management Strategy

The *Marine Estate Management Strategy 2018 - 2028* (MEMS, MEMA, 2018) provides an overarching strategic approach to the coordinated management of the NSW marine estate (the coastal waters, estuaries, lakes, lagoons and coastal wetlands). The MEMS sets out nine initiatives and the actions needed to deliver improved management of the marine estate over ten years from 2018 - 2028. The initiatives were developed based on the threat and risk assessment (TARA) prepared for the MEMS (BMT WBM, 2017), stakeholder and community feedback and marine estate values:

1. Improving water quality and reducing litter.
2. Delivering healthy coastal habitats with sustainable use and development.
3. Planning for climate change.
4. Protecting the Aboriginal cultural values of the marine estate.
5. Reducing impacts on threatened and protected species.
6. Ensuring sustainable fishing and aquaculture.
7. Enabling safe and sustainable boating.
8. Enhancing social, cultural and economic benefits.
9. Delivering effective governance.

CMPs are required to support the objectives of the *Marine Estate Management Act 2014* and are strongly aligned with improving outcomes for the marine estate. The development and implementation of the MEMS and CMPs are bound by legislation and rely on a risk-based approach. The CMP development:

- Considers the state-wide TARA: Priority threats to estuaries and coastal and marine areas were considered during the preparation of the CMP Scoping Study.
- Aligns CMP actions with the initiatives and actions in the MEMS.
- Draws on the outcomes and key learnings from projects piloted through the Strategy since 2018 to help inform the design and implementation of local management actions.

The implementation of the MEMS since 2018 aims to address many of the key issues impacting the health of the Clarence coastline and estuaries and there appears to be many opportunities for integrating the MEMS with the CMP to draw on the work done to date and collaborate with future projects. Stage 1 of the MEMS (ending June 2020) focused on addressing the most severe threats to the health of the marine estate, particularly water pollution, which was identified as the greatest threat to the marine estate by the NSW community and through the evidence-based TARA (BMT WBM, 2017). Some MEMS actions have included projects in Stages 1 and 2 (to June 2022) in the Clarence Valley LGA and other management actions have state-wide benefits. The MEMS will continue to be delivered over the next two years to June 2024.

MEMA prepares regular summary updates on the status of MEMS projects and further details are expected to become available during the development of the CMP. The aims and outcomes of relevant MEMS projects are discussed in the following sections.

7.7.1 Migration of Estuarine Vegetation with Sea Level Rise

Sea level rise is expected to increase the average water depth and extend tidal propagation in estuaries with associated changes in salinity regime. It is anticipated that sea level rise will result in the landward recession of fringing estuarine wetland systems. The location of estuarine habitats such as mangrove stands and saltmarsh are controlled principally by tidal range and salinity influence and will gradually respond to changes resulting from sea level rise. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, rock walls, retaining walls, altered drainage and urban development on the landward side. Under these conditions the landward side of these important habitats will be fixed but the lower margin will gradually be pared away, leading to a loss of habitat area. In contrast, rising water levels and increased upstream salinity propagation will facilitate opportunities for the expansion of estuarine vegetation in unrestricted low-lying areas.

The DPI - Fisheries Marine Vegetation Strategy is a state-wide program as part of the MEMS to develop estuary specific plans to manage estuarine vegetation. The strategies aim to provide scientific evidence to support and guide the protection of existing and potential future coastal wetlands. The strategy will address the priority threats and risks, maximise wetland values and services, facilitate rehabilitation opportunities and improve resilience for sea-level rise. The strategies aim to take the long-standing NSW policy of ‘no net loss of key fish habitats’ toward more active management of intertidal systems that maximise and sustain the ecosystem values and services. There is growing recognition that rehabilitation of coastal wetlands is needed to enhance the delivery of important ecosystem services and values such as providing a habitat for terrestrial and aquatic species, improving water quality through filtration, blue carbon sequestration (Section 7.7.2), Aboriginal and cultural heritage values, economic prosperity, fishing and tourism. In particular, there is increasing interest in the rehabilitation of mangroves to allow for improved coastal protection and reduced exposure to coastal hazards. Policy tools and active rehabilitation is required to manage existing wetlands and increase the capacity for mangroves and saltmarsh to migrate inland with sea-level rise.

The Marine Vegetation Strategies use a systematic spatial tool and method for estuary wide prioritisation to map and quantify the potential for mangrove and saltmarsh communities to thrive and deliver social, economic and environmental services under current conditions and into the future under scenarios of sea level rise. The approach integrates datasets which indicate the physical nature of the landscape, anthropogenic exposure and vulnerability to sea level rise to identify high priority areas within estuaries. The high priority areas delimit locations that are ideal priority offset locations and rehabilitation sites and areas

where initiatives should be directed to manage existing wetlands and for future trajectories of change to direct rehabilitation projects to the most meaningful locations given the biophysical conditions, anthropogenic exposure and the future wetland trajectory with sea level rise.

As part of the strategy a new method and dataset has been developed by Hughes *et al* (undated). The method is used to predict the future spatial distribution of mangroves and saltmarsh in NSW estuaries for three sea level rise scenarios. The method uses machine learning to develop a statistical model of the present-day landscape using a combination of response and predictor variables. The response variables were defined by using the mapping of intertidal mangroves and saltmarsh wetlands, high resolution imagery and object-based image analysis and field validation to model the present-day distribution of these variables and provide a guide to where saltmarsh and mangroves might occur in future landscapes. Three sets of predictions were prepared for each of the three sea level rise scenarios based on potential land use constraints. The study offers several caveats regarding the various errors in the datasets and recommends a moderate level of caution when using the dataset to inform decision making for future sea-level rise impacts. It is intended as a regional scale guide where more detailed higher resolution datasets would improve the predictions.

The study used a measure of the error in the predictions to determine accuracy similar to the Pearson correlation co-efficient called the Matthews Correlation Co-efficient (MCC). For the Cakora Lagoon catchment mangrove prediction had an MCC of 0.37 whilst saltmarsh had an MCC of 0.57, representing weak correlation and moderate correlation respectively. For the Sandon River catchment mangrove prediction had an MCC of 0.56 whilst saltmarsh had an MCC of 0.51, representing moderate correlation for both. For the Wooli River catchment mangrove prediction had an MCC of 0.6 whilst saltmarsh had an MCC of 0.45, representing moderate and strong correlation respectively. Lake Arragan was not assessed as part of this study. The study offers several caveats regarding the various errors in the datasets and recommends a moderate level of caution when using the dataset to inform decision making for future sea-level rise impacts. It is intended as a regional scale guide where more detailed higher resolution datasets would improve the predictions.

The potential changes in salinity regime and implications for estuarine ecosystems and adjoining land uses has not been fully explored. There may be increasing pressure to reduce saline intrusion into low-lying lands and long-term policies will need to consider the implications of sea level rise and potential salinity increases

To examine the likely migration of estuarine vegetation in the coastal estuaries (Lake Cakora, Sandon River, Wooli Wooli River) with sea level rise and the impact of barriers to migration, an assessment could be undertaken based on the existing extent of estuarine vegetation (based on available mapping) and documented tidal/ elevation ranges of the different vegetation types and mapped sea level rise/ tidal inundation scenarios. The potential areas could then be compared to the existing barriers to migration such as the river training walls, retaining walls along the foreshore, footpaths, roads, property boundaries and residential areas. This would allow for an estimate of the impact of sea level rise on future estuarine habitats in these estuaries. This is identified in the Scoping Study as a Stage 5 task. However, given that tidal inundation mapping has been completed in Stage 2 there is a good opportunity to directly apply this information and undertake the estuarine vegetation migration mapping and management priority classification. Outcomes from this exercise could then be used to identify potential options.

7.7.2 Blue Carbon

Blue carbon is the term used to describe the carbon which is captured by oceans and coastal ecosystems, such as intertidal wetlands and supratidal forests (saltmarsh, seagrass meadows and mangrove forests, (Rayner *et al.,* 2021). Sequestration of blue carbon in mangrove forests, salt marshes and seagrass meadows is an important benefit of coastal wetlands. These ecosystems sequester carbon from the atmosphere at extremely high rates, in certain instances nearly four times that of terrestrial ecosystems (WRL, 2021). Restoring the coastal wetlands of the region poses a potentially substantial role in CVC achieving net zero emissions in accordance with the *CVC Community Energy and Emissions Reduction Strategy* (100% Renewables, 2021), the NSW Government's plan to reach net zero emissions by 2050 and the NPWS plan to be carbon positive by 2028.

Since European colonisation there has been a reduction in available blue carbon ecosystems around Australia, mostly attributed to the conversion of coastal wetlands into arable land via floodplain drainage networks. Australia, and in particular NSW, is considered highly favourable for large-scale blue carbon ecosystem restoration due to legislative and geographic conditions. Introducing or re-establishing tidal flushing and inundation in suitable low-lying coastal areas would reduce impacts of sea level rise (Sadat-Noori *et al.* 2021). Blue carbon initiatives create socio-economic benefits, enhance biological and ecological productivity of the marine estate and create economic incentives for landholders to change land management practices or land use to cater for climate change and sea level rise.

Australia's Emission Reduction Fund developed a *Blue Carbon Method* which supports projects which introduce or re-establish tidal flows back onto modified floodplains. The *Blue Carbon Method* also supports the removal or modification of infrastructure which restricts tidal flow, subsequently supporting re-establishment of coastal wetland ecosystems (Clean Energy Regulator, 2022). The aim of these projects is to increase the blue carbon being stored. When a landholder implements a Blue Carbon Method project, they will be eligible to receive Australian Carbon Credit Units which can then be sold or traded to the Australian Government or private companies for a profit (WRL, 2021). The blue carbon accounting model (BlueCAM) has been developed to calculate the net carbon abatement from each of the soil and vegetation sequestration and emissions avoidance components of a project.

The NSW Government has assessed and mapped the blue carbon storage potential of areas across coastal NSW and identified and the areas that are most suitable for re-establishing coastal wetlands. The output from the project includes eight spatial datasets as follows:

- NSW Blue Carbon stored within coastal quaternary sediments - defines the volume of blue carbon present based on geology, in particular, the type of sediment present and how this affects blue carbon.
- NSW Blue Carbon preservation for long-term sequestration - estimates the capacity for blue carbon longer term storage capability based on the sediments present, saline conditions, oxidation and other factors.
- NSW Blue Carbon generation from existing mangroves and saltmarsh - "generation" is defined as the capacity for existing mangrove forests and saltmarshes to contribute to carbon additionality from living biomass, dead organic material, and soil organic carbon.

- NSW Blue Carbon permanency in belowground sediments - defines the capacity for carbon to be preserved and not reworked under conditions of higher hydrodynamic energy associated with storms and changes to tidal regimes.
- NSW Blue Carbon indicator - a blue carbon indicator layer was created by combining the above four layers.
- NSW Blue Carbon compatibility under land use - attempts to quantify human induced impacts/ pressures on blue carbon potential using the 2017 land use dataset.
- NSW Blue Carbon in watersheds of instream barriers - shows wetland drainage and flood mitigation works which have had a profound influence on hydrology, especially hydroperiod and tidal exchange across coastal NSW. Barriers or instream artificial tidal impediments that may limit blue carbon opportunities were selected from the NSW Government fish passage dataset.

NSW Blue Carbon potential priority areas (a combination of all the above layers) for the CMP study area are illustrated in Figure 28 and Table 7 (high or moderately high blue carbon potential areas). The majority of blue carbon potential areas identified are within national parks and reserves (74% of high blue carbon potential areas and 70% of moderately high blue carbon potential areas). Specific project locations for re-establishment of coastal wetlands have not yet been identified in the CMP study area. While no tributaries within the CMP study area are included in the top 20 areas for blue carbon ecosystem restoration in the state, wetland restoration projects within the study area with the highest potential (Table 7) would contribute to achievement of the overarching priorities of the *NSW Blue Carbon Strategy.* The Clarence River estuary CMP may also identify public and freehold land for transition to blue carbon farming, particularly for those areas at risk from tidal inundation.

The NSW Government is taking a lead role in working with all levels of government, industries, landowners, and communities to conserve existing blue carbon ecosystems. The NSW Government will work with the Biodiversity Conservation Trust to accelerate new opportunities to protect blue carbon ecosystem. The NSW Government will also support councils to integrate blue carbon projects in CMPs and transition land uses on low lying floodplains vulnerable to extreme events and climate change (DPE, 2022a).

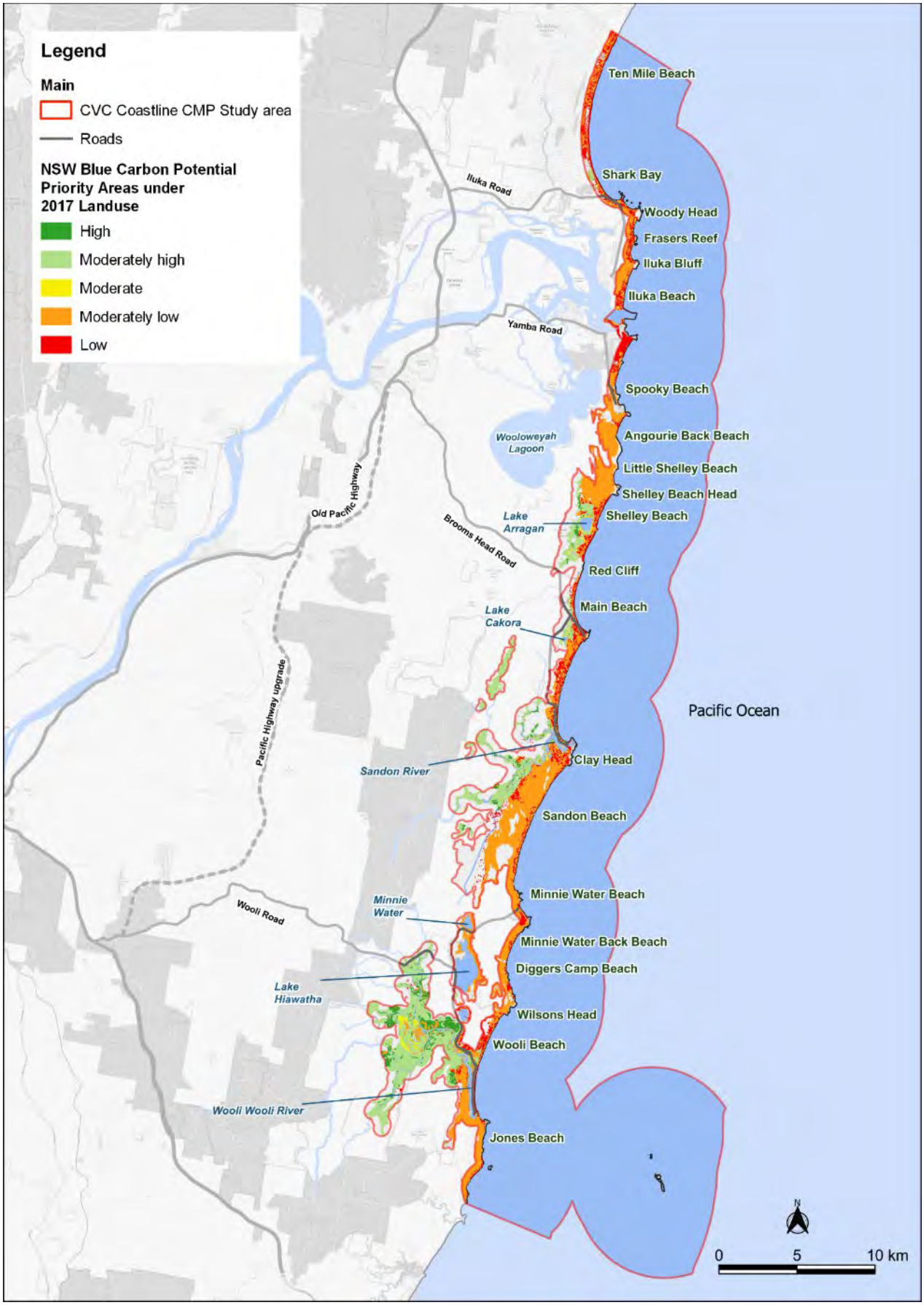


Figure 28: Blue Carbon Potential priority areas

Source: Data from SEED (2023)

Table 7: High or moderately high blue carbon potential areas within the CMP area

Location	High blue carbon potential					Moderately high blue carbon potential				
	Area (ha) within study area	CVC managed land (ha)	National parks/ reserves (ha)	Private land (ha)	Crown land (ha)	Area (ha) within study area	CVC managed land (ha)	National parks/ reserves (ha)	Private land (ha)	Crown land (ha)
Clarence River	*1.2*	1.2	-	-	-	*5.3*	1.0	4.3	-	-
Lake Arragan	*37.8*	-	37.8	-	-	*249.5*	-	249.5	-	-
Cakora Lagoon	*5.8*	0.5	3.7	-	1.6	*56.1*	5	44.4	-	6.7
Sandon River and surrounds	*109.0*	-	91.1	8.1	9.8	*813.8*	-	696	63	54.8
Sandon to Wooli coastal	*0.9*	0.4	0.4	0.1	-	*11.6*	3.8	5.7	2.1	-
Wooli Wooli River and surrounds	*390.1*	5.0	270.0	112.0	3.1	*1,593.2*	20.5	896	667	9.7
Entrance North coastal	*2.0*	-	2.0	-	-	*26.2*	-	26.2	-	-

Source: Data from SEED (2023)

7.7.3 Breakwater management

The NSW Department of Planning and Environment - Crown Lands (DPE - Crown Lands) is leading several projects for the NSW Marine Estate Management Strategy 2018-2028 (MEMS) in collaboration with other State agencies and local councils. Initiative 2 of the MEMS focuses on delivering healthy coastal habitats with sustainable use and development. Action 2.1 (Breakwall governance and management) involves the identification of responsibility for breakwater assets, working toward sound management strategies, or their removal where social, environmental, cultural and economic values will also be enhanced.

In 2021, NSW Department of Primary Industries - Fisheries (DPI - Fisheries) completed an audit (the breakwater audit) of the 134 breakwater structures that train river entrances, armour harbours and manage sand along the NSW coastline (Dwyer P. G. and Dengate C., 2021a; 2021b). The audit was a first-pass assessment of these structures, their multi-use and eco-features and their impacts on the environment. DPE - Crown Lands also investigated the governance of structures on coastal and submerged Crown land, to clarify responsibilities and facilitate improved management and assigned management responsibility for these structures to TfNSW - MIDO (Hydrosphere Consulting, 2023a). The breakwater audit included the Clarence River entrance breakwaters and Wooli Wooli River breakwaters. Audit outputs for these breakwalls are included in Appendix 8. The audit recommended multi-use and eco-features for possible inclusion in future maintenance or upgrade works.

7.7.4 Other MEMS projects

A summary of the status of the MEMS projects that are either state-wide or being undertaken in other NSW catchments, and are relevant to the CMP study area is provided below (MEMA, 2021b; MEMA, 2021c; MEMA, 2022):

- Initiative 1: Improving water quality and reducing litter:
    - Risk-based framework for regional waterway health - a governance framework is being developed and trialled for the Richmond River catchment to coordinate management, reduce diffuse source runoff and improve waterway health. An improved governance framework may also be appropriate for the Clarence River catchment.
    - Improved management of diffuse source water pollution - a review of the NSW Diffuse Source Water Pollution Strategy (DECC, 2009b) will provide recommendations to effectively manage diffuse source water pollution.
    - Review of the NSW Water Quality Objectives - updated community values and uses have been obtained through consultation with the general public and local government. A state-wide database will be developed for water quality data collation to generate either regional or site specific (trigger) guideline values for coastal waterways. These are intended to replace the old generic trigger values in the ANZECC guidelines.
    - Marine litter campaign - development of an integrated strategy and new animated works to support the “Don't be a Tosser” marine litter campaign as well as a stormwater litter prevention program.

- Fish friendly workshops for councils - building capacity to integrate fish friendly concepts into development and on-ground works.
- Construction sediment management - reduce run-off from construction sites into waterways. Coastal councils can use these conditions in development approvals (Section 8.4).
- Oyster reef restoration and research - facilitate increased protection and restoration of oyster reef habitat in NSW through provision of planning information, contributions to on-ground works, education, engagement and ongoing research and monitoring.
- Riverbank vegetation improvements - plant new riverbank vegetation, maintain previous revegetation work, undertake weeding, erect fencing and implement other improvements to enhance the health of waterways and their foreshores.
- Riverbank stabilisation - maintain existing stabilising structures constructed since 2018 and undertake new work, such as the construction of log, rock and vegetation bank protection works that stabilise erosion hotspots, helping to reduce sediment entering waterways.
- Coastal wetland rehabilitation - undertake assessments, plan for future rehabilitation activities (including priority wetland purchases to add to NPWS and Council reserve estates) and contribute to wetland restoration on-ground works in priority locations.
- Improving roads and tracks - seal gravel roads and undertake other works to reduce sediment entering waterways.
- Marine debris research and management program - the Marine Debris Working Group (agency representatives and academic experts) will oversee a marine debris risk assessment and coordinate research, monitoring and analysis activities associated with marine debris actions.
- Estuarine water quality monitoring - monitoring and reporting on water quality and ecosystem health in estuaries and relevant catchments to track broadscale condition over time.

- Initiative 2: Delivering healthy coastal habitats with sustainable use and development:
  - Develop and implement a state-wide policy for the management of coastal Crown lands (including submerged lands) in collaboration with CMPs in priority areas. A draft policy and guidelines have been developed in consultation with marine estate agencies. This policy aligns the management of Crown land with the NSW coastal management framework.
  - Development of Domestic Waterfront Structures Strategies to guide and streamline future applications for domestic developments along foreshores (such as pontoons and boat ramps).
  - Estuary bank management strategies - develop estuary-wide bank protection management strategies that guide bank protection works proposals, including beach nourishment and grooming options, and facilitate rehabilitation opportunities.

- Intermittently closed and open lakes and lagoons (ICOLL) management - develop a framework for consistent approvals and management of ICOLLs that can be included in CMPs.
- Coastal Design Guidelines Review - refer Section 8.2.
- Aquatic biodiversity offsets - develop and implement policy to protect high-value fish habitats through the use of biodiversity offsets.
- Threats to estuarine fish assemblages - research to quantify the influence of boating infrastructure, stormwater drains and natural habitats on fish assemblages and better understand potential human impacts.

- Initiative 3: Planning for climate change:
  - Estuarine habitat monitoring and threat assessment - monitoring threats to, and extent of seagrasses, mangroves and saltmarshes to fill knowledge gaps, assess the effectiveness of management actions and inform blue carbon storage estimates and predictive models.
  - Informing the Climate Change Adaptation Strategy - developing and consolidating marine estate information to contribute to the NSW Climate Change Adaptation Strategy, promoting alignment of actions between the NSW Climate Change Adaptation Strategy with the MEMS, ensuring innovative on-ground climate adaptation actions are delivered.
- Initiative 4: Protecting the Aboriginal cultural values of the marine estate:
  - Sea Country management - enhance opportunities for Aboriginal employment in NSW Government to manage Sea Country.
  - Cultural interpretations - collaborating with Aboriginal communities on additional signage and artwork depicting their cultural connection to Sea Country. Discussions with Yaegl on cultural interpretation projects commenced but was delayed due to COVID-19.
  - Reviving culture - working with Aboriginal communities to revive cultural knowledge and practices of Sea Country.
  - Cultural economic development - increasing the number of people engaged in Aboriginal businesses in the marine estate.
  - Cultural immersion - Aboriginal Elders spend time working with and mentoring marine estate staff and imparting their knowledge so that staff gain a greater respect and appreciation of Sea Country and Aboriginal cultural values which is transferred into the day-to-day management of Sea Country.
  - Sea Country rangers - work with Aboriginal communities to design and deliver a Caring for Sea Country ranger model and activities across the marine estate.
  - Cultural fishing funds - delivering targeted funds to increase economic opportunities for Aboriginal people in the fishing and seafood industry.

- Cultural research and monitoring - develop research, monitoring and evaluation approach that is integrated with the Aboriginal Engagement Framework and aligns with the Marine Integrated Monitoring Program.
- Cultural site protection - undertake local cultural research activities with local Elders and communities targeting important cultural sites and informing management strategies to conserve cultural sites and artefacts.
- Pipi harvest - consolidate research and implement Stage 2 of the Safe and Sustainable Sea Country Harvest of Shellfish project enabling Aboriginal people to harvest pipis and consume them safely for cultural purposes.
- Climate change on culture - investigate the impacts of climate change on Aboriginal communities and culture in the marine estate and develop strategies to reduce or adapt to this risk.

- Initiative 5: Reducing impacts on threatened and protected species:
  - Planning to protect marine wildlife - improve strategic planning and coordination for threatened and protected species programs across NSW, including implementation of the Marine Wildlife Manual to address priority threats.
  - Partnerships to protect marine wildlife - strengthen partnerships for marine threatened and protected species conservation response (e.g. whale entanglement, shorebird monitoring, pinniped assessment and capture) to ensure effective wildlife management, incident response and rehabilitation.
  - Education to protect and conserve marine wildlife - improve awareness of threats to threatened and protected species and community compliance with regulations, to reduce impacts through education campaigns, social research and effective compliance.
  - Improve reporting of interactions with marine wildlife - improve reporting and data sharing on marine threatened and protected species to support evidence-based decision making, including linking and enhancing existing databases, raising awareness of reporting pathways, actively analysing and communicating data more regularly and integrating research and data into the monitoring program.
  - Species habitat research - understand and reduce impacts of habitat modification on threatened and protected species.
  - Estuary general fishery observer survey - observer-based survey of the Estuary General mesh net fishery to address threats to fish assemblages (harvest and bycatch).
- Initiative 6: Ensuring sustainable fishing and aquaculture:
  - Recreational fishing environment assessment - develop an environmental assessment of recreational fishing (saltwater), prepare a Recreational Fishing Management Strategy and commence implementation of key recommendations.

  - Oyster aquaculture business and environment - bridging the gap between academic research and policy needs with regard to water quality in the marine estate, and the role of oyster aquaculture.
  - Cultural fishing monitoring - explore potential pathways to enable assessment of cultural fishing in NSW in terms of participation, catch and effort and relate these to access arrangements within current resource management decision making processes, including harvest strategies.
  - Aquaculture socio-economic research - undertake a socio-economic valuation of the aquaculture industry in the marine estate, filling key social and economic knowledge gaps.

- Initiative 7: Enabling safe and sustainable boating:
  - Environmentally friendly moorings - establish a performance-based standard for Environmentally Friendly Moorings (EFM) and review policy and regulatory options for improving adoption and maintenance of EFM.
  - Mooring strategy - review and modernise the strategy for mooring management and administration to improve access to moorings.
  - End-of-Life vessel management - develop options to manage vessels that are reaching or have reached the end of their useful life to mitigate potential environmental risks and enhance access to moorings.
  - Vessel environmental standards - continue to enforce environmental standards and regulations among domestic commercial vessels and recreational vessels.
  - Vessel monitoring - identify available data and undertake gap analysis.
  - Maritime infrastructure - collaborate with key stakeholders in the implementation of the *Maritime Infrastructure Plan 2019-2024* that sets out an overarching strategy to support maritime infrastructure in priority areas in NSW.
- Initiative 8: Enhancing social, cultural and economic benefits:
  - Marine estate education strategy - implement the NSW Marine Estate Education Strategy and curriculum-based school package.
  - Values and activity mapping - pilot a comprehensive, spatial mapping project of socio-cultural values and human use activities, to support marine planning prioritisation and management.
  - Blue economy - working across multiple sectors to develop a Blue Growth Strategy for NSW which explores opportunities for coordinated, innovative, long-term, sustainable development of the marine estate with a focus on those current and emerging activities which provide the greatest opportunity for sustainable growth for NSW.
- Initiative 9: Delivering effective governance:
  - Improved marine protected area planning and management - improve planning and management for marine parks and aquatic reserves.

8. PLANNING CONTROLS

There is a need for inclusion of current coastal hazard information into Council's planning framework through the appropriate, transparent processes offered through the NSW coastal management framework or local planning provisions as discussed in the following sections. The CMP also provides an opportunity to update local planning provisions on a range of matters to better protect coastal values in future (cultural heritage, social values, environmental values). Council's preferred approach will be developed during Stage 3.

8.1 Existing Planning Controls

8.1.1 Local Environmental Plan and Development Control Plans

The *Clarence Valley Local Environmental Plan 2011* (LEP) makes local environmental planning provisions for land in Clarence Valley in accordance with the relevant standard environmental planning instrument under section 3.20 of the *Environmental Planning and Assessment Act 1979*.

Land use zoning for the coastal areas within the CMP area are zoned:

- C1 National Parks and Nature Reserves.
- C2 Environmental Conservation.
- C3 Environmental Management.
- W1 Natural Waterways.
- W3 Working Waterways.

The LEP includes local provisions for coastal risk planning (Part 7, Clause 7.5 of the LEP). The Coastal Risk Planning Map includes parts of the coastline at Wooli (Figure 29). The LEP also includes local provisions for development on land subject to riverbank erosion (Part 7, Clause 7.6 of the LEP). However, the Riverbank Erosion Planning Map does not include any areas of erosion risk within the study area.

Development Control Plans (DCPs) provide detailed planning and design guidelines to support the planning controls in the LEP. The *Residential Zones DCP 2011* requires consideration of the NSW Coastal Policy and *NSW Coastal Design Guidelines* (Coastal Council, 2003) which are being updated by DPE (draft guidelines were published for consultation in 2022, refer Section 8.3). Development in the coastal zone must comply with the principles of the NSW Coastal Policy. Development within the coastal zone in Clarence Valley LEP 2011 requires consideration of a number of matters related to access, impacts on coastal processes and the scenic and visual impacts of proposed development in the coastal zone before granting consent to development. The *NSW Coastal Design Guidelines* must also be considered in the design of new buildings and additions in areas within the coastal zone.

Part H of the Residential Zones DCP (Sustainable Water Controls) specifies objectives, controls and water sensitive urban design principles and stormwater quality targets. Part I of the Residential Zones DCP (Erosion and Sediment Control) specifies the principles and requirements for erosion and sediment control plans.

Wooli Village Controls (Part V of the Residential DCP 2011 and Part Q of the Business Zones DCP 2020) document the development restrictions that apply within the "Wooli Beach Coastline Management Plan". The

Wooli Coastline Management Plan (Patterson Britton & Partners, 1997) was adopted by Council in 1998. The *Wooli Village Coastline Management Strategy Update and Options Review* (WorleyParsons, 2010a) includes a review of management options for Wooli, based on revised hazard lines determined in the *Wooli Beach/ Village Review of Coastal Hazards* (WorleyParsons, 2010b). These plans are superseded by the Wooli CZMP (Royal HaskoningDHV, 2018) which will also be updated and incorporated into the new CMP.

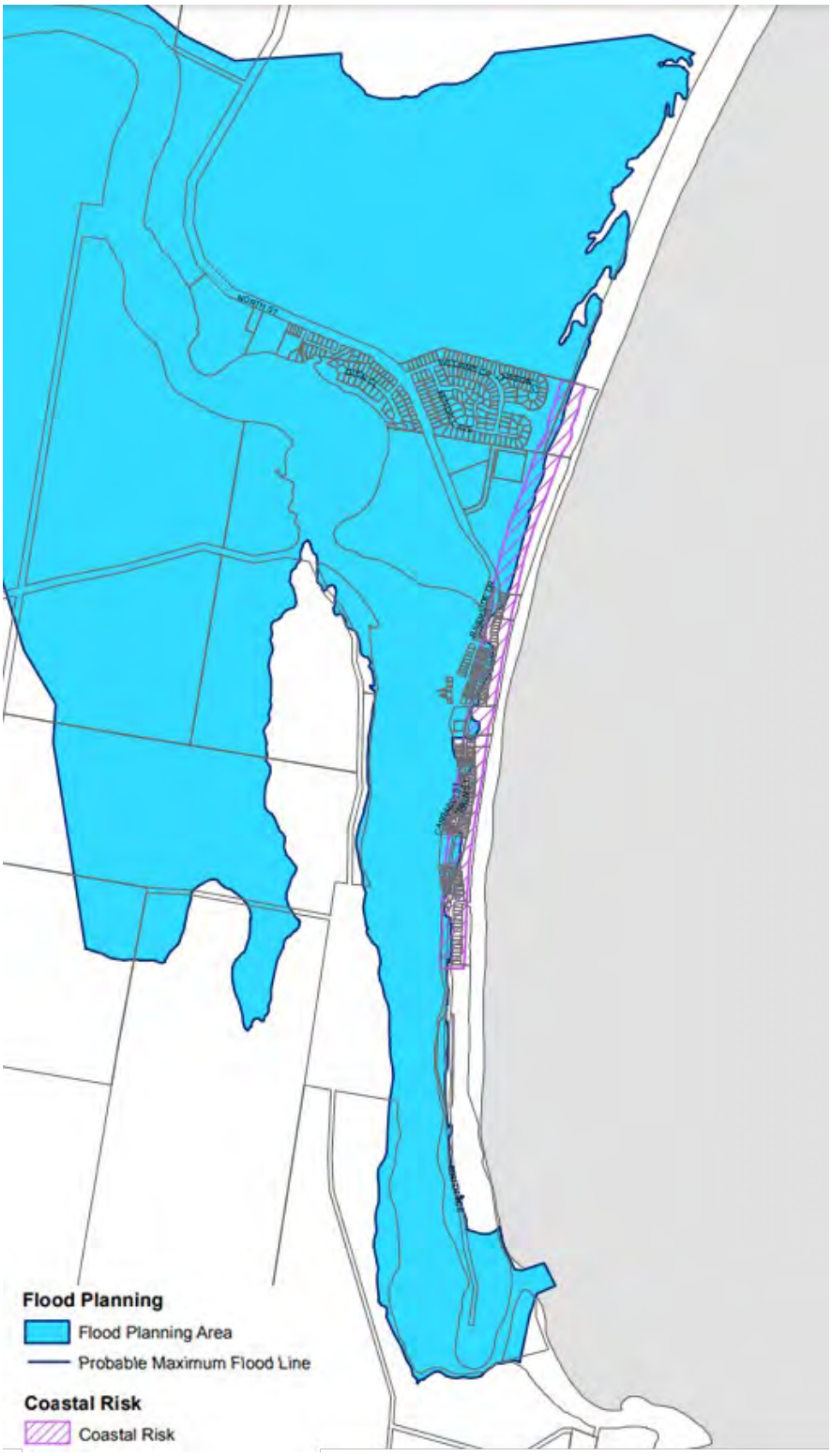


Figure 29: Coastal Risk Planning Map (2011 LEP) Sheet CL1_012F

Source: https://eplanningdlprod.blob.core.windows.net/pdfmaps/1730_COM_CL1_012F_040_20111115.pdf

Yamba Hill Controls (Part W of the DCP) do not specifically address the risk of slope instability although the Residential Zones DCP, Business Zones DCP (2020) and Industrial Zones DCP (2011) require geotechnical investigations for land subject to land slip/ geotechnical hazard.

8.1.2 State Environmental Planning Policy (Resilience and Hazards) 2021

The Resilience and Hazards SEPP consolidates and repeals the provisions of the Coastal Management SEPP, SEPP 33 - Hazardous and Offensive Development and SEPP 55 - Remediation of Land. Chapter 2 (Coastal Management) of the Resilience and Hazard SEPP is the key environmental planning instrument for land-use planning in the coastal zone and delivers the statutory management objectives for each of the four coastal management areas that make up the coastal zone:

- CWLRA - Coastal wetlands and littoral rainforests area: support high value biodiversity that are particularly sensitive to development. This management area is defined in the Act as land which displays 'the hydrological and floristic characteristics of coastal wetlands or littoral rainforests and land adjoining those features. This area focusses on protecting well established and more extensive vegetation communities (as opposed to single trees or isolated stands). The maps include a 100 m proximity area, applying to all land use zones, around coastal wetlands and littoral rainforests. The objectives of the CWLRA within the Act are to:
    - Protect coastal wetlands and littoral rainforests in their natural state, including their biological diversity and ecosystem integrity.
    - Promote the rehabilitation and restoration of degraded coastal wetlands and littoral rainforests.
    - Improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration.
    - Support the social and cultural values of coastal wetland and littoral rainforest communities.
    - Promote the objectives of State policies and programs for wetlands or littoral rainforest management.
- CVA - Coastal vulnerability area: land which is subject to current and future coastal hazards including beach erosion, shoreline recession, entrance instability, coastal inundation, tidal inundation, slope instability and foreshore tidal erosion. The objectives of the CVA within the Act are to:
    - Ensure public safety and prevent risks to human life.
    - Mitigate current and future coastal hazards.
    - Maintain the presence of beaches, dunes and other natural features.
    - Maintain public access, amenity and use of the coast.
    - Encourage land use that reduces exposure to hazards, including through siting, design, construction and operational decisions.

- Adopt coastal management strategies that reduce exposure to hazards, in the first instance by restoring or enhancing natural defences such as dunes, and thereafter by taking other action and if taking other action, to:
    - avoid significant degradation or disruption of biological diversity, ecosystem integrity, coastal processes (ecological, biophysical, geological, geomorphological), beach and foreshore amenity, and social and cultural values.
    - avoid adverse offsite impacts, or otherwise restore the land if any impacts are caused by the action to reduce exposure to hazards.
- Maintain essential infrastructure.
- Improve community resilience and reduce reliance on emergency responses

- CEA - Coastal environment area: areas that are characterised by natural coastal features such as beaches, rock platforms, undeveloped headlands, coastal lakes and marine and estuarine waters. The area is made up of estuaries and a 100 m landward area, coastal lakes and lagoons and a 500 m landward area and specified sensitive coastal lakes and lagoons. The coastal management area is mapped upstream to one kilometre beyond the highest astronomical tide. The objectives of the CEA within the Act are to:
    - Protect and enhance coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes, coastal lagoons, and enhance natural character, scenic value, biological diversity and ecosystem integrity.
    - Reduce threats to and improve resilience of these coastal environments, including in response to climate change.
    - Maintain and improve water quality and estuary health.
    - Support social and cultural values of the coastal environments.
    - Maintain the presence of beaches, dunes and natural features of the foreshore.
    - Maintain and improve public access, amenity and use of the coast.
- CUA - The coastal use area: land adjacent to coastal waters, estuaries and coastal lakes and lagoons where impacts of development on the use and enjoyment of the beaches, dunes, estuaries and lakes need to be considered. The area starts at the seaward local government boundary, typically the low water mark and extends to the estuary limit (one km landward of coastal waters, estuaries and coastal lakes). The objectives of the CUA within the Act are to:
    - Protect and enhance the scenic, social and cultural values of the coast by ensuring that:
        - the type, bulk, scale and size of development is appropriate for the location and natural scenic quality of the coast.
        - adverse impacts of development on cultural and built environmental heritage are avoided or mitigated.
        - urban design, including water sensitive urban design, is supported and incorporated into development activities.

- adequate public open space is provided, including for recreational activities and associated infrastructure.
- the use of the surf zone is considered.

o Accommodate both urbanised and natural stretches of coastline

The SEPP gives effect to the objectives of the *Coastal Management Act 2016* from a land use planning perspective, by specifying how development proposals are to be assessed if they fall within the coastal zone. This becomes relevant to the preparation of the CMP with regards to the intent and description of recommended actions and their intended approval pathways (if required) under the SEPP. For example, under the Resilience and Hazards SEPP, in order for certain coastal protection works to be undertaken without consent they need to be identified in a certified CMP.

Planning Circular PS 21-009 (NSW Government, 2021) provides guidance on assessment of coastal hazards under the *State Environmental Planning Policy (Coastal Management) 2018 (*now Resilience and Hazards SEPP*)* and *Coastal Management Act 2016* and Local Planning Direction 4.2 (Coastal Management) supports councils when developing and assessing planning proposals (such as proposals to rezone land) in coastal areas*.* Where a council has existing coastal risk provisions in its LEP, these generally continue to have effect, although this must be determined on a case-by-case basis as the LEP may be inconsistent with the SEPP. Any DCPs will continue to apply as they did prior to the commencement of the SEPP, noting they only provide guidance to consent authorities and people proposing to carry out development. An LEP or the SEPP will always prevail over a DCP if the DCP is inconsistent with them.

The CWLRA, CUA and CEAA are mapped in the SEPP as shown on Figure 2. The CVA has not been mapped as part of the SEPP or CVC's LEP. Consequently, development controls applying specifically to development on land within the CVA in clause 2.9 of the Resilience and Hazards SEPP are not yet active. Notwithstanding, clause 2.12 of the Resilience and Hazards SEPP requires all consent authorities, in the context of considering proposed development in the coastal zone generally, to be satisfied that the proposed development is not likely to cause increased risk of coastal hazards on that land or other land. When assessing the risk of a current or future coastal hazard, councils and other consent authorities have discretion to consider:

- Any relevant floodplain risk management plans or estuary management plans prepared by or on behalf of a council or public authority that take into account tidal inundation in combination with catchment flooding.
- Coastal hazards identified in a relevant environmental planning instrument or DCP.
- Relevant coastal hazard, risk and vulnerability studies prepared by an appropriately qualified expert.
- Historic data, such as past storm event data and impacts, that identify risk exposure of coastal land (such as shoreline recession, coastal inundation, or geomorphic trends).
- Relevant scientific modelling (such as relating to sea level rise and climate variability).
- Relevant advice in the NSW Coastal Management Manual and associated Toolkit.
- Any other relevant information.

The CMP may identify land subject to one or more coastal hazards. This land can then be considered for inclusion in the CVA mapped under the Resilience and Hazards SEPP, which will also trigger a requirement for disclosure in planning certificates.

When assessing proposed development on land within the coastal zone, including where there may be a risk of a current or future coastal hazard, councils and other consent authorities must consider any relevant CMP that has been certified by the Minister, or any CZMP adopted under the *Coastal Protection Act 1979* that continues to have effect under clause 4 of Schedule 3 to the *Coastal Management Act 2016*. CZMPs for Wooli Beach and Brooms Head have been certified by the Minister and will remain in force until 31 December 2023 or until replaced by a certified CMP. Where land affected by a coastal hazard is identified in a policy adopted by a Council (or another public authority that has notified the Council), this information must be disclosed on a planning certificate issued under section 10.7 of the *Environmental Planning and Assessment Act 1979*.

Once a CVA map is adopted under the Resilience and Hazards SEPP, clause 2.9 of the Resilience and Hazards SEPP will apply to land identified on that map as a CVA.

8.2 Council Plans of Management

Most of the beach areas of the study area not within National Park or Nature Reserve are Crown reserve. These Crown reserves are owned by the State but generally are managed by either DPE - Crown Lands or Council. Under the *Crown Land Management Act 2016*, Council manages Crown reserves as community land under the *Local Government Act 1993.*

Plans of Management (PoMs) establish the policy framework for Council's network of parks and reserves. They provide a broad-based mechanism to address issues common to all parks and reserves concerning management, maintenance, community use and environmental protection and provide the community with direction on how Council's parks and reserves can and cannot be used. Site specific PoMs contain detailed management strategies that target the unique values of the area, provide for the protection and enhancement of its social, cultural and/or natural attributes, identify likely future pressures and facility/service requirements and outline priorities, actions and work programs for the effective long-term management of the community land or Crown reserve area. A PoM is also a critical tool to ensure that any authorisation or restriction on the use of a Crown reserve, including proposed development and tenures, considers Aboriginal rights and interests in Crown land under the Commonwealth *Native Title Act 1993* and the NSW *Aboriginal Land Rights Act 1983*.

Council is currently updating the PoMs for community land, Crown reserves and other public places for coastal areas including Angourie Reserve, Brooms Head Public Reserve, Diggers Headland Reserve, Minnie Water Foreshore Reserve, Wooli Public Reserve and Sportsground, South Terrace, Wooli, Hickey Island Reserve, Pippi Beach and Dolphin Park, and the Brooms Head Holiday Park. The PoMs permit future development to safeguard against the effects of climate change, significant climatic events, bushfires and pandemics including climate change adaption measures, extension(s), renovations and improvements to the existing buildings and infrastructure pursuant to relevant legislation and planning controls, flood mitigation, implementing actions identified as part of the CMP and mitigation works to reduce coastal erosion, storm surge and landslide risks. Potential CMP actions should consider the scope and outcomes of related plans of management and identify the most appropriate mechanism for funding and delivery of these actions.

8.3 Review of NSW Coastal Design Guidelines

The draft *2022 Coastal Design Guidelines* (DPE, 2022b) will guide planning and decision-making to protect the coastline and ensure better-designed homes and places. The updated guidelines will give councils, communities and industry modern solutions that balance the needs of growing communities with the responsibility to preserve the NSW coastline including guiding decisions on:

- Requests for changes to planning rules in coastal communities (planning proposals).
- Appropriate design for homes and building.
- Managing growing coastal communities.

The guidelines aim to ensure that development in coastal areas is appropriate and sensitive to its environment through best practice strategic planning and approach to urban design. A renewed focus on connecting and collaborating with Aboriginal communities is central to the guidelines to ensure that land use planning and design begins with respect for Country and Aboriginal heritage (DPE, 2022b).

The guidelines will be used in strategic planning to inform planning rules along the NSW coast. Planning proposals in the NSW coastal zone must be consistent with and give effect to Chapter 3 of the guidelines. This is an existing requirement through Local Planning Direction 4.2: Coastal Management (DPE, 2022b).

The urban design guidance in Chapter 4 in the draft guidelines can also be used to inform:

- Master plans.
- Business cases.
- Development applications including coastal subdivisions.
- Infrastructure development.

8.4 Standard Conditions of Consent for Residential Development

The NSW Government has released a set of conditions for erosion and sediment control on construction sites as part of an initiative to improve water quality and reduce litter (DPIE, 2021). The aim is to increase consistency on all sites to ensure erosion and sediment control is a core part of all residential construction. These conditions are available as part of a broader set of standard conditions for residential development. The conditions are optional but may become mandatory in future. DPE Planning will update guidelines to help small-scale developers understand their obligations.

8.5 Potential Planning Amendments

There is a need for inclusion of current natural hazard information into Council's planning framework through the appropriate, transparent processes offered through the NSW coastal management framework or local planning provisions to ensure the community is informed about natural hazards and risk to property, and to minimise Council's risk of litigation from future planning and development decisions and coastal management actions. A coordinated and consistent approach to strategic planning and an appropriate level of protection of environmental, cultural, built and commercial assets in the coastal zone will ensure adequate planning for and protection from coastal hazards, future development pressures and emerging threats associated with a changing climate.

The Resilience and Hazards SEPP (and its maps) can be amended (e.g. to include CVA mapping or modify CWLRA maps) by another SEPP or a LEP made to implement a planning proposal. A planning proposal can be prepared by a local council or in some cases another planning authority. Before Council can make a LEP relating to SEPP maps, the minister who administers the *Coastal Management Act 2016* must make a recommendation confirming the mapping aligns with the objectives outlined in Section 3 of the Act. Where a council has existing additional local controls in a LEP or DCP, such as coastal risk planning provisions, these can continue to apply however duplicated planning controls should be removed from local provisions where practical. However, there may be localised reasons for councils to retain these provisions.

A planning proposal may propose to amend the Resilience and Hazards SEPP maps, including increasing or decreasing the land within the maps. A planning proposal must be supported by evidence in a relevant CMP that has been certified by the Minister, or by a CZMP under the former *Coastal Protection Act 1979* that continues to have effect under clause 4 of Schedule 3 to the *Coastal Management Act 2016.*

8.5.1 Coastal Vulnerability Areas

CVA mapping can include the seven coastal hazards (Section 2). The coastal hazard mapping developed in Stage 2 could be used in the development of CVA mapping. The coastal hazard mapping for erosion, recession and inundation is consistent across the CVC LGA urban areas and has quantified the nature and extent of exposure to these coastal hazards and threats to public and private assets (both natural and built) and allow the community to understand the factors that contribute to vulnerability to current and future risks. Mapping of coastal lake or watercourse entrance instability has not been undertaken due to the limited entrance instability. Mapping of foreshore erosion (part of hazard 7) is not available but may be considered (e.g. for the Wooli Wooli River) as part of CMP Stage 3. Mapping to address the inundation of foreshores under tides, waves and catchment flood waters will be undertaken through Council's flood risk planning.

FSG Geotechnics and Foundations (2022) recommended a review and update of planning and development controls relating to slope instability. This could be similar to landslide hazard mapping undertaken for a number of regional councils in Queensland including guidance for developers and property owners. This approach would remove the direct focus on the Pilot Hill properties and would place an emphasis on to all property owners to ensure that they keep their property internally and externally stable. This would also allow residents to undertake individual risk assessments for their properties to allow future development.

A planning proposal is required for the inclusion of a CVA in the Resilience and Hazards SEPP or as amended local provisions in the LEP. The DCPs may also be amended to support any SEPP or LEP

amendments. Interim measures such as a development code may also be appropriate. Council planning certificates will continue to identify land exposed to coastal hazards currently or potentially in future.

Potential CVA areas will be considered as part of Stage 3 and 4 of the CMP development to support a future planning proposal if adopted by CVC potentially addressing:

- Beach erosion/ coastal recession: based on the 1% EP (2123 SSP2 or SSP5) mapping.
- Tidal/ coastal inundation: based on the 1% EP (2123 SSP2 or SSP5) mapping.
- Slope instability: Areas to be determined following the additional geotechnical assessment recommended by FSG Geotechnics (2022) for Pilot Hill and Convent Beach but potentially applying to all areas within the coastal zone with slope instability.
- Erosion of foreshores: Wooli - areas to be determined require additional assessment.

Sea level rise may result in landward migration of coastal dune systems. Future planning should also consider the natural coastal landforms and processes that will continue to occur.

8.5.2 Other Coastal Management Areas

The Scoping Study found that the existing mapping for the CWLRA, CEA and CUA is considered suitable for management of the coastline and the estuaries. However, it was noted that there was no detailed recent mapping of the wetland and littoral rainforest communities in the study area available at that time. Detailed contemporary vegetation mapping was released by the NSW Government in 2022. The current SEPP CWLRA mapping is based on the now repealed SEPP No. 14 - Coastal Wetlands and SEPP No. 26 - Littoral Rainforests, amended based on a 2018 review. A review of the SEPP mapping of CWLRA is recommended to afford the ecological communities the required level of protection from future land use pressures, development and coastal hazards.

It may be advantageous to undertake a review of the CWLRA at the same time as the planning requirements for the CVA are investigated so that any changes to the CWLRA can also be included with the CVA in a single planning proposal. The NSW Government detailed vegetation mapping provides an opportunity to undertake a review of the CWLRA mapping during the CMP development.

The management of the river/ estuary catchments has a significant impact on the health of the estuary and coastal zone. Recognising the influence of the catchments on the health of the coastal zone, mapping of the CEA to include some or all of the estuary catchment areas within the study area has been considered. Given that the majority of the catchments for the estuaries within the CMP area are National Parks and Reserves, the catchments are largely protected by the C1 zoning and reserve designation, therefore this approach is not considered necessary for the CMP study area. There is an opportunity to consider the appropriateness of CEA mapping and expand this mapping to include important coastal features that are coastal dependant or would become 'coastal' under projected sea level rise scenarios, or areas that are critical to the coastal zone (e.g. areas currently upstream of tidal waters).

8.5.3 Blue Carbon projects

The *Coastal Management Act 2016* specifies management objectives that are to protect, rehabilitate and improve the resilience of coastal wetlands, including opportunities for migration. The Resilience and Hazards SEPP includes development controls to protect coastal wetlands and guide appropriate development (Section 8.1.2). Several other Acts, including the *Fisheries Management Act 1994* protect seagrass, mangrove and saltmarsh species.

Blue carbon projects (Section 7.7.1) will likely require a number of regulatory approvals under planning and other state and Commonwealth legislation. The NSW Government recognises that having certainty about the process to undertake a blue carbon project can greatly influence a proponent's decision to plan for and deliver such a project. There is an opportunity to streamline and simplify approvals for restoration projects to assist with reducing upfront costs and increasing investment certainty and project take-up. The NSW Government will embed blue carbon ecosystem projects and associated works into existing planning system provisions, with a view to streamlining approvals and facilitating project delivery. This will align the existing framework around aquatic habitat offsets for development impacts under the *Fisheries Management Act 1994* that generally also achieve blue carbon outcomes (DPE, 2022a).

9. NATIONAL PARKS AND RESERVES

NPWS is responsible for management of the *National Parks and Wildlife Act 1974* and management of National Parks and reserves across the CMP study area. NPWS responsibilities in these areas includes a wide range of activities such as active conservation and habitat protection, fire management, management of tourism and visitation, research and education. The coastline and small estuaries in the National Parks and Nature Reserves were included in the study area for the CMP Scoping Study. The *Bundjalung National Park and Iluka Nature Reserve Plan of Management* (NPWS, 1997) and *Yuraygir National Park and Yuraygir State Conservation Area Plan of Management* (NPWS, 2003) outline how these areas will be managed.

9.1 Coastal Hazard Response Plans for Campgrounds

NPWS has collaborated with CVC on the assessments of tidal/ coastal inundation and erosion/ recession with detailed assessments undertaken for Woody Head and Sandon (Section 2.4 and 2.5).

Woody Head campground in Bundjalung National Park and Sandon campground in Yuraygir National Park are culturally, recreationally and ecologically significant landscape features within the NPWS coastal reserve system. The values of the campgrounds are related to the scenic beauty, recreational opportunities and natural landscapes. The areas also have significant cultural heritage value including sites which are of spiritual significance and of contemporary importance to the Yaegl People as well as examples of European heritage. The high levels of biodiversity in the study area reflect climatic conditions which support a diverse range of subtropical coastal communities.

The Woody Head campground precinct has experienced significant historical coastal erosion and recession and there is a risk of further impact in future, particularly with the expected influence of climate change. NPWS considers that the coastal hazards are a major issue for the location and the long-term viability of the campground. NPWS has made significant investment in facilities and coastal protection works at Woody Head. A seawall and artificial dune were constructed to provide protection against beach erosion and shoreline recession. The aim of these works was to protect the camping ground amenities while a phased retreat program from the eroding section of the campground was formulated and carried out.

Coastal erosion and shoreline recession are occurring along Sandon Beach impacting foredunes, pedestrian and 4WD beach access and threatening the northern section of the campground. Hazard assessments indicate that some parts of the campground and sections of Sandon River Road (the only access to the campground) is at immediate risk of erosion and this risk is expected to increase into the future. Periodic inundation of Sandon River Road also occurs at present and the area impacted by inundation is expected to increase into the future. There is concern that the combined impacts of coastal recession and inundation will significantly impact Sandon River Road and access to the campground. Although, dune stabilisation measures have been implemented in response to coastal erosion events, there has been no formal strategic approach to coastal management at Sandon.

The Woody Head and Sandon campgrounds are addressed in separate Coastal Hazard Response Plans being prepared by NPWS. The NPWS Coastal Hazard Response Plans align with Stages 2 and 3 of the Clarence Valley Coastline CMP as they develop strategies and identify coastal management actions that address coastal management issues, reduce exposure to coastal hazards and take advantage of opportunities.

The draft Coastal Hazard Response Plans will be placed on public exhibition in early 2024 and NPWS will consider any feedback received in the finalisation of the Plans. Once adopted, NPWS intends to incorporate the outcomes of the Plans as actions in the CMP (Stage 4) to ensure integration of the CVC and NPWS management approach for the Clarence coastline. The Plans will include the expected timing and budget for implementation of the recommended actions suitable for inclusion in the CMP.

10. EMERGENCY RESPONSE

Emergency Action Subplans (EASPs) have been prepared for Brooms Head and Lake Cakora (CVC, 2017) and Wooli (Royal HaskoningDHV, 2018) as part of the respective CZMPs. The Yamba Coastline Emergency Management Plan supports the *Clarence Valley Local Emergency Management Plan 2020*. The EASPs will be reviewed and updated as a Coastal Zone Emergency Action Subplan (CZEAS) to form part of the CMP in accordance with statutory requirements and relevant guidelines.

The CZEAS will detail arrangements for the four emergency phases (prevention, preparation, response and recovery) to manage coastal emergency events relating to coastal erosion, cliff instability and coastal inundation. The purpose of the CZEAS is to provide emergency response actions in order to:

- Protect human life and public safety.
- Minimise damage to property and assets.
- Minimise impacts on social environmental and economic values.
- Not create additional hazards or risks.

A CZEAS is consistent with the objects of the *Coastal Management Act 2016* and the management objectives for the CVA, specifically to prioritise actions that support the continued functionality of essential infrastructure during and immediately after a coastal hazard emergency and to improve the resilience of coastal development and communities by improving adaptive capacity and reducing reliance on emergency responses. A CZEAS is also consistent with the emergency management provisions addressed in the state, regional and local emergency management plan (EMPLANs) and state and local flood plans (Figure 30).

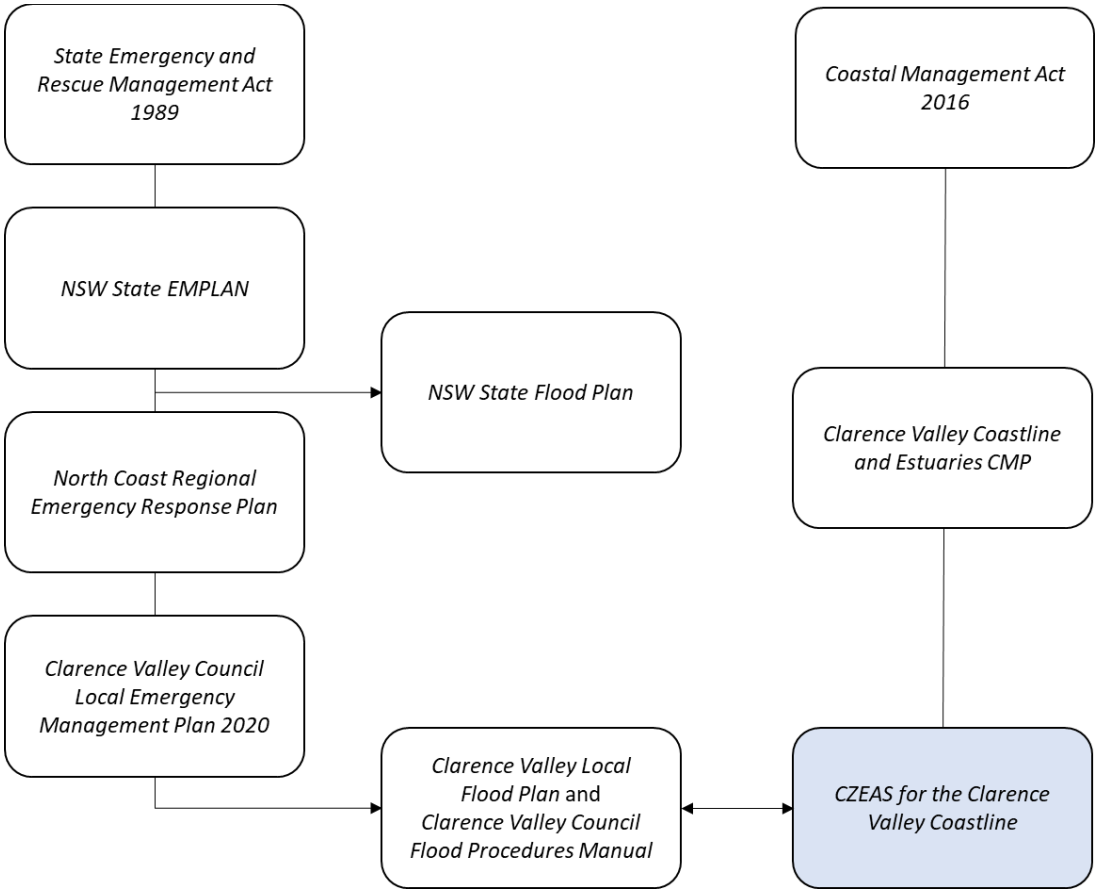


Figure 30: CZEAS legislative context

The CZEAS will detail:

- The triggers which define when a 'coastal emergency' is occurring (beach erosion, coastal inundation or cliff instability, where the beach erosion, coastal inundation or cliff instability occurs through storm activity or an extreme or irregular event).
- Areas at risk during coastal emergencies.
- Roles and responsibilities immediately preceding and during coastal emergencies. These roles may include the carrying out of works for the protection of property affected or likely to be affected by beach erosion, coastal inundation or cliff instability.
- Communications required before during and after an emergency to inform the public and potentially affected property owners about their responsibilities during a coastal emergency and what actions they are and are not permitted to undertake.
- The actions required to mitigate, prepare for, respond to and recover from coastal emergencies.
- The potential location and types of works that may be undertaken for the protection of property and assets.

11. STAKEHOLDER ENGAGEMENT

CVC is collaborating with land managers, state government agencies, industry and community representatives to provide effective and integrated coastal management outcomes. In particular, CVC has worked closely with the National Parks and Wildlife Service (NPWS) and Department of Planning and environment (DPE) to deliver the Stage 1 Scoping Study and Stage 2 detailed coastal hazard studies for the coastline.

Development of the Stage 1 Scoping Study included stakeholder engagement activities designed to inform and involve stakeholders by bringing all interested parties on board early to share information and ideas, identify stakeholders and prepare a stakeholder profile. Feedback from the community and other stakeholders was used to identify values and coastal management issues.

The CMP vision statement was developed from community feedback and is consistent with the objects of the *Coastal Management Act 2016*, the management objectives for the coastal management areas and Council's vision and objectives as identified in its Community Strategic Plan.

> *"The natural values of the Clarence Valley coastline and estuaries will be conserved and enhanced. Sustainable management of the coastline will include adequate resourcing and funding to preserve the environmental, cultural, recreational, amenity, local and tourism values with consideration of existing and emerging threats to improve resilience to current and future pressures."*

11.1 Engagement Strategy

A stakeholder engagement strategy for the preparation of the CMP was developed as part of the Scoping Study. This strategy was developed from the previous stakeholder consultation outcomes and the outcomes/ findings of consultation activities undertaken during Stage 1. The strategy for engagement with stakeholders during Stage 2 of the CMP development includes the following components (Appendix D of Hydrosphere Consulting, 2021):

- Engagement intent - empower community and stakeholders with knowledge to contribute to decisions in subsequent stages and share information equitably among stakeholders.
- Level of community influence on decisions - Council retains decision making. The community and stakeholders may contribute to detailed studies on issues of concern and participate in risk assessment and evaluation.
- Desired engagement outcomes:
    - Shared understanding of risks and opportunities over different timeframes, and the range of actions that could address different risks.
    - A shared understanding of the varied perspectives about coastal management within the community.
    - Council understands the community's 'attitude to risk'.
    - Community and stakeholders understand vulnerabilities, risks and opportunities, including technical aspects such as scenarios for sea level rise, hazards and impacts.

- Increased community trust of technical information based on their involvement and understanding of assumptions and limitations.

- Engagement tools:
  - Yaegl native title holders - meetings communicating progress of project, studies and outcomes.
  - Coast and Estuary Management Committee (CEMC) - workshops on study outcomes.
  - Government agencies (in addition to involvement through CEMC) - meetings or workshops as required.
  - General community, community groups and business/ industry groups - Clarence Conversations and webpage tools, Council's Noticeboard ENews and Clarence Magazine (depending on timing of publication).

11.2 Stage 2 Engagement Activities

11.2.1 Yaegl

Representatives from CVC, NPWS and the project team held several discussions with Yaegl RNTBC members and NTSCorp representatives throughout 2021 and 2022 including a presentation introducing and explaining the projects and inviting Yaegl involvement. Stages 2 - 4 of the CVC coastline CMP will require ongoing liaison with Yaegl regarding outcomes of the CMP investigations. The project team recognises Council's requirements for Native Title Act notifications, although further information is required to clarify the requirements for these projects.

A summary of engagement during Stage 2 is provided below.

- 13/12/21: Presentation to Yaegl RNTBC on CVC CMPs and request for engagement with First Nations representatives.
- 9/2/22: Proposed scope for engagement with Yaegl Native Title holders including on Country meeting provided to YTOAC.
- 20/6/22: Meeting with traditional owners (RNTBC) - Native Title arrangements, Yaegl business activities, Yaegl history, language, knowledge and activities, discussion of project scope and study area for the CVC CMPs and the NPWS coastal hazard response plans for the campgrounds, request for ongoing involvement with Yaegl traditional owners, CMP forward plan tasks that are likely to be of interest to Yaegl, potential involvement and outcomes, Yaegl cultural mapping project.
- 13/4/22: The project team received written comments on the Clarence River CMP Scoping Study and Coastline and Estuaries CMP from NTSCorp, endorsed by the RNTBC. Background to the native title claims was also provided by NTSCorp. Comments on the CMP are as follows:

  Yaegl People have a deep and abiding connection to the lands and waters of their traditional country, and attribute particular cultural significance to the waterways, coastline and seas.

  The development of strong and mutually beneficial relationships between Yaegl People and the people and organisations working on Yaegl Country is of great importance to YTOAC.

We note that Hydrosphere and YTOAC have already begun an open dialogue and thank Hydrosphere for their commitment to collaborating with YTOAC throughout the studies.

The coastlines within Yaegl Country contain a high incidence of cultural sites of significance, middens and Aboriginal objects. Care must be taken throughout the study to ensure staff do not disturb or access Aboriginal sites. As such, ongoing consultation with YTOAC is essential for the entirety of the study, including before researchers do any activities on Yaegl Country.

Yaegl People also have a great interest in the methodologies and results of the studies, given that they will inform future management of Yaegl Country. It is also our view that the involvement and guidance of Yaegl People throughout the studies will lead to more accurate and reliable research.

We therefore seek a commitment from Hydrosphere to ensure their studies integrate the perspectives and wishes of Yaegl People, as Traditional Owners of a large portion of the relevant research locations, and that any cultural information received by researchers is handled with respect and sensitivity and is kept secure and only published with consent of the relevant Traditional Owners.

The directors of YTOAC suggest that opportunities should be provided for Yaegl People to be involved in the research activities. We submit that it is extremely important for researchers working on Yaegl Country to facilitate the involvement of and collaboration with Yaegl People in their studies.

We also note that it is appropriate for YTOAC representatives to be paid a fee for service in relation to any time and expertise offered to the study.

Due to the cultural importance and sensitivity of the study area to Yaegl People, it may be necessary at times for the engagement of paid cultural heritage officers to be present during the works, as advised by YTOAC.

The directors of YTOAC note Hydrosphere's commitment to provide ongoing updates as well as reports, and information relating to the progress of the study to YTOAC. The directors of YTOAC look forward to working further with Hydrosphere in relation to this study and to continue strengthening the relationship between the organisations.

- 12/9/22 - Presentation to Yaegl RNTBC on CVC CMPs and NPWS plans. Feedback from the Board was as follows:
    - Yaegl cultural mapping project is nearly finished. Cultural mapping could be overlaid with coastal hazard (erosion, recession, inundation) mapping to identify cultural sites/values at risk and inform future management. This mapping task could be a CMP project.
    - Cultural sites need to be considered in the design of projects including sites in the water such as fish traps.
    - Weeds are also an issue impacting coastal cultural sites.
    - Sandon and Woody Head are both culturally significant sites. Assessments have been done that indicate significant artefacts/values. Both Sandon and Woody Head are women's sites.

- Yaegl are working with Ashley Moran (NPWS - Heritage Conservation) to develop management approaches for cultural heritage values/sites e.g. Plover Island at Sandon. This could also feed into future coastal management options.
- Moving forward, Yaegl would like to be involved in any discussion around planning/ management options in the coastal zone. The project team needs to consult with the traditional knowledge holders. To do this the project team needs to contact the RNTBC who will advise the relevant knowledge holders.
- NTSCorp suggested on-Country discussions for consultation about specific sites.
- Next step is to present the coastal hazard mapping to Yaegl once it is finalised, then consult with Yaegl about management options for particular areas.

11.2.2 Coast and Estuary Management Committee

Updates have been presented to the CEMC on a regular basis as shown in Table 8.

Table 8: CEMC Meetings - Stage 2

Meeting date	Discussion topics	Feedback/ outcomes
24/9/21	• Coast and Estuary Grants received for follow up Wooli Beach nourishment, Coastline and Estuaries CMP (Stage 2 to 4). • Background to Wooli Beach Management Strategy.	Concerns with potential impacts of the Brooms Head revetment wall on properties located north of the bridge. Some protection of those properties is required. This would be considered through the hazard assessment in the CMP Stage 2 and physical modelling. It is also proposed there be a community meeting at Brooms Head to present assessment outcomes and potential management options.
9/9/22	• Introduction to CMP Stages 2-4, CMP study area, scope of detailed studies, consultation activities, • Wooli Beach Nourishment - no sand on beach so project is on hold, Brooms Head physical modelling - Council allocated funding to undertake modelling of proposed sea wall at the lake entrance. DPE has advised a method which can be followed. • Presentation of FSG Geotechnics and Foundations (2022) report and recommendations	Carried motion: *That the Clarence Valley Coast and Estuary Management Committee recommends Council adopts the following short-term options as recommended by FSG (geotechnical consultants), subject to grant funding:* • *Review and repair existing instrumentation* • *Review monitoring program* • *Additional geotech investigations* • *Update slope stability analysis and risk assessment* • *Undertake stormwater and landscaping improvements where recommended*
November 2023	• Stage 2 coastal hazard assessment outcomes	Not yet available.

11.2.3 Clarence Valley Council

Following commencement of Stage 2, an information report and recommendations were presented to Council at the Ordinary Council meeting of 27/9/22 - Pilot Hill Yamba Geotechnical Assessment (07.22.221). At that meeting, Council resolved [07.22.221] to:

…

3. Adopt the following short-term options for Pilot Hill Yamba as recommended by FSG (geotechnical consultants), subject to grant funding:

a. Review and repair existing instrumentation

b. Review monitoring program

c. Additional geotech investigations

d. Update slope stability analysis and risk assessment

e. Undertake stormwater and landscaping improvements where recommended

4. Include funding of the matching contribution for the Pilot Hill Yamba investigations as one of the projects within the Category D Local Government Recovery - Local Council Support "Improved drainage and flood immunity initiatives" allocation resolved at the August Meeting.

5. Investigate the feasibility of releasing land risk zoned properties from this study if they are zoned LRZ2 "acceptable/tolerable risk" and these properties have submitted their own current geotechnical reports to Council and report back to Council.

Ongoing meetings have been held with CVC staff to discuss project outcomes including a planned workshop with the Council Working Group on Stage 2 outcomes.

11.2.4 Government agencies

In addition to the CEMC meetings, engagement with NSW Government agencies has included:

- Department of Planning and Environment - Biodiversity and Conservation Division (DPE - BCD):
    - Ongoing liaison regarding technical aspects of the project including review of methodology, progress and reports.
    - In late December 2022, DPE representatives advised that the Department would conduct an external peer review of the draft coastal erosion/ recession assessment. The aim of the peer review was to contribute to a state-wide approach that DPE is developing to ensure a consistent, robust and legally defensible coastal hazard modelling and assessment approach is undertaken by all NSW councils. This is a developing specialist field and DPE - BCD is transitioning to a better-defined approach for the coastal hazard assessments. The peer review and delays in the project do not suggest any flaws in the approach undertaken by the project team to date. The project team has been working with DPE to confirm the approach to be undertaken to finalise this stage of the CMP development.

- NPWS:
    - Outcomes of Stage 2 studies for National Parks and Reserves.
    - Development of the Coastal Hazard Response Plans for Woody Head and Sandon campgrounds (Section 9.1).

11.2.5 Community and interest groups

The Clarence Conversations website includes project information, useful links, downloads, a discussion forum and questions page. The webpage will be updated through all stages of the CMP development. During Stage 2, the website included a link to the Scoping Study, a summary of feedback received during Stage 1, a summary of the Stage 2 studies and invitation to engage through the Questions Page or Discussion Forum.

Project updates were also provided on the Clarence Valley Noticeboard on 26 November 2021.

Social media posts were included on Council's Facebook page e.g.:

- 17 December 2021: providing an update and inviting feedback via the Clarence Conversations website.
- 11 January 2022: Erosion prevention measures at Wooli.
- 31 March 2022: Erosion at Brooms Head.
- 18 February 2022: Envite Recovery team repair of Brooms Head walking track.
- 28 March 2022, 30 March 2022, 14 April 2022: Pilot Hill landslip update and closure of roads and pedestrian access.
- 30 March 2022: Closure of pedestrian access at Brooms Head beach and caravan park due to hazardous surf warning and recent heavy rain.
- 6 April 2022: Construction of elevated walkway at Convent Beach
- 3 May 2022: Update on Yamba Hill zig zag pathway construction.
- 22 September 2022: New accessible walkway from William Ager Park to Pippi Beach.
- 14 August 2023: Wooli Beach access renewal project.

Since the preparation of the Scoping Study, community members have expressed concerns to CVC about coastal management issues including:

- Erosion along Brooms Head foreshore, recession of the shoreline beyond the extent of the existing seawall and the loss of foreshore.
- The application of the Emergency Management Plan for Pilot Hill and the response to rainfall events, particularly the restrictions imposed.
- Water quality in Lake Cakora when the entrance is closed.

Feedback from the community has been considered in the detailed risk assessment (Section 6).

11.3 Other stakeholder engagement activities

11.3.1 Wooli Beach Management Strategy

Community consultation was undertaken in November 2020 for the Wooli Beach Management Strategy (Section 7.2). A drop-in session was held at the Wooli Public Hall with approximately 20 local residents attending. All representatives were supportive of BMS proposed. The strategy was also presented to the CEMC in November 2020. Key comments received from the community consultation have influenced the design of the strategy (Royal HaskoningDHV, 2021).

11.3.2 NPWS Coastal Hazard Response Plans

In partnership with NPWS, community reference groups were established to assist in the development of the NPWS Coastal Hazard Response Plans. The group consisted of Aboriginal representatives, community representatives, site users, state government agencies, Council and other interest groups. Two meetings were held with the community reference group:

- Meeting 1 - introduction to the project, presentation of information on coastal hazards and asset risks, determine community objectives and gather information
- Meeting 2 - present management options, obtain input into options, discuss management plan components.

Representatives from Yaegl traditional owners were included in the community reference group but were unable to attend the meetings. A separate meeting was held with the YTOAC to present the project scope. Yaegl requested further consultation on planning and management options for the coastal zone. This will be undertaken during the public exhibition phase and during the development of the Clarence Valley Coastline CMP.

DPE also provided a technical review role during the development of the plans.

Ongoing consultation with stakeholders will also be required as part of the plan implementation.

12. RECOMMENDATIONS FOR STAGE 3

Stage 2 has provided detailed information on coastal management threats and identified the highest risk threats to be addressed in the CMP. The recommended scope of Stage 3 is discussed in the following sections.

12.1 Scope of Stage 3

The work undertaken in Stages 1 and 2 of the CMP development provides information on the issues and risks affecting the CVC coastal zone. Stage 3 involves the identification and evaluation of management options and will include:

- Development of a strategic approach to risk management: (e.g. alert, avoid risks, active intervention, planning for change, emergency response, Section 12.3).
- Evaluating management actions, considering feasibility (is it an effective and sustainable way to treat the risks?), viability and acceptability to stakeholders.
- Engaging public authorities about implications for their assets and responsibilities.
- Preparing a business plan for implementation - capital and operational costs, distribution of costs and benefits, funding and delivery.

Stage 3 will consider all findings from Stage 1, Stage 2 and stakeholder engagement activities. Key Stage 3 stakeholders include Native Title holders, the CEMC, government agencies and the community. The Stakeholder Engagement Plan included in the Scoping Study details the required community engagement activities. Consultation will take also place with each agency with either a responsible or supporting role for each action.

The level of risk for each threat determines the options assessment process that will be followed in Stage 3 (Figure 31). Stage 2 has confirmed that some of the risks are high and it is anticipated that decision making in Stage 3 will be of moderate complexity. An intermediate level of economic assessment involving a net present value analysis of capital and operating costs is required to assess the viability of active intervention options. Benefits of potential management responses will be expressed qualitatively. A more detailed cost-benefit analysis may be required if any options require detailed analysis to determine socio-economic viability (potentially required for options >$5 million).

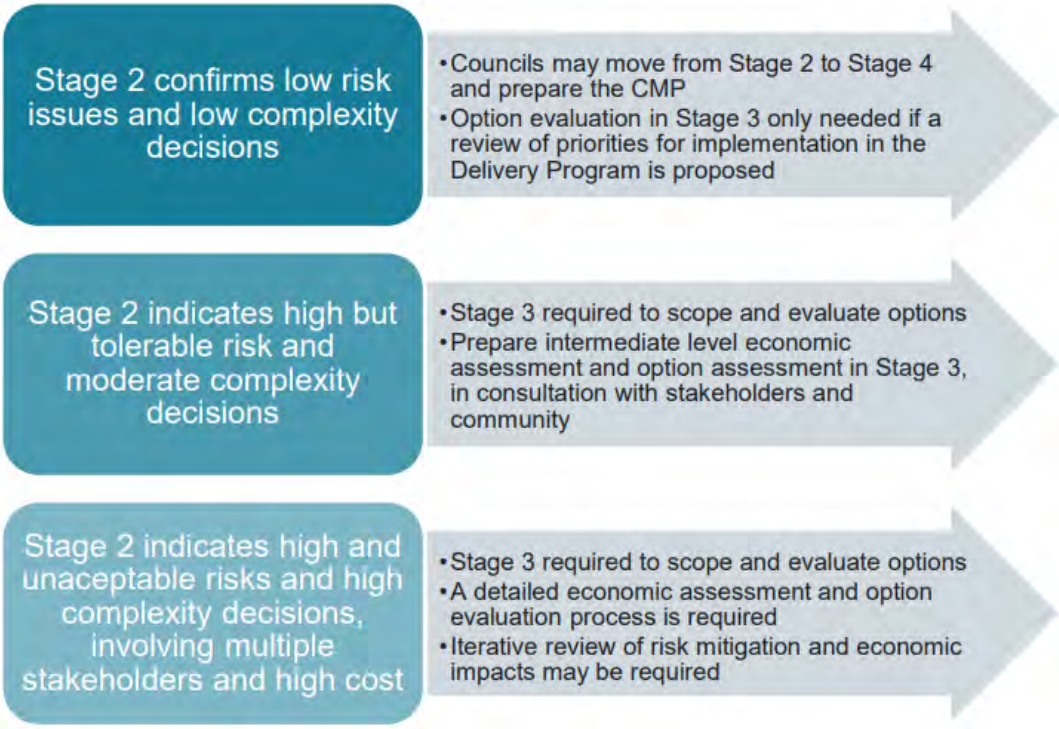


Figure 31: Level of options assessment required and moving on to Stages 3 or 4

Source: Figure B2.29, *Coastal Management Manual Part B* (NSW Government, 2019)

12.2 Key Present-Day Threats

Due to the large geographical area, environmental, social and cultural values of the study area and projected climate change impacts, there are several key management threats to be considered in the CMP. Based on the existing information, the threats with a moderate or high risk in the current timeframe are listed Table 9 and shown on Figure 32 to Figure 36 (refer risk assessment in Appendix 7). These threats will be the focus of the CMP and will require development and assessment of management options in Stage 3 including those discussed in Section 7. Stage 3 will identify which threats and actions will be prioritised in the CMP.

Table 9: Key threats to be considered in Stage 3 of the CMP - moderate or high present-day risk

Key threats	Locations
North of Clarence River	
T1 - Beach erosion	Shark Bay, Woody Head campground[1], Woody Bay[2]
T2 – Shoreline recession	Shark Bay, Iluka Road, Woody Bay[1,2]
T9 - Invasive weeds	Bundjalung National Park[2]
T17 - 4WD/ motorbikes on beaches	Shark Bay (Bundjalung National Park)[2]
T18 - Predation and invasion by introduced animals	Bundjalung National Park[2]
T22 - Modification of coastal wetland habitat due to coastal hazards	Bundjalung National Park
T43 - Damage to beach access points	Shark Bay[2], Iluka

Key threats	Locations
T47 - Reduced accessible beach at high tide due to coastal protection works	Woody Head[1]
T60 - Fallen/ dangerous trees on eroded beaches	Woody Bay[1,2]
Clarence River entrance	
T1 - Beach erosion	Whiting Beach
T2 – Shoreline recession	Whiting Beach
T3 - Tidal/ coastal Inundation	Whiting Beach
T22 - Modification of coastal wetland habitat due to coastal hazards	Hickey Island
T31 - Shoaling and sediment movement within estuaries	Clarence River entrance
T32 - Erosion and sedimentation affecting navigation	Clarence River entrance
Yamba/ Angourie	
T1 - Beach erosion	Yamba Main Beach, Convent Beach
T5 - Slope instability/ landslip	Pilot Hill, Convent Beach
T8 - Foreshore development	Yamba - Angourie
T9 - Invasive weeds	Yamba - Angourie coast
T17 - 4WD/ motorbikes on beaches	Barri Point
T43 - Damage to beach access points	Yamba, Spooky Beach
Brooms Head/ Lake Cakora	
T1 - Beach erosion	Lake Cakora (Ocean Road properties), Lake Cakora entrance, Brooms Head (foreshore reserve)
T2 – Shoreline recession	Lake Cakora entrance, Ocean Road properties, Brooms Head (foreshore reserve)
T3 - Tidal/ coastal Inundation	Lake Cakora (Ocean Road properties), Brooms Head (village)
T4 - Entrance instability	Lake Cakora
T6 - Erosion of foreshores	Lake Cakora
T9 - Invasive weeds	Brooms Head beach, Yuraygir National Park[2]
T16 - Uncontrolled dog access	Brooms Head beach
T17 - 4WD/ motorbikes on beaches	Brooms Head beach

Key threats	Locations
T22 - Modification of coastal wetland habitat due to coastal hazards	Brooms Head north, Lake Cakora
T25 - Poor flushing of ICOLLs	Lake Cakora
T43 - Damage to beach access points	Brooms Head
T47 - Reduced accessible beach at high tide due to coastal protection works	Brooms Head
Sandon	
T1 - Beach erosion	Sandon campground[3], Sandon village
T2 – Shoreline recession	Sandon campground[3], Sandon village
T3 - Tidal/ coastal Inundation	Sandon campground and access road[3], Sandon village
T9 - Invasive weeds	Yuraygir National Park[2]
T11 - Seagrass decline	Sandon River (particularly Toumbaal Creek)
T17 - 4WD/ motorbikes on beaches	Sandon (Yuraygir National Park) [2]
T18 - Predation and invasion by introduced animals	Yuraygir National Park[2]
T22 - Modification of coastal wetland habitat due to coastal hazards	Yuraygir National Park and surrounds[2]
Wooli/ Diggers Camp/ Minnie Water	
T1 - Beach erosion	Diggers Camp, Wooli village (south)
T2 – Shoreline recession	Wooli village
T3 - Tidal/ coastal Inundation	Wooli village (north), Wooli village (south)
T6 - Erosion of foreshores	Wooli Wooli River
T7 - Historic clearing of riparian vegetation and adjacent habitat	Wooli Wooli River
T9 - Invasive weeds	Wooli Wooli River, Wooli Beach, Yuraygir National Park[2]
T11 - Seagrass decline	Wooli Wooli River
T17 - 4WD/ motorbikes on beaches	Wooli Beach
T18 - Predation and invasion by introduced animals	Yuraygir National Park[2]
T22 - Modification of coastal wetland habitat due to coastal hazards	Minnie Water Beach, Wooli Wooli River, Yuraygir National Park[2]
T31 - Shoaling and sediment movement within estuaries	Wooli Wooli River
T32 - Erosion and sedimentation affecting navigation	Wooli Wooli River

Key threats	Locations
T43 - Damage to beach access points	Wooli, Diggers Camp, Minnie Water
All areas	
T52 - Inaccurate or incomplete mapping of coastal management areas	CVA, CWLRA
T53 - Inadequate land use planning and development controls	All areas
T54 - Damage to cultural heritage items/ sites	All areas
T62 - Litter	All areas

1. Likely to be addressed through inclusion of recommendations from the Coastal Hazard Response Plan for Woody Head Campground (Section 9.1) in the CMP.

2. Likely to be addressed through NPWS operations and plans of management. Actions may also be included in the CMP.

3. Likely to be addressed through inclusion of recommendations from the Coastal Hazard Response Plan for Sandon Campground (Section 9.1) in the CMP.

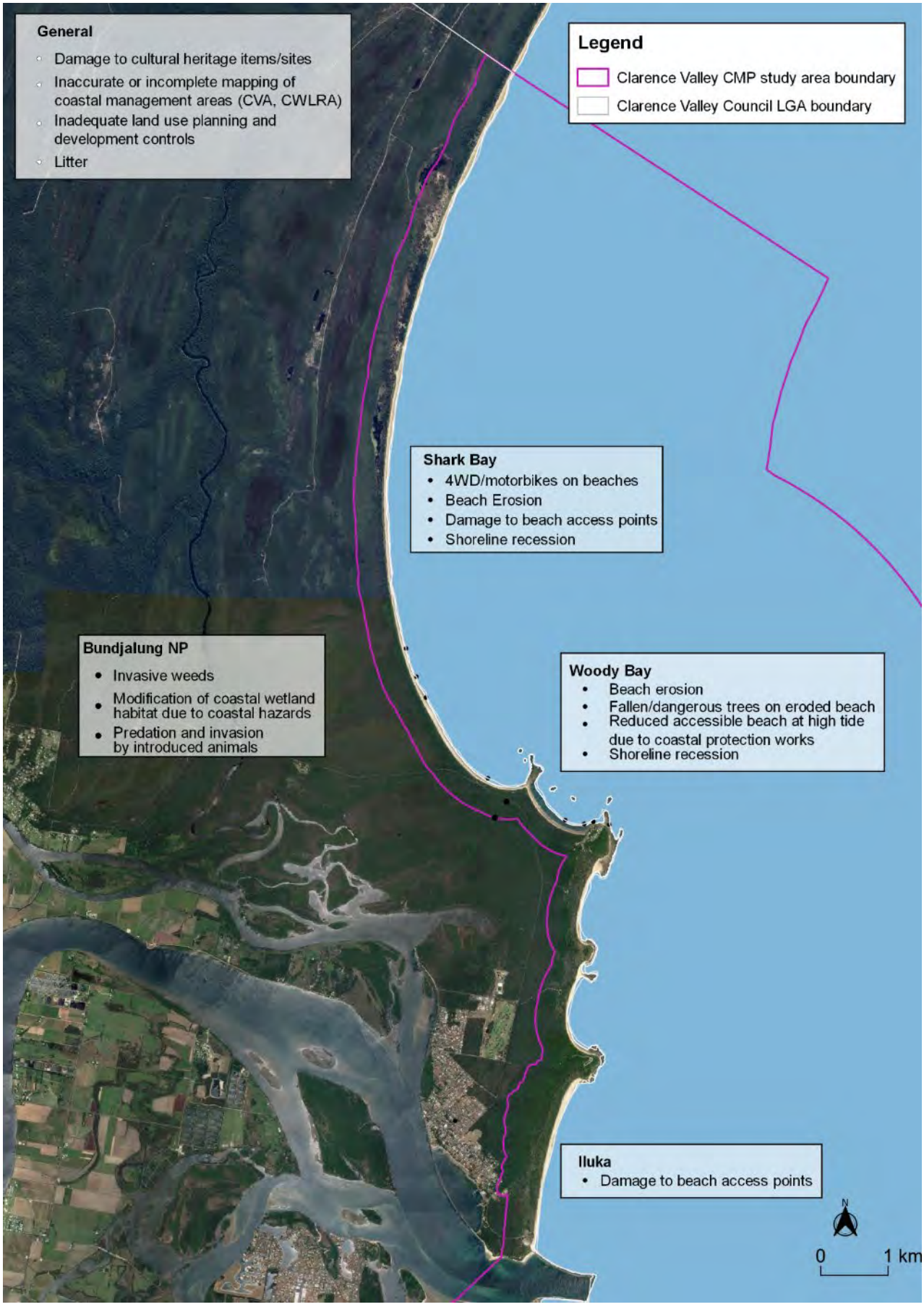


Figure 32: Key risks and threats to be addressed in the CMP - moderate or high present-day risk: Shark Bay to Iluka

Figure 33: Key risks and threats to be addressed in the CMP - moderate or high present-day risk: Clarence River to Angourie

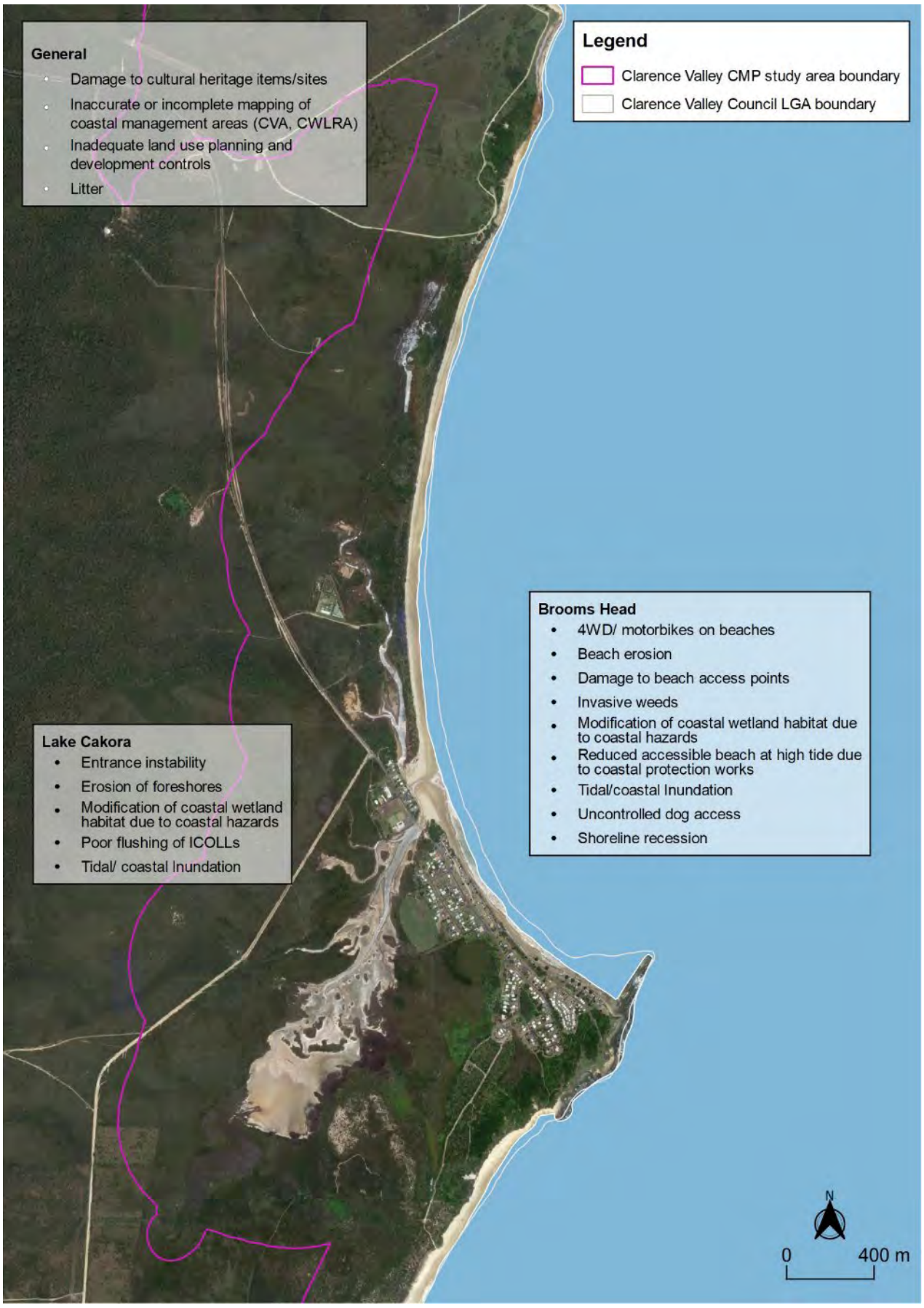


Figure 34: Key risks and threats to be addressed in the CMP - moderate or high present-day risk: Brooms Head and Lake Cakora

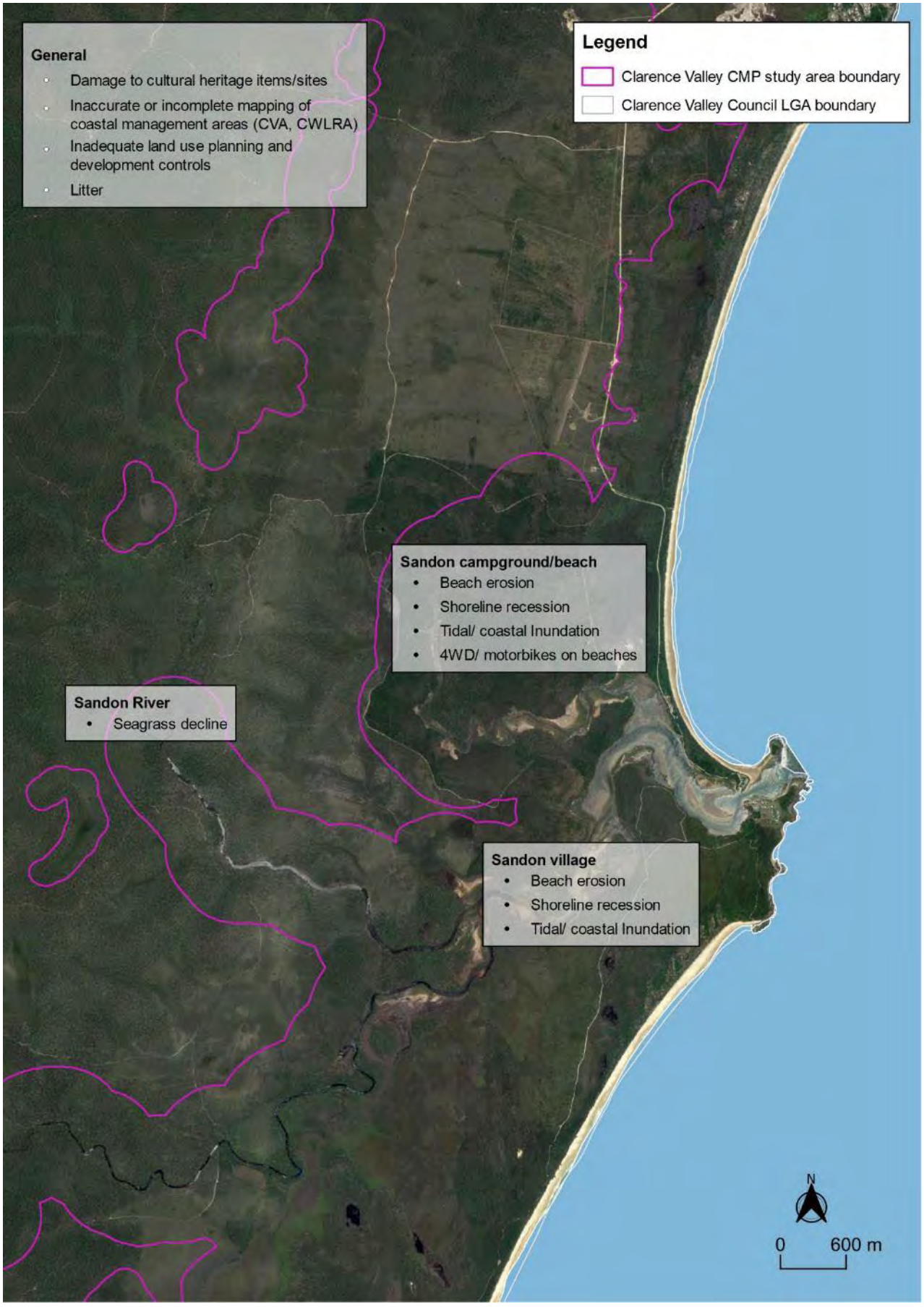


Figure 35: Key risks and threats to be addressed in the CMP - moderate or high present-day risk: Sandon area

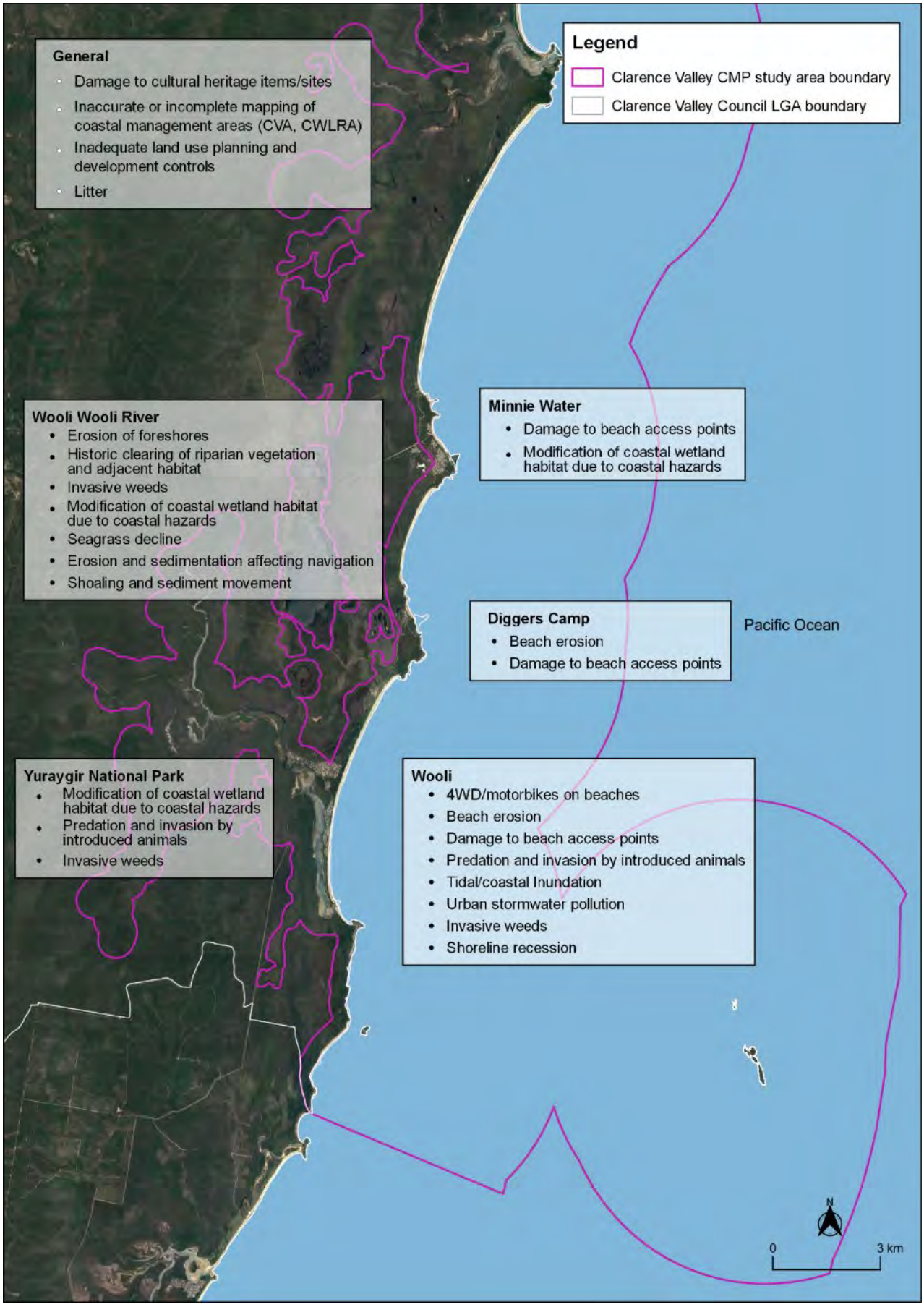


Figure 36: Key risks and threats to be addressed in the CMP - moderate or high present-day risk: Minnie Water to Wooli

12.3 Emerging Threats

Even though some risks may not be apparent at present, risks that require complex strategies such as updates to planning controls or address complex and/or large-scale risks that require longer term planning will also be considered in the CMP (Table 10). General, shire-wide management actions to be considered in Stage 3 (e.g. planning amendments discussed in Section 8.5) are also likely to address other lower priority threats and the threats that are expected to emerge over time.

Table 10: Emerging threats to be considered in Stage 3 of the CMP - moderate or high present-day risk

Emerging threats	Locations	Timeframe
T1 - Beach erosion	Ten Mile Beach, Illaroo campground, Minnie Water Beach	20 years
	Pippi Beach, The Sandon, Wooli Beach (north), Wooli village (north)	50 years
T2 – Shoreline recession	Yamba Main Beach, Brooms Head (Main Beach)	20 years
	Convent Beach, Pippi Beach, The Sandon, Illaroo campground, Minnie Water Beach, Wooli Beach (north)	50 years
	Turners Beach	100 years
T3 - Tidal/ coastal Inundation	Illaro campground	20 years
	Iluka, Yamba Main Beach, Diggers Camp	50 years
	Shark Bay, Brooms Head Foreshore Reserve	100 years
T6 - Erosion of foreshores	Sandon River	50 years
T15 - Anthropogenic barriers (i.e. physical barriers, land use and planning constraints) to migration of vegetation communities with sea level rise	Lake Cakora, Sandon River, Wooli Wooli River	50 years
T26 - Sea level rise increasing salinity within the estuary	Lake Cakora, Sandon River, Wooli Wooli River	50 years
T27 - Climate warming and extreme temperatures	Study area	50 years
T28 - Increased storminess and changed rainfall patterns	Study area	50 years

12.4 Potential Strategic Approaches

Stage 3 will consider the strategic approaches adopted in the Coastal Management Manual (OEH, 2019b) with identification of management options to reduce the identified risks and create opportunities to manage any unacceptable risks, development of adaptation pathways over time and evaluation of potential actions. The potential strategic risk management approaches are:

- Alert - coastal management actions that seek to 'watch and wait' such as monitoring change and setting thresholds, "low regret" responses and research to improve knowledge.
- Avoid future impact - proactive land use planning and development only in low-risk locations.
- Active intervention - includes coastal management actions that seek to protect assets or accommodate change, while maintaining current systems and values.
- Planning for change - includes planning to relocate or redevelop assets to consider the dynamic and ambulatory nature of the shoreline. This may be timed to commence as opportunities arise or when thresholds of exposure, impact and risk are exceeded.
- Emergency response - includes actions to address residual risk in emergency situations.

It is recognised that coastal processes will impact on the natural landscape over time and that intervention may not be able to stop "nature taking its course". However, there is uncertainty with the extent and timing of the coastal hazards. This uncertainty and the need to be adaptive to changing circumstances will be acknowledged in the selection of management options.

The broad strategic approaches that will be applied are shown on Figure 37. Management approaches will aim to enhance natural defences and/or avoid future risk by encouraging land uses that reduce exposure to coastal hazards.

Figure 37: Strategic risk management approaches to address coastal hazards
Source: OEH (2019b)

12.5 Stakeholder Engagement

The outcomes of Stage 2 will be presented to stakeholders including:

- The CEMC including representatives from Council, state government authorities, Native Title holders and the community.
- Yaegl Traditional Owners.
- NPWS (in relation to Parks and Reserves).
- Update of the Stage 1 webpage on Clarence Conversations including webpage tools to enable provision of information and collection of feedback from the community.

This Stage 2 report and detailed studies will be available for download from the Clarence Conversations webpage once adopted by CVC.

Stage 3 consultation activities will include:

- Meetings with the CEMC and NSW government agencies.
- Community displays - Stage 2 outcomes and potential management options.
- Workshop/s with community/industry and business groups.
- Meeting with YTOAC - Stage 3 potential management options.
- CEMC workshop - Stage 3 potential management options.
- Ongoing meetings will be held with CVC staff to discuss project outcomes including a workshop with the Council Working Group on Stage 3 outcomes.

The Stage 3 report and detailed studies will be available for download from the Clarence Conversations webpage once adopted by CVC. Feedback on Stage 3 outcomes and input into Stage 4 will be invited.

Where CMP actions are required to be implemented by government agencies, agreement with these agencies will be obtained as part of Stage 3 and 4.

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APPENDIX 1 2022 TOPOGRAPHIC SURVEYS

Plans and cross-sections from the 2022 surveys undertaken at Pilot Hill, Convent Beach, Brooms Head and Wooli are attached.

Notes:

1. UAV Lidar survey undertaken 10/02/2022 by Hydrosphere Consulting.
2. Aerial photography supplied by Nearmaps Imagery dated 28/05/2016.
3. All vertical levels relative to AHD.
4. Horizontal datum used MGA.
5. Refer Figure 4 for vertical profiles.
6. Survey referenced to CORSnet-NSW.
7. Survey elevation accuracy assessed against Yraygir2018-C3-AHD_5356743_56_0001_0001 Lidar dataset.

DRAWING PRODUCED BY: HYDROSPHERE CONSULTING P.O. BOX 7059 BALLINA NSW 2478 WWW.HYDROSPHERE.COM.AU	Hydrosphere Consulting — Strategy in Water & Environment	SCALES 0 20 40 Metres	CLIENT: Clarence Valley Council	JOB NUMBER: 22-009	REVISION	DATE / DESCRIPTION / DRAWN: 2022-02-27 / REV 0 / JF	DRAWING NUMBER: FIGURE 3

Pilot Hill Profile locations
Yamba

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Notes:

1. UAV Lidar survey undertaken 10/02/2022 by Hydrosphere Consulting.
2. Aerial photography supplied by Nearmaps Imagery dated 28/05/2016.
3. All vertical levels relative to AHD.
4. Horizontal datum used MGA.
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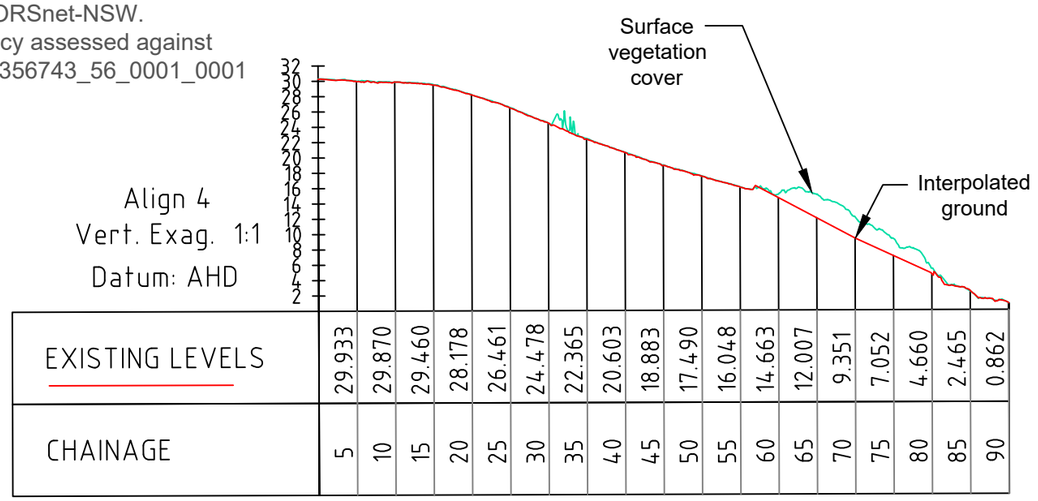
6. Survey referenced to CORSnet-NSW.
7. Survey elevation accuracy assessed against Yraygir2018-C3-AHD_5356743_56_0001_0001 Lidar dataset .

Lidar sub-sampled ground level (unedited)

Lidar edited interpolated minimum values for ground level (approximate)



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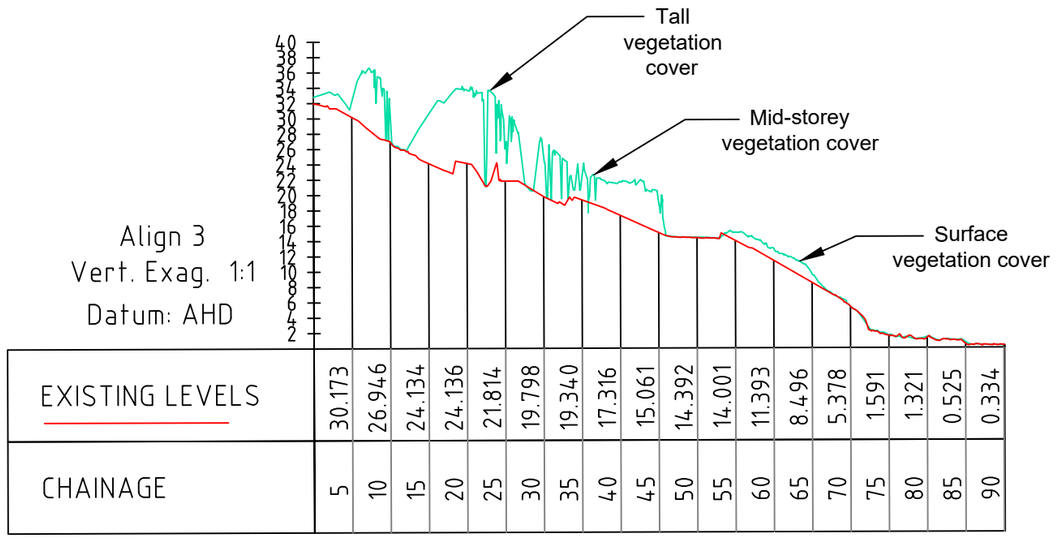

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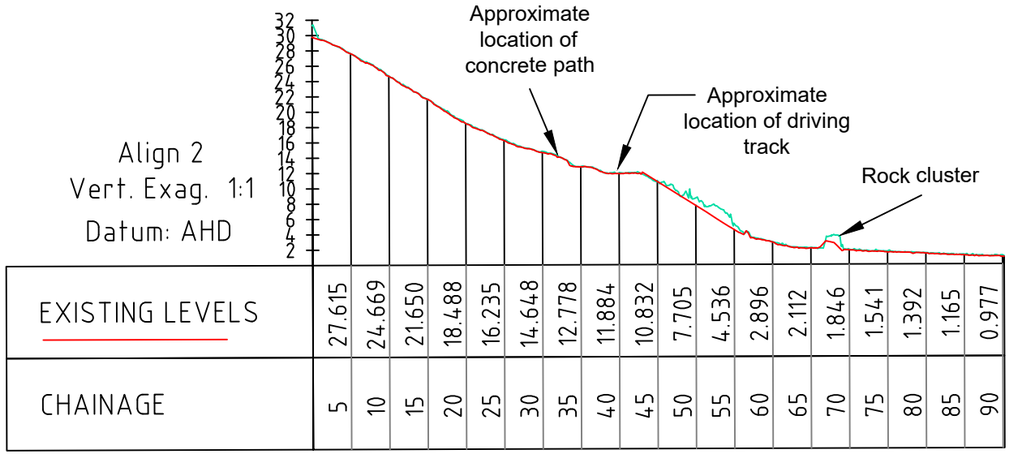

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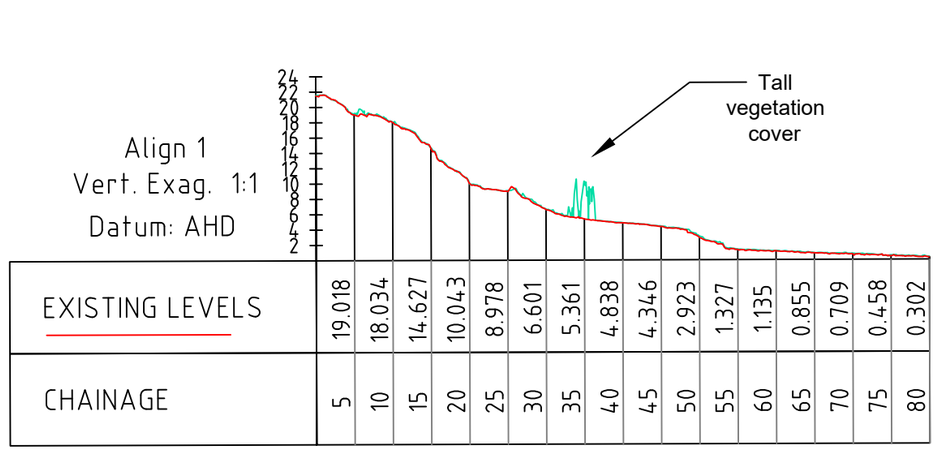

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DRAWING PRODUCED BY: HYDROSPHERE CONSULTING P.O. BOX 7059 BALLINA NSW 2478 WWW.HYDROSPHERE.COM.AU	Hydrosphere Consulting Strategy in Water & Environment	SCALES 0 20 40 Metres	CLIENT Clarence Valley Council Pilot Hill Profile Sections Yamba	JOB NUMBER 22-009	REVISION DATE: 2022-02-27 DESCRIPTION: REV 0 DRAWN: JF	DRAWING NUMBER FIGURE 4

Y:\22-009 Clarence coastline CMP stage 2-4\Drawings\Pilot Hill sections.dwg

Notes:

1. UAV Lidar survey undertaken 10/02/2022 by Hydrosphere Consulting.
2. Aerial photography supplied by Nearmaps Imagery dated 28/05/2016.
3. All vertical levels relative to AHD.
4. Horizontal datum used MGA.
5. Refer Figure 2 for vertical profiles.
6. Survey referenced to CORSnet-NSW.
7. Survey elevation accuracy assessed against Yraygir2018-C3-AHD_5356743_56_0001_0001 Lidar dataset .

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Strategy in Water & Environment

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Metres

CLIENT: Clarence Valley Council

JOB NUMBER: 22-009

Convent Beach Profile locations
Yamba

REVISION	DATE	DESCRIPTION	DRAWN
	2022-02-27	REV 0	JF

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FIGURE 1

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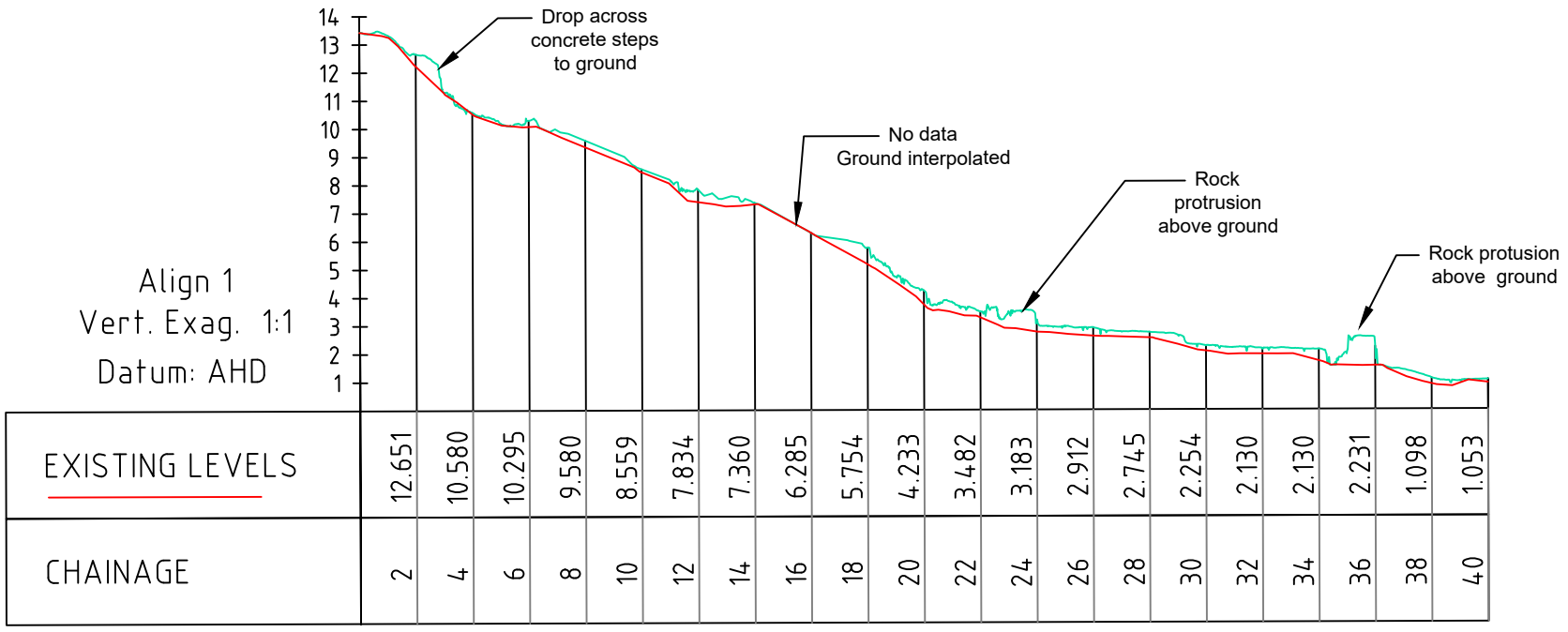
Notes:

1. UAV Lidar survey undertaken 10/02/2022 by Hydrosphere Consulting.
2. All vertical levels relative to AHD.
3. Horizontal datum used MGA.
4. Refer Figure 1 for vertical profile locations
5. Survey referenced to CORSnet-NSW.
6. Survey elevation accuracy assessed against Yraygir2018-C3-AHD_5356743_56_0001_0001 Lidar dataset.

KEY

Lidar edited interpolated minimum values for ground level (approximate)

Lidar sub-sampled ground level (unedited)



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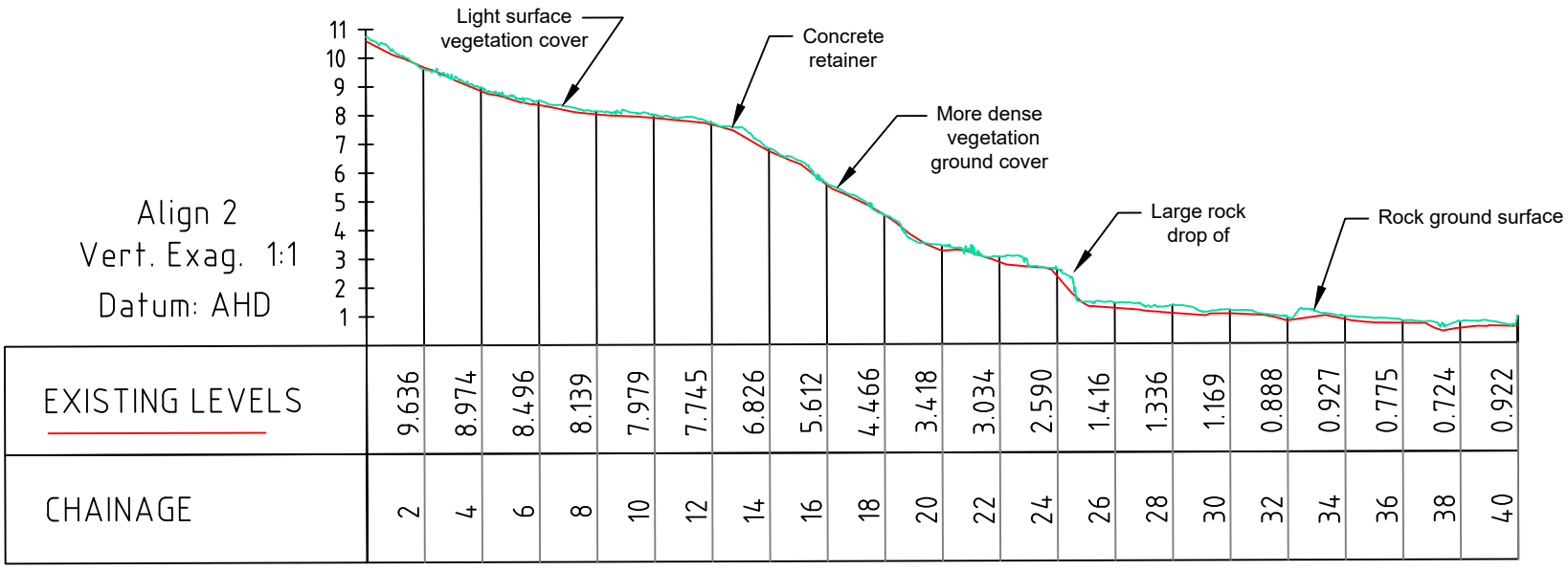

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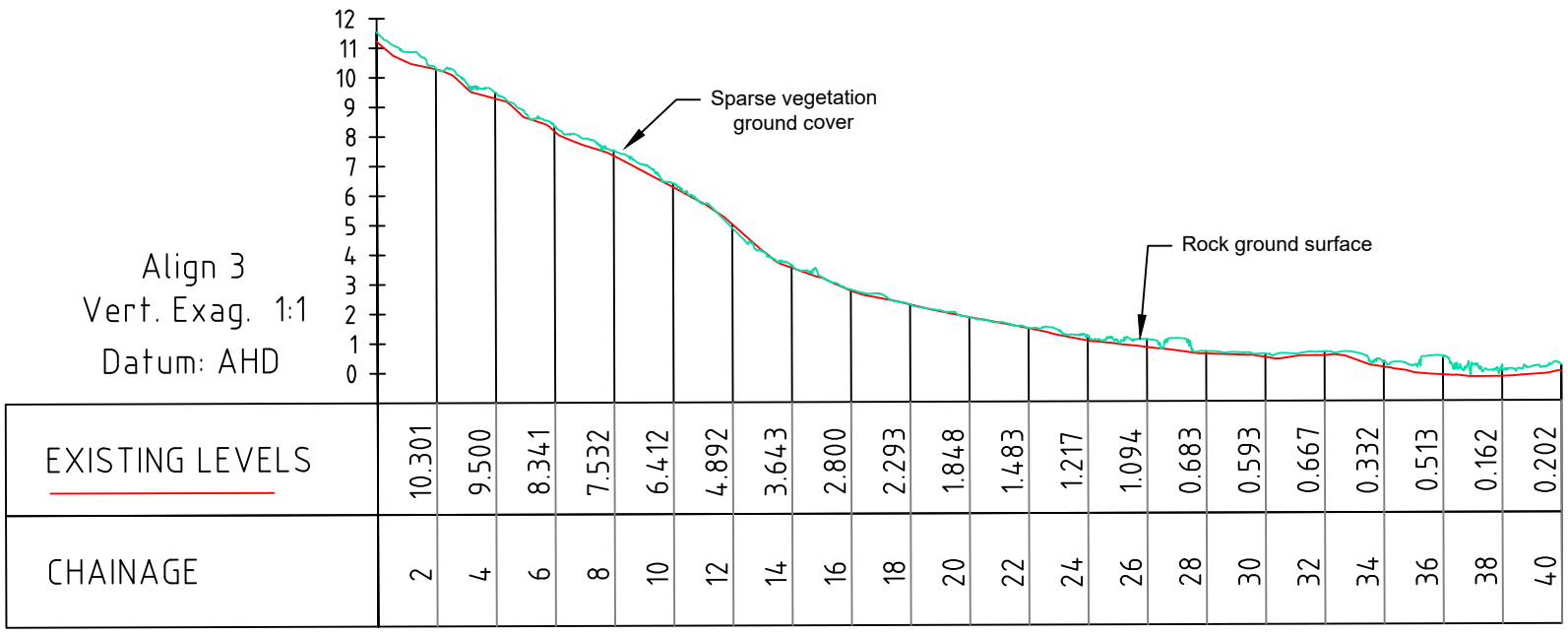

ALIGN 3

DRAWING PRODUCED BY: HYDROSPHERE CONSULTING P.O. BOX 7059 BALLINA NSW 2478 WWW.HYDROSPHERE.COM.AU	Hydrosphere Consulting	CLIENT: Clarence Valley Council	JOB NUMBER: 22-009	REVISION	DRAWING NUMBER: FIGURE 2
	SCALE: 0 10 20 Metres	TITLE: Convent Beach Sections Yamba		DATE: 2022/02/27 — DESCRIPTION: REV 0 — DRAWN: JF	

Notes:

1. UAV LIDAR survey undertaken 08/06/2022 by Hydrosphere Consulting.
2. Aerial photography supplied by Nearmap Imagery dated 04/05/2022.
3. Refer Figure 2 for vertical profile.

Y:\22-009 Clarence coastline CMP stage 2-4\Drawings\Brooms with additional sections.dwg

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Hydrosphere Consulting

Strategy in Water & Environment

SCALES

0 50 100

Metres

CLIENT: Clarence Valley Council

JOB NUMBER: 22-009

Brooms Head beach profile locations

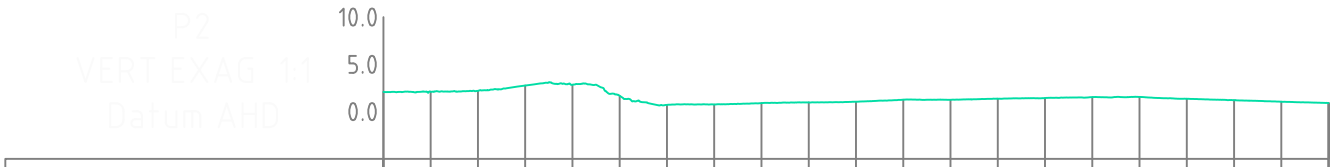
REVISION	DATE	DESCRIPTION	DRAWN
	2023-03-09	REV 0	JF

DRAWING NUMBER

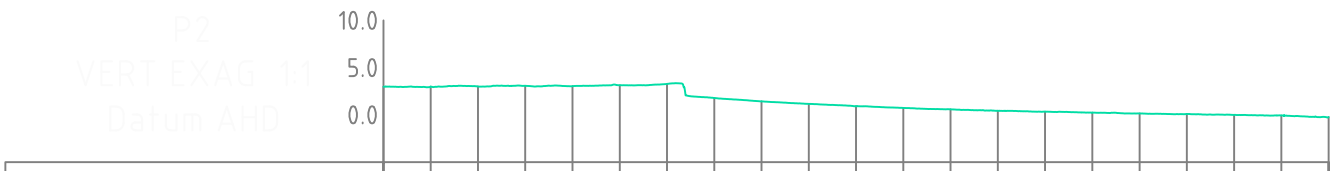
FIGURE 1

Notes:

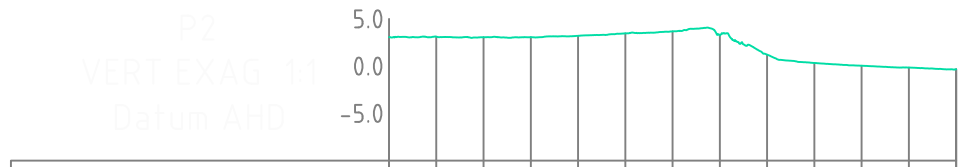
1. UAV LIDAR survey undertaken 08/06/2022 by Hydrosphere Consulting.
2. Refer Figure 1 for profile locations.



CHAINAGE	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
EXISTING LEVELS	2.105	2.188	2.761	2.839	1.671	0.711	0.752	0.902	0.977	1.042	1.259	1.251	1.365	1.434	1.533	1.554	1.359	1.210	1.046	0.910



CHAINAGE	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
EXISTING LEVELS	2.994	3.003	3.075	3.040	3.136	3.278	1.783	1.431	1.159	0.921	0.733	0.583	0.432	0.342	0.235	0.151	0.094	0.002	−0.068	−0.226



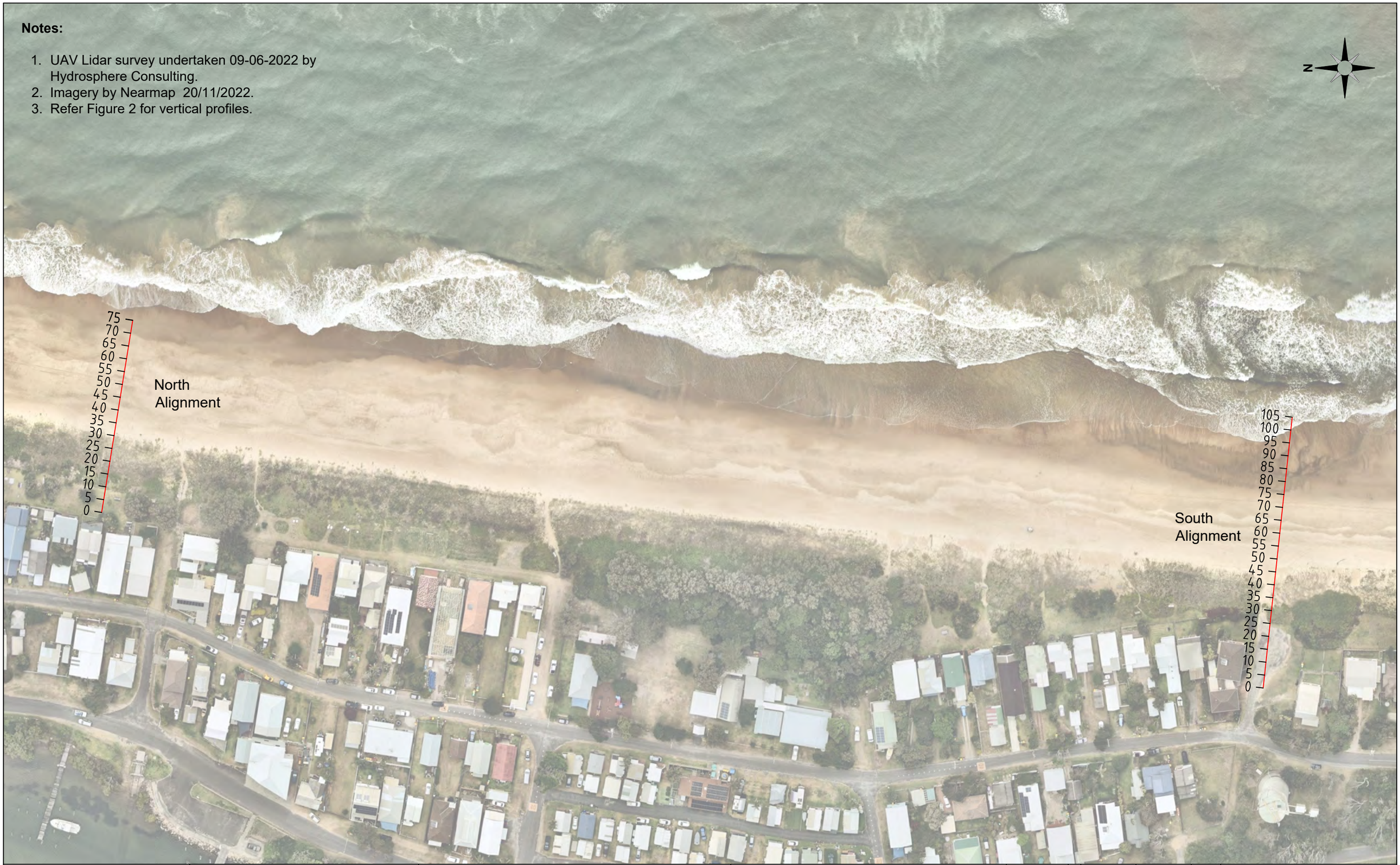
CHAINAGE	5	10	15	20	25	30	35	40	45	50	55	60
EXISTING LEVELS	3.114	3.060	3.067	3.208	3.469	3.679	3.243	1.208	0.333	0.043	−0.156	−0.342

SCALES	CLIENT	JOB NUMBER	REVISION	DATE	DESCRIPTION	DRAWN	DRAWING NUMBER
	Clarence Valley Council	18-000		YYYY-MM-DD	REV 0	MH	FIGURE 2
	Brooms Head Beach Profiles						SHEET 1 OF 1

Y:\22-009 Clarence coastline CMP stage 2-4\Drawings\Brooms with additional sections.dwg

Notes:

1. UAV Lidar survey undertaken 09-06-2022 by Hydrosphere Consulting.
2. Imagery by Nearmap 20/11/2022.
3. Refer Figure 2 for vertical profiles.



DRAWING PRODUCED BY:

HYDROSPHERE CONSULTING
P.O. BOX 7059
BALLINA NSW 2478

WWW.HYDROSPHERE.COM.AU

Hydrosphere Consulting

Strategy in Water & Environment

SCALES

0 50 100

Metres

CLIENT: Clarence Valley Council

JOB NUMBER: 22-009

Wooli Beach Profile Locations

REVISION	DATE	DESCRIPTION	DRAWN
	2022-02-27	Rev 0	JF

DRAWING NUMBER

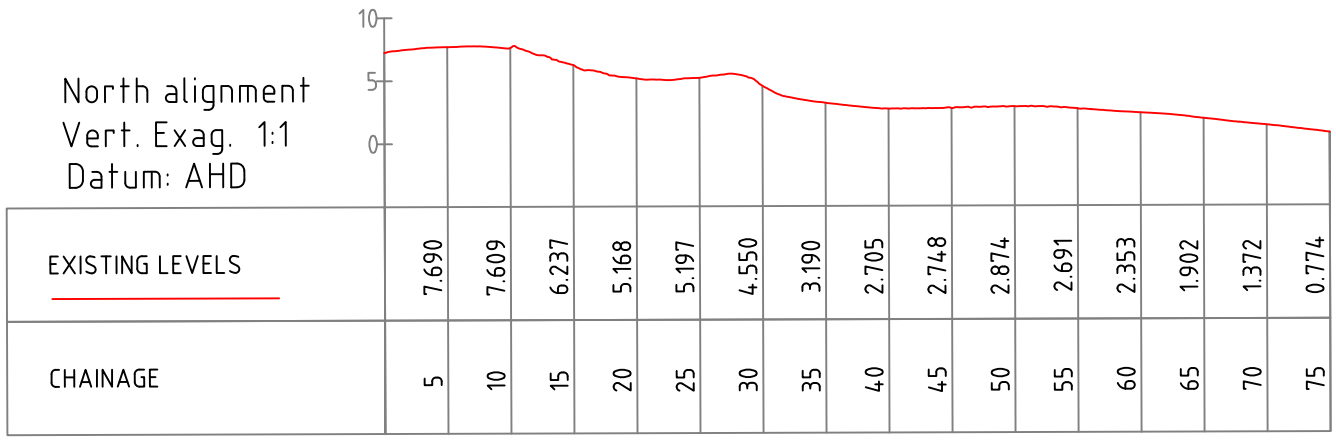
FIGURE 1

SHEET 1 OF 1

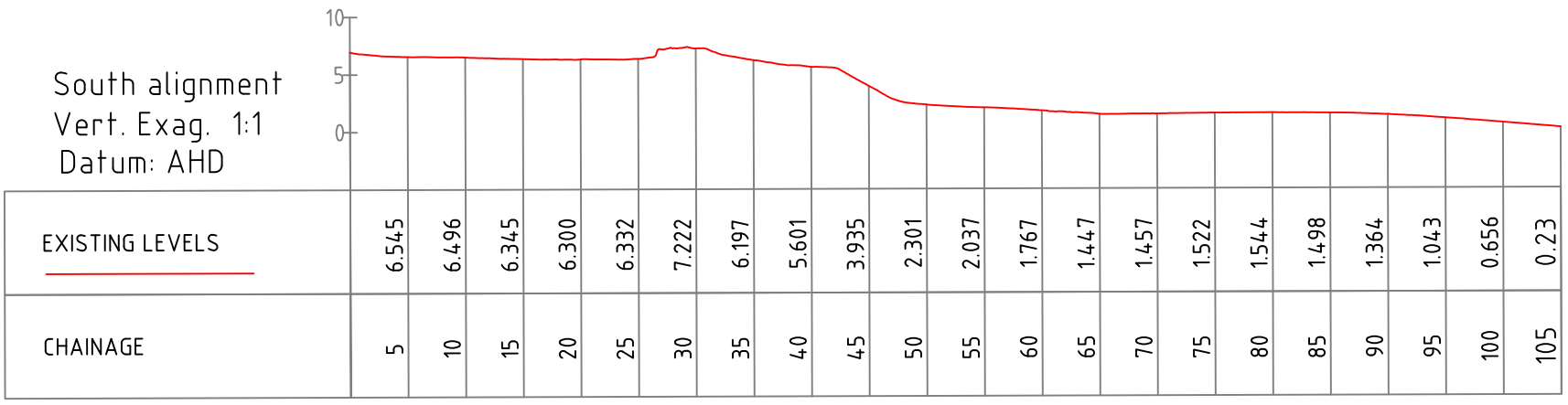
Y:\22-009 Clarence coastline CMP stage 2-4\Drawings\Wooli revised for scalebar issue.dwg

Notes:

1. UAV Lidar survey undertaken 09/06/2022 by Hydrosphere Consulting.
2. All vertical levels relative to AHD.
3. Refer Figure 1 for vertical profile locations
4. Survey referenced to CORSnet-NSW.
5. Survey elevation accuracy assessed against Yraygir2018-C3-AHD_5356743_56_0001_0001 Lidar dataset.



EXISTING LEVELS	7.690	7.609	6.237	5.168	5.197	4.550	3.190	2.705	2.748	2.874	2.691	2.353	1.902	1.372	0.774
CHAINAGE	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75



EXISTING LEVELS	6.545	6.496	6.345	6.300	6.332	7.222	6.197	5.601	3.935	2.301	2.037	1.767	1.447	1.457	1.522	1.544	1.498	1.364	1.043	0.656	0.23
CHAINAGE	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105

DRAWING PRODUCED BY:

HYDROSPHERE CONSULTING
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BALLINA NSW 2478

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Hydrosphere Consulting

SCALE

CLIENT: Clarence Valley Council

JOB NUMBER: 22-009

TITLE: Wooli Beach Sections

REVISION	DATE	DESCRIPTION	DRAWN
	2022/02/27	REV 0	JF

DRAWING NUMBER

FIGURE 2

Y:\22-009 Clarence coastline CMP stage 2-4\Drawings\Wooli beach sections.dwg

APPENDIX 2 TIDAL AND COASTAL INUNDATION ASSESSMENT

JBP (2022) *Clarence Coastline Tidal and Coastal Inundation Hazard Mapping*, 20 June 2022 and maping

Provided in a separate volume.

APPENDIX 3 COASTAL EROSION AND RECESSION ASSESSMENT

JBP (2023) *Coastal Erosion and Recession Hazard Assessment*, October 2023 and mapping

Provided in a separate volume.

APPENDIX 4 REGIONAL SCALE EROSION MAPPING

Provided in a separate volume.

APPENDIX 5 NORTHERN NSW COASTAL HAZARD ASSESSMENT – DESKTOP REVIEW

FSG Geotechnics and Foundations (2022) *Northern NSW Coastal Hazard Assessment - Desktop Review*

Provided in a separate volume.

APPENDIX 6 RISK AND EXPOSURE ASSESSMENT - COUNCIL ASSETS AND INFRASTRUCTURE

Methodology

An assessment of risks to Council infrastructure and Council-managed land from the coastal hazards of tidal/coastal inundation and beach erosion/ shoreline recession was undertaken for the study area. The methodology involved the following steps:

- Identification of relevant assets within the study area. The assets considered are shown on Figure 38 to Figure 44. NPWS assets within Woody Head and Sandon campgrounds are being assessed as part of the NPWS Coastal Hazard Response Plans and have not been included here. Similarly, other non-Council assets (e.g. electricity infrastructure and Crown assets) have not been considered.
- Application of a likelihood of occurrence (based on event frequency) for each coastal hazard (tidal inundation, coastal inundation and beach erosion/shoreline recession) and for various timeframes - refer Table 11.
- Application of a consequence rating for each hazard and type of asset - refer Table 12 and Table 13.
- Assessment of risk (consequence x likelihood) to each type of asset using the matrix provided in Table 14.
- Assessment of exposure of each asset to each hazard scenario - refer Table 15 to Table 29.

The risk assessment was undertaken for the combined coastal erosion/ recession hazard as a single set of hazard zones are provided. Although the timeframe for erosion (shorter term storm bite) is different to recession (longer-term net landward movement), the consequence to each asset/ value is generally the same for each hazard. Similarly, the consequence of tidal and coastal inundation hazard is the same (marine flooding) although the likelihood of each hazard may vary.

The hazard assessments for the study area are provided in JBP (2022) and JBP (2023). The hazard scenarios considered in the risk assessment are provided in Table 11.

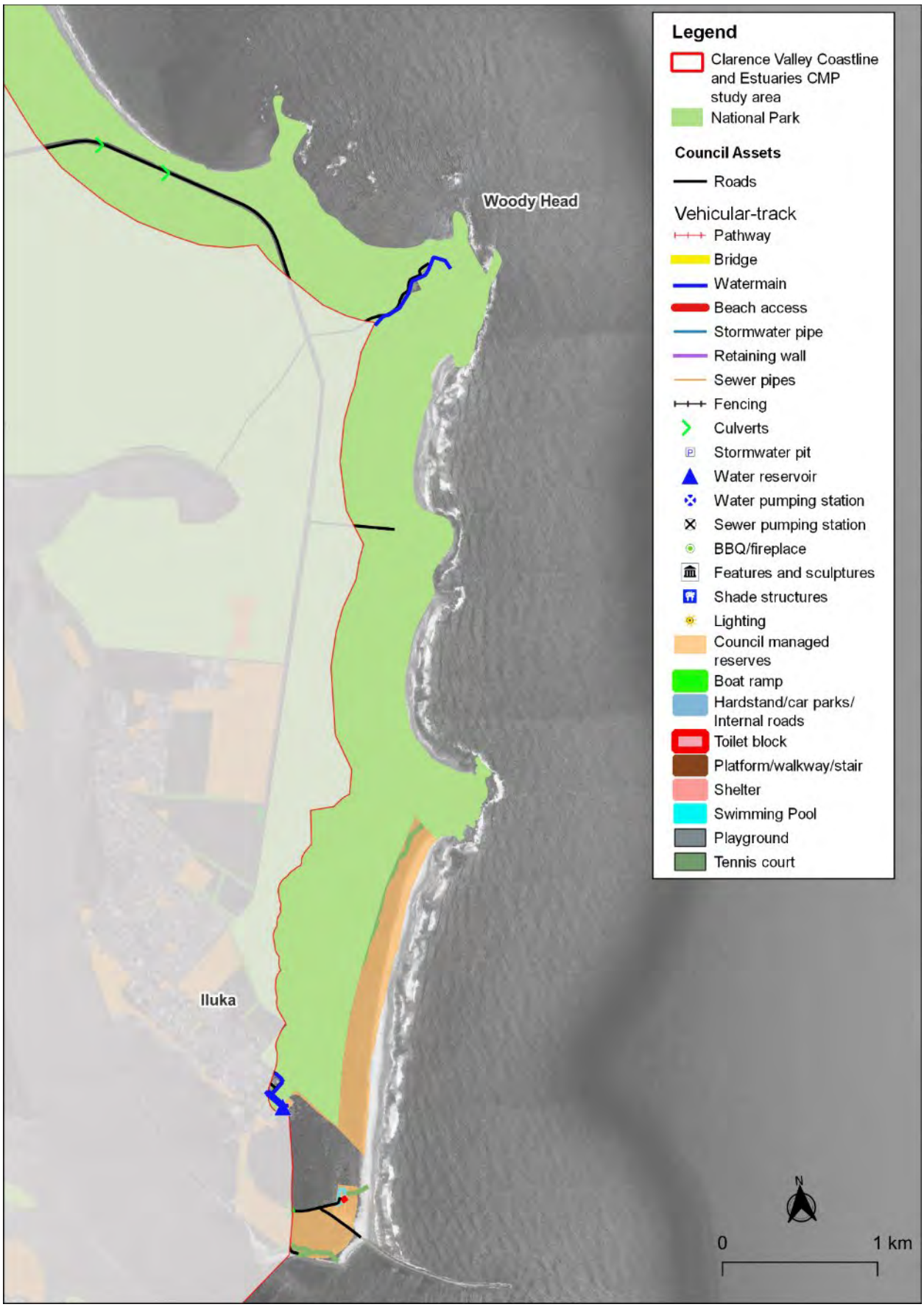


Figure 38: Council assets and infrastructure considered in risk and exposure assessment - Iluka and Woody Head

Source: data provided by CVC

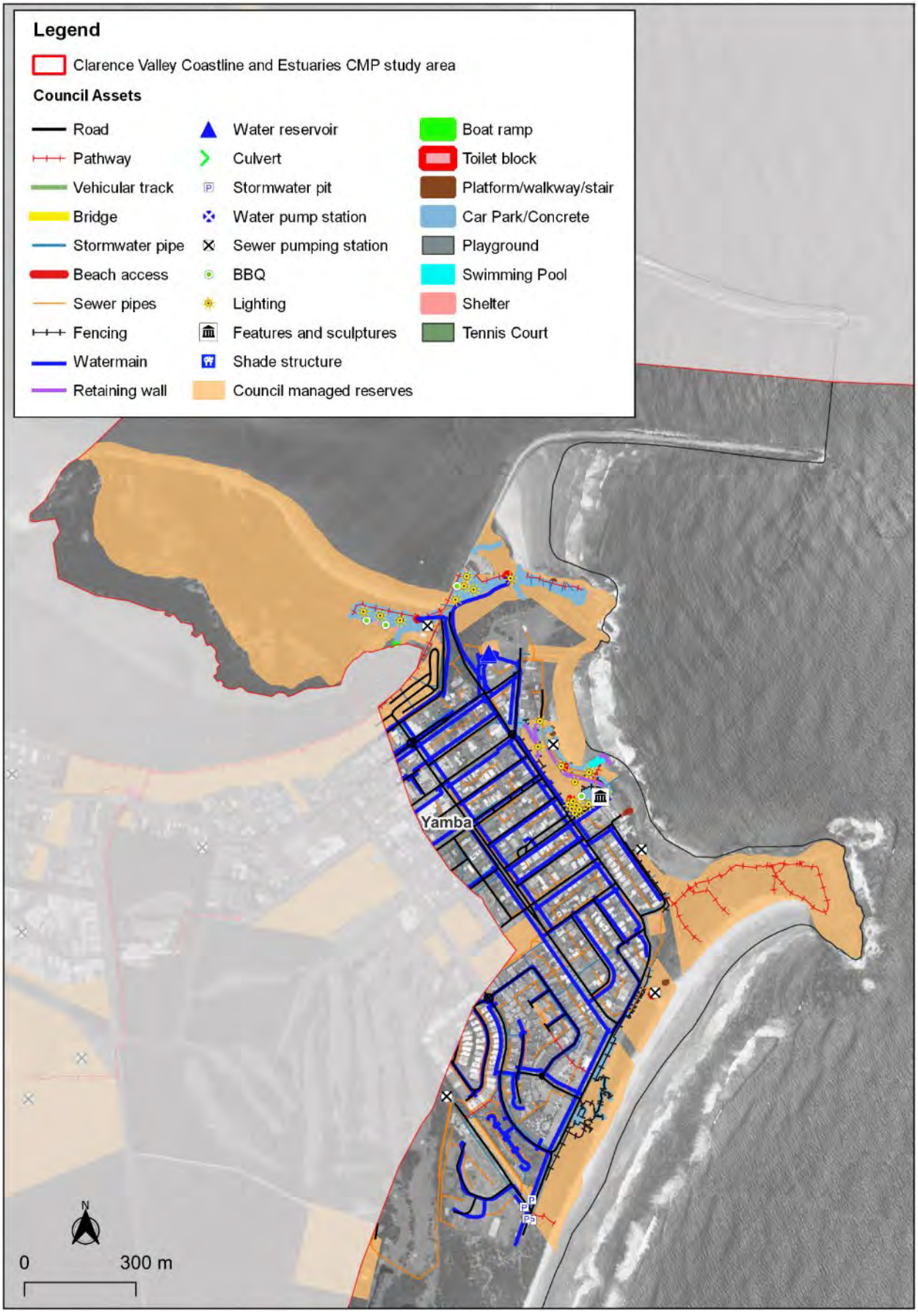


Figure 39: Council assets and infrastructure considered in risk and exposure assessment - Yamba

Source: data provided by CVC

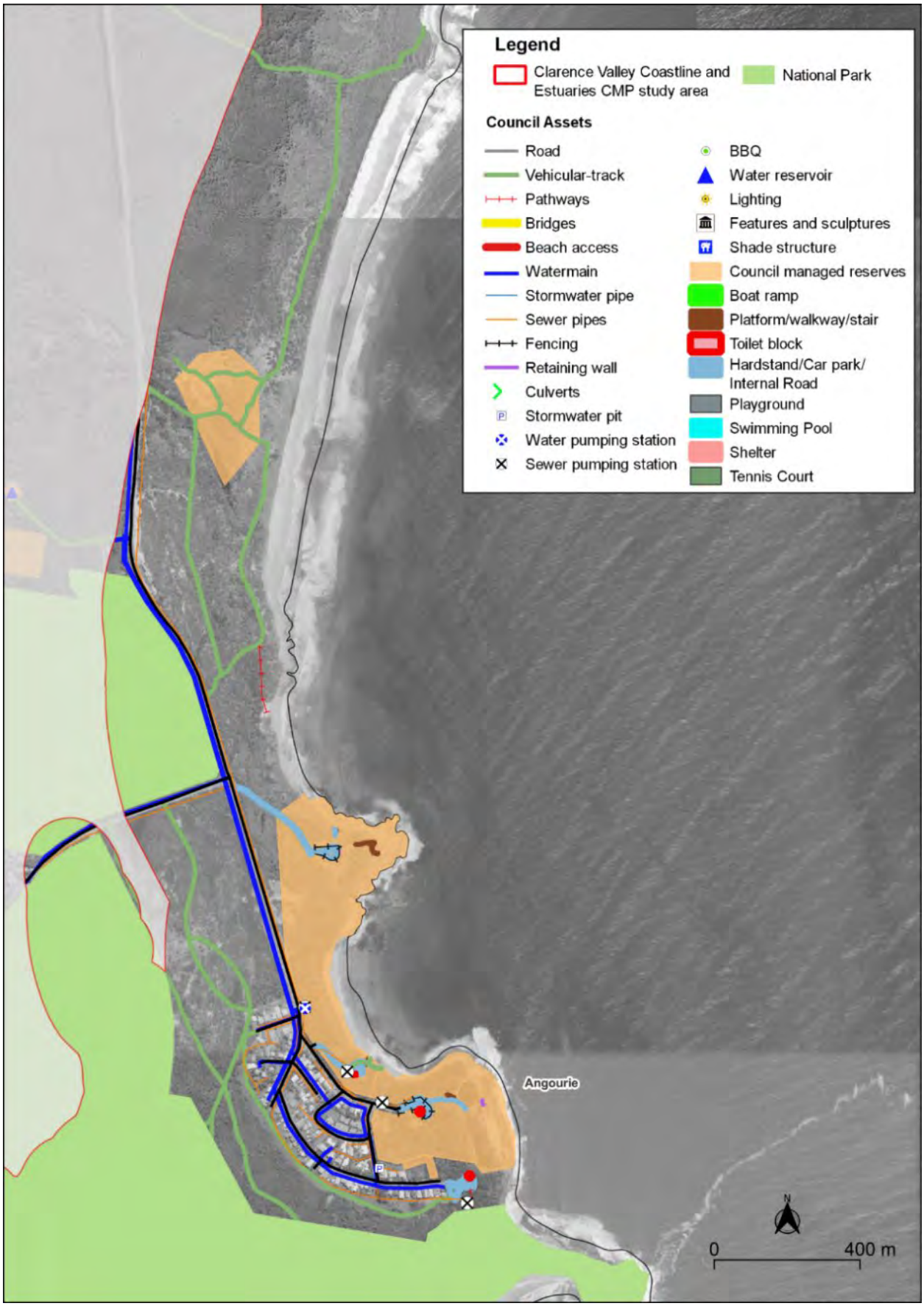


Figure 40: Council assets and infrastructure considered in risk and exposure assessment – Angourie

Source: data provided by CVC

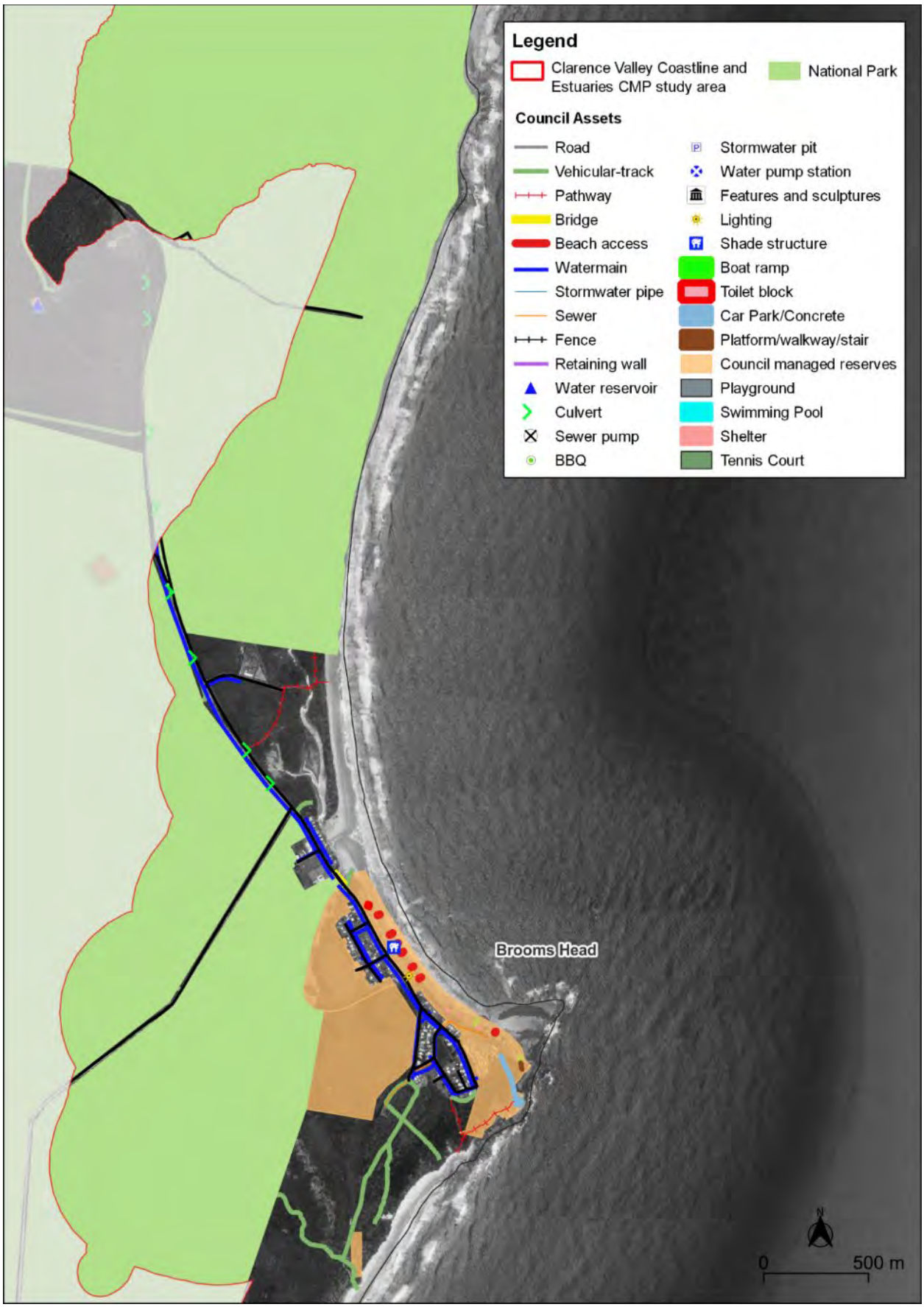


Figure 41: Council assets and infrastructure considered in risk and exposure assessment - Brooms Head and Lake Arragan

Source: data provided by CVC

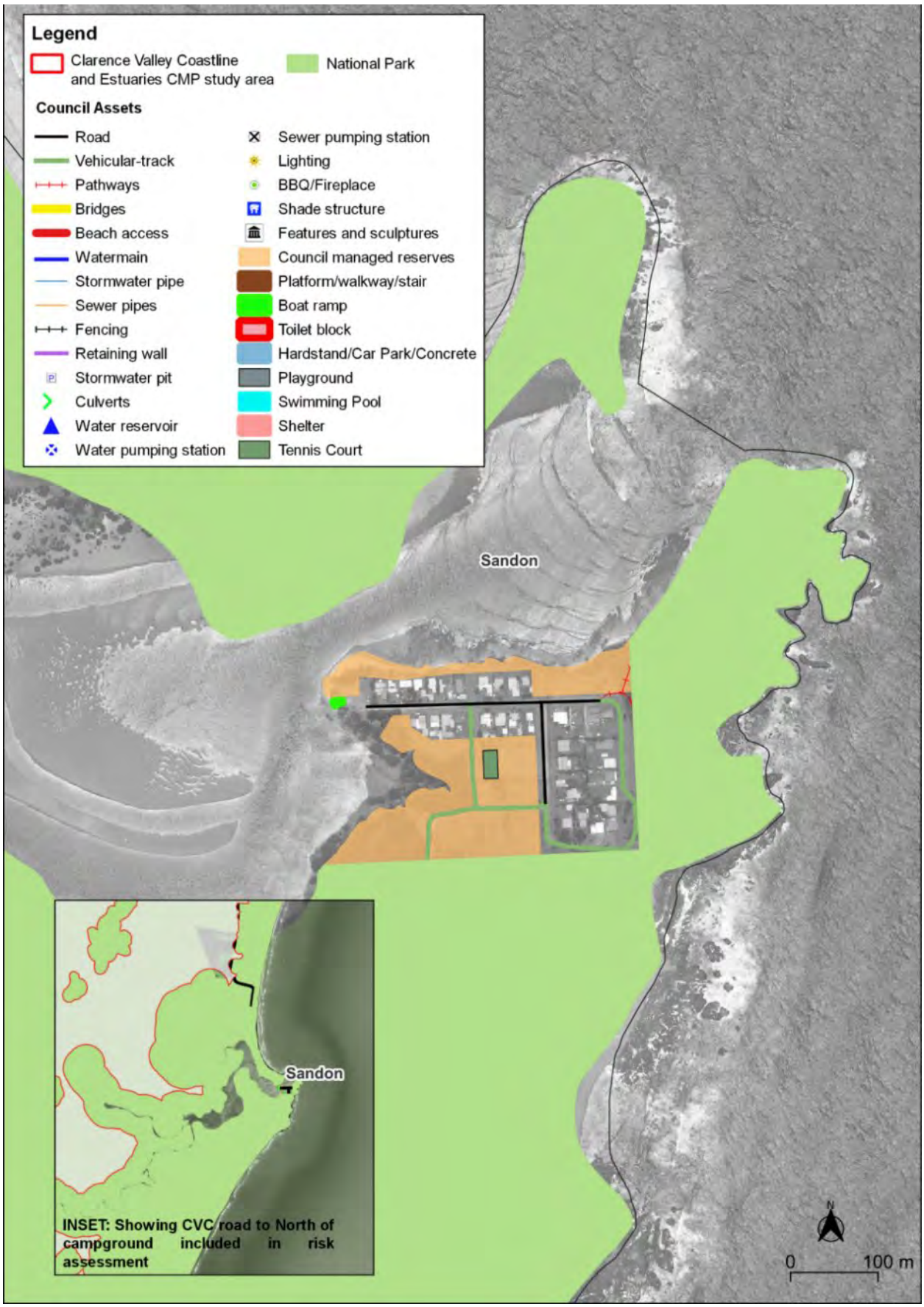


Figure 42: Council assets and infrastructure considered in risk and exposure assessment – Sandon

Source: data provided by CVC

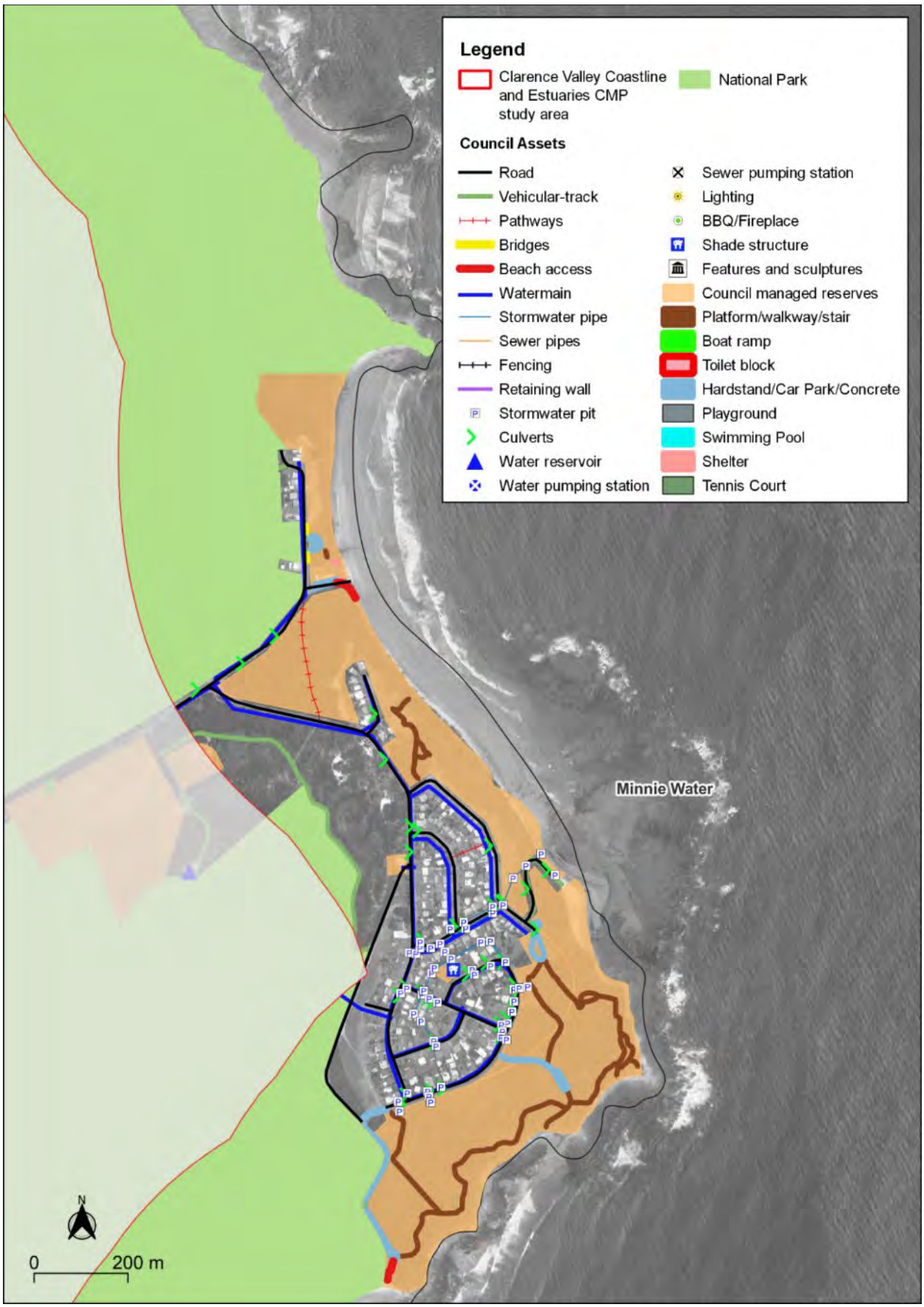


Figure 43: Council assets and infrastructure considered in risk and exposure assessment - Minnie Water

Source: data provided by CVC

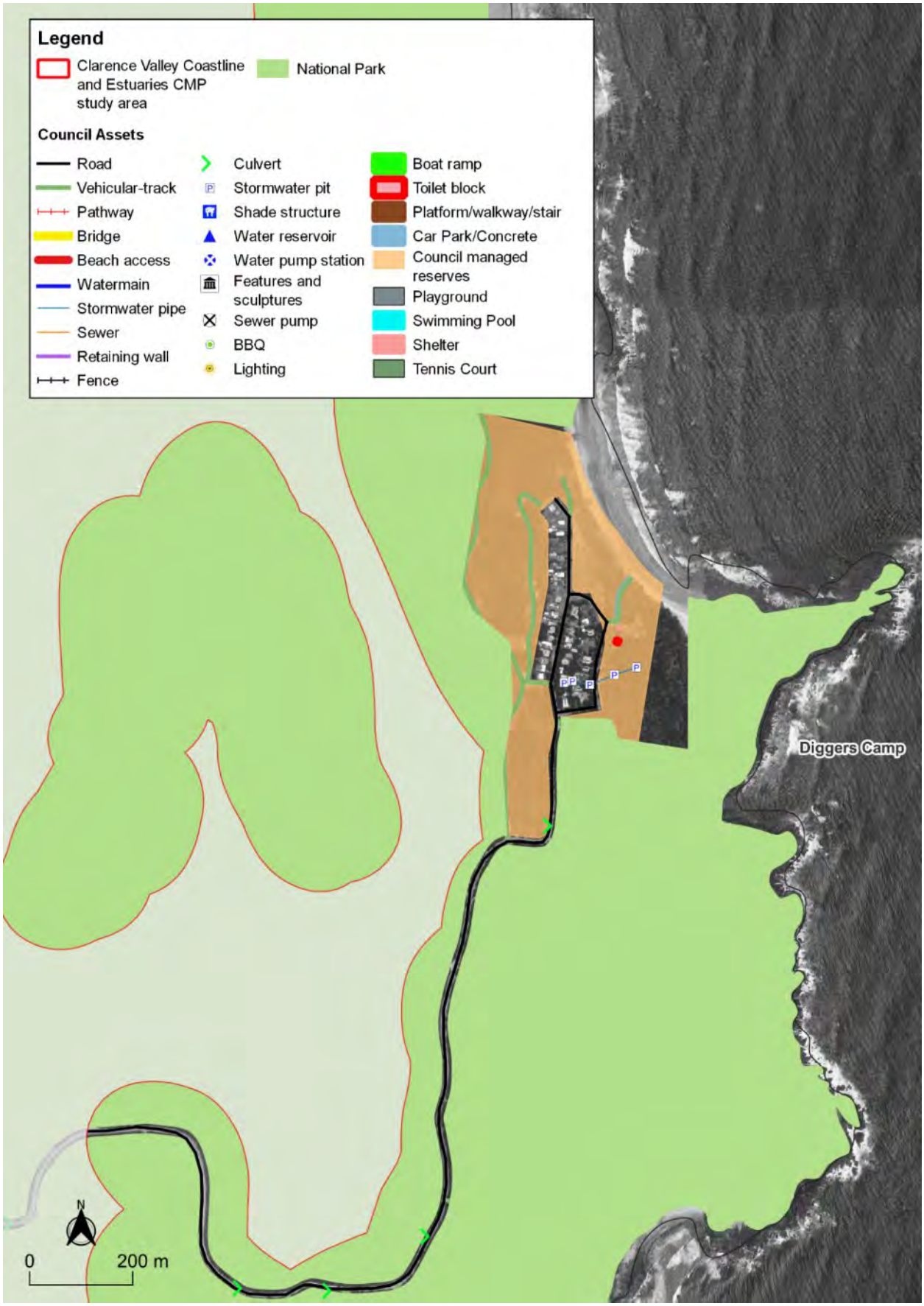


Figure 44: Council assets and infrastructure considered in risk and exposure assessment - Diggers Camp

Source: data provided by CVC

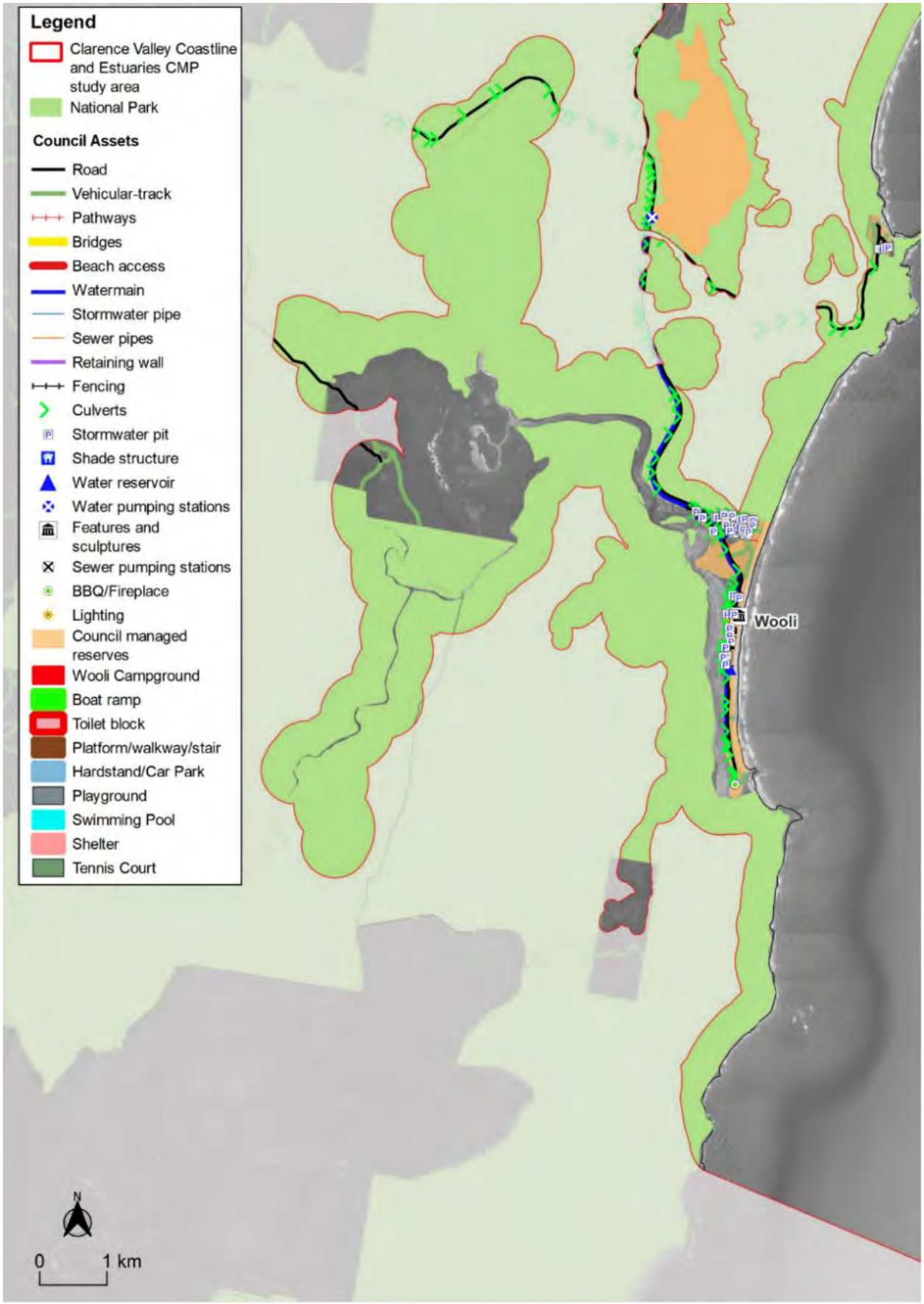


Figure 45: Council assets and infrastructure considered in risk and exposure assessment – Wooli

Source: data provided by CVC

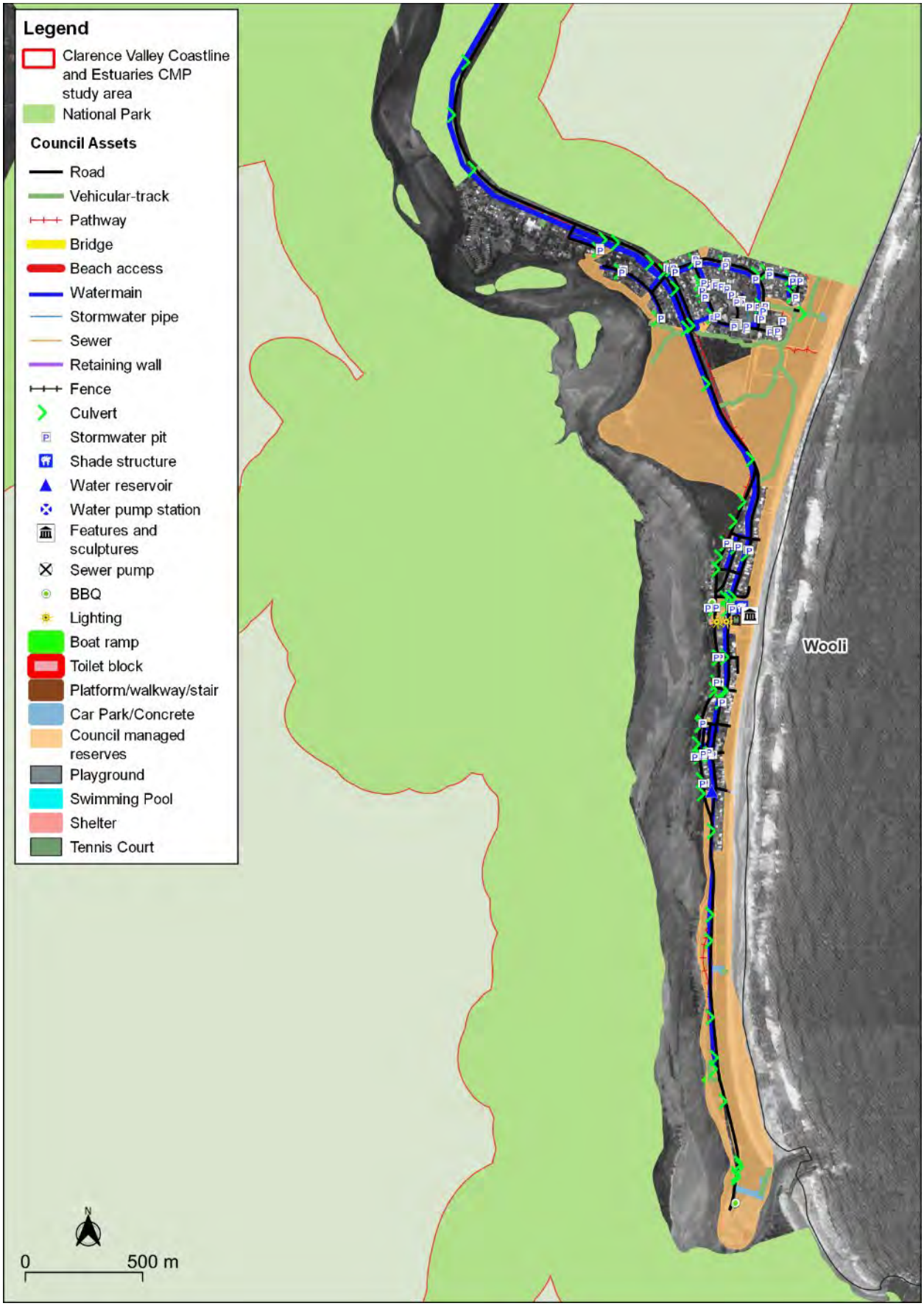


Figure 46: Council assets and infrastructure considered in risk and exposure assessment - Wooli village

Source: data provided by CVC

Table 11: Coastal hazard scenarios - asset risk and exposure assessment

Hazard	Planning timeframes	Event frequency (AEP)	Event frequency (EP)	Frequency descriptor	Future climate
Tidal inundation (High High Water Solstice Spring, HHWSS)	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	> 1 per year	-	Very Frequent	SSP2 and SSP5
Coastal inundation (extreme sea level)	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	10% AEP	-	Frequent to Rare	SSP2 and SSP5
		2% AEP		Rare	
		1% AEP		Rare to Very Rare	
Beach erosion and shoreline recession	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	-	50% EP	Frequent	SSP2 and SSP5
			10% EP	Frequent to Rare	
			2% EP	Rare	
			1% EP	Rare to Very Rare	

Consequence criteria are provided in Table 12. The consequence of each hazard for each type of asset is given in Table 13. The consequence assessment considers the current usage, function, life and replacement cost of each asset. The depth of inundation and physical features of the asset (e.g. elevation, water proofing, structural stability etc.) and resulting impact on the operation of the asset has not been considered. The location of the asset within the hazard zone is the primary consideration for this assessment.

Table 12: Consequence criteria - public assets and coastal hazards

Consequence	Public safety	Recreational amenity	Community services/ infrastructure	Economic
Considerations	*Death, permanent disability and injury or illness*	*How asset is used by people, and how frequently the asset is used*	*Availability of service and the impact this will have on people*	*Current financial and future value, business growth opportunities*
Catastrophic	Death or permanent disability	Long-term (> 1 year) or permanent damage to asset/ service provided which is used regularly which require long repair timeframes or which are irreparable and where no substitute facility can be provided	Access to essential services or infrastructure is disrupted permanently (> 1 year)	Major damage to property and/or infrastructure assets > $500,000, permanent reduction in business income
Major	Serious injury or illness	Major (> 6 months) damage to asset/ service provided which is used regularly where no substitute facility can be provided	Access to essential services or infrastructure is impaired (> 6 months) requiring significant cost to restore	Major damage to property and/or infrastructure assets > $100,000, long-term (> 6 months) reduction in business income
Moderate	Some serious injuries or illness and multiple minor injuries or illness	Medium-term (> 3 months) disruption to asset/ service provided	Access to essential services or infrastructure is impaired (> 3 months) requiring moderate cost to restore	Moderate damage to property and/or infrastructure assets > $30,000, medium-term (> 3 months) reduction in business income
Minor	Minor injuries or illness.	Temporary (< 1 month) disruption to asset/ service provided	Access to essential services or infrastructure is impaired (> 1 month) requiring minor cost to restore	Minor damage to property and/or infrastructure assets > $5,000, temporary (<3 months) reduction in business income
Insignificant	Minimal injury or illness.	Minor (< 1 week) disruption to asset/ service provided	Minor short-term (< 1 week) disruption and minimal cost required to restore services or infrastructure	Minimal damage to property and/or infrastructure assets, minor reduction in business income.

Table 13: Hazard consequence - public assets and coastal hazards

Asset category, type, feature	Consequence of coastal erosion/ recession	Consequence of tidal/ coastal inundation	Comments
Road	Catastrophic	Major	Essential infrastructure, high-cost, short-term impacts could be repaired with time and money, prolonged/ frequent damage would require alternative access arrangements
Vehicular track	Major	Major	Short-term impacts could be repaired with time and money, prolonged/ frequent damage or inundation would compromise access and functions
Pathway	Major	Moderate	Temporary disruption to site users and potential safety issues could be repaired with time and money, prolonged/ frequent damage would make the footpath unviable
Bridge	Catastrophic	Major	Essential infrastructure, high-cost, short-term impacts could be repaired with time and money, prolonged/ frequent damage would require alternative access arrangements
Hardstand, carpark, internal road	Major	Major	Essential infrastructure, high-cost, short-term impacts could be repaired with time and money, prolonged/ frequent damage would require alternative access arrangements
Culverts	Moderate	Major	Short-term impacts could be repaired with time and money, prolonged/ frequent damage or inundation would inhibit drainage
Water main	Major	Major	Essential infrastructure, short-term impacts could be repaired with time and money although service would be restricted, prolonged/ frequent damage would make the site unserviceable
Water pump station	Catastrophic	Major	Essential infrastructure, short-term impacts could be repaired with time and money although service would be restricted, prolonged/ frequent damage would make the site unserviceable
Water reservoir	Catastrophic	Major	Essential infrastructure, short-term impacts could be repaired with time and money although service would be restricted, prolonged/ frequent damage would make the site unserviceable

Asset category, type, feature	Consequence of coastal erosion/ recession	Consequence of tidal/ coastal inundation	Comments
Stormwater drain, pipe, outlet and pit, floodgates	Major	Major	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would inhibit drainage
Sewer main	Catastrophic	Major	Essential infrastructure, short-term impacts could be repaired with time and money although service would be restricted, prolonged/ frequent damage would make the facility unserviceable
Sewer pump station	Catastrophic	Major	Essential infrastructure, short-term impacts could be repaired with time and money although service would be restricted, prolonged/ frequent damage would make the site unserviceable
Lighting	Moderate	Minor	Short-term impacts could be repaired with time and money although site would be affected, prolonged/ frequent damage would make the lighting unviable
Fencing	Moderate	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise safety/ access
Steps/ stairs/ platform	Moderate	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise safety/ access
Sport facilities (cricket pitch, skate park, tennis court)	Moderate	Moderate	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise safety/ recreational value
Ocean pool	Major	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise safety of facility
BBQ	Minor	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise facilities
Features and sculptures	Minor	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise structure

Asset category, type, feature	Consequence of coastal erosion/ recession	Consequence of tidal/ coastal inundation	Comments
Shade structure	Minor	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise structure
Playground	Minor	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise facilities
Shelter	Minor	Minor	Short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise facilities
Amenities block	Major	Major	Essential service, short-term impacts could be repaired with time and money although service would be restricted, prolonged/ frequent damage would make the amenities unserviceable
Council managed reserves	Major	Major	Higher value asset that is integral part of the urban area, short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise facility
Boat ramp, jetty, beach access	Major	Moderate	Higher value asset that is integral part of the wider area, short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise facility
Retaining wall, rock revetment	Major	Major	Higher value asset that provides essential protection to site, short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise stability
Buildings (Surf club, RFS etc.)	Major	Moderate	Higher value asset that is integral part of the area, short-term impacts could be repaired with time and money, prolonged/ frequent damage would compromise facility

Risk and exposure assessment

The risk assessment considers the likelihood of hazards (Table 11) and consequence (Table 13), in accordance with the matrix shown in Table 14.

Table 14: Risk matrix - public assets and coastal hazards

Risk		Consequence				
Likelihood		Insignificant	Minor	Moderate	Major	Catastrophic
	Very frequent	Minimal	Moderate	Moderate	High	High
	Frequent	Minimal	Moderate	Moderate	High	High
	Frequent to rare	Minimal	Low	Moderate	High	High
	Rare	Minimal	Low	Low	Moderate	High
	Rare to very rare	Minimal	Minimal	Low	Low	Moderate

The exposure of each asset type, feature or value to the coastal hazards and the risk rating (combination of likelihood and consequence from Table 14) is presented in the following tables for each hazard scenario. The exposure is presented as the additional assets by count of items, length or area affected in each scenario. With the increasing likelihood of the hazards occurring as well as future timeframes, the amount of each asset expected to be impacted will increase. The tables also show the risk rating (green - low, blue - medium, orange - high or red - extreme) for each asset for each hazard scenario. Assets that are not impacted by the coastal hazards for any of the scenarios considered are not included in the tables.

Table 15: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Iluka and Woody Head

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Vehicular track	Major	m	67				67				67				27			
Carparks	Major	m^2	58				58				58				58			
Water main	Major	m														15	20	11
Council managed reserves	Major	ha	0.016	0.021	0.001		0.019	0.021			0.030	0.010			0.073			

Table 16: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Yamba

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Vehicular track	Major	m	57	137			89	109	71	182	206	347		24	542	55		1
Pathway	Moderate	m	590	76			593	73			604	62		20	696	46		70
Carparks	Major	m^2	12	137	258	156	28	535	1,363	843	154	2,715		354	3,120	2,214	92	296
Water main	Major	m										2				21		
Stormwater pipe	Major	m	4	10			4	10			8	12		23	63	15		
Sewer main	Major	m												2		88		
Sewer pump station	Major	No.														1		
Fencing	Minor	m													13	2		
Platform/ walkway/ stair	Minor	m^2	12	15			18	9			19	9		5	31	9		
BBQ/ fireplace	Minor	No.							1		1	1			1	1		
Council managed reserves	Major	Ha	0.11	0.3		0.01	0.18				0.14	0.05		0.01	0.19	0.03	0.01	
Lighting	Minor	No.							1	1		3			4			
Retaining wall	Major	m	22			4	23	7	2	6	23	15			38			
Rock revetment	Major	m	13	51			13	51			13	51			109	35		
Ocean pool	Minor	m^2	653				653				653				653			
Shelter	Minor	No.		1				1	1	1	1	3		1	5	2		
Boat ramp	Moderate	m^2	60				60				60				60			
Amenities block	Major	No.										1			1	1		

Table 17: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Angourie

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Council managed reserves	Major	Ha	0.012	0.008		0.003	0.013	0.017			0.030				0.034	0.006		

Table 18: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Brooms Head and Lake Arragan

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Roads	Major	m	40	272	51	83	50	629		298	50	1,106	85	124	50	2,440	210	13
Vehicular track	Major	m		93	13			142	22	3		177			9	168		1
Pathway	Moderate	m		248	36	63		450	90	80		640	30	20	100	983	31	25
Bridge	Major	No.	1				1				1				1			
Carparks	Major	m^2		98				98				98				98		
Water main	Major	m	54	405	98	86	54	754	120	70	54	1,126	30	110	61	2,269	70	20
Council managed reserves	Major	Ha	0.032	0.211	0.008	0.005	0.037	0.228	0.005	0.006	0.050	0.235	0.005	0.004	0.080	0.259	0.007	0.005
Shade structures	Minor	No.																1
Rock revetment	Major	m														6		1
Amenities block	Major	No.														1		
Sportsground	Moderate	Ha		27				27				27				27		

Table 19: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Sandon

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Roads	Major	m		52				62		10		105			88	132	38	25
Vehicular track	Major	m		7	1	2		20	1			31	5	5		63	10	6
Council managed reserves	Major	Ha		0.006				0.007			0.001	0.007			0.002	0.008		
Rock revetment	Major	m														6		1
Jetty	Major	No.	1				1				1				1			
Boat ramp	Moderate	No.		1				1				1				1		

Table 20: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Minnie Water

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Stormwater pipe	Major	m														5		
Stormwater pit	Major	No.														1		
Water pump station	Major	No.		1				1				1				1		
Council managed reserves	Major	Ha	0.002	0.001			0.003	0.001	0.001	0.001	0.003	0.001	0.001		0.007	0.001		

Table 21: Risk and exposure of Council assets with the various inundation scenarios and SSP2 climate change scenario - Wooli

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare	Very frequent	Frequent to rare	Rare	Rare to very rare
Roads	Major	m		1,300		100		1,500		200		1,900	100	100	130	2,820	70	150
Vehicular track	Major	m		200				300		100	10	450	30	80	70	630	100	
Pathway	Moderate	m		537	3	170		780	29	70		1,043	22	46	288	1,193	26	41
Bridge	Major	No.		3				3				3				3		
Carparks	Major	m^2					225	75		125	225	75	812			1,734		
Culverts	Major	No.		10	2	3		15				16				19	4	11
Water main	Major	m		1,436	124	87		1,814	143	61		2,396	118	111	108	4,159	132	154
Stormwater pipe	Major	m	6	21		4	11	27	1	1	6	54	6		18	117	15	8
Stormwater pit	Major	No.	1	3	1		1	6	1		1	8			3	10	1	2
Water pump station	Major	No.																1
BBQ/ fireplace	Minor	No.														3		
Council managed reserves	Major	Ha	0.130	0.146	0.007	0.024	0.171	0.165	0.017	0.010	0.197	0.194	0.013	0.012	0.256	0.218	0.007	0.009
Shelter	Minor	No.														4		
Skate park	Minor	No.							1			1				1		
RFS building	Moderate	No.														1		
Sportsground	Moderate	ha				0.1		0.2				0.7				1.6		

Table 22: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario – Hickey Island

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Amenities/ toilet block	Major	No.									1				1			
BBQ/ fireplace	Minor	No.									2				2			
Boat ramp	Moderate	m^2										60			60			
Carparks	Major	m^2					32	11	14	7	7,843	10			7,853			
Council managed reserves	Major	ha	0.60	0.14	0.13	0.13	2.75	0.44	0.42	0.19	11.0	16.3	0.1		27.4			
Lighting	Minor	No.									3				3			
Pathway	Moderate	m					16	6	7	3	270	35			309	2		
Sewer main	Major	m						3	6	3	112				112			
Sewer pump station	Major	No.									1				1			
Shelter	Minor	No.									5				5			
Vehicular track	Major	m									494	105			599			
Water main	Major	m									44				44			

Table 23: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario – Pippi Beach

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Amenities/ toilet block	Major	No.				1			1			1			1			
Carparks	Major	m^2		188	127	25	58	230	56		239	664	755	665	1,445	1,155		
Council managed reserves	Major	ha	1.44	2.88	1.38	0.6	2.94	2.56	1.8	0.6	4.9	3.7	1.1	0.4	9.4	2.6	0.7	0.1
Fencing	Minor	m		211	190	56	36	275	163	72	269	459	263	138	978	342	29	3
Pathway	Moderate	m	37	97	67	28	75	108	91	34	152	188	64	25	364	653	417	5
Platform/ walkway/ stairs	Minor	m^2		12	38			50			14	36			50			
Roads	Major	m											146	43		890	173	143
Sewer main	Major	m							26	10		136	71	36	129	593	354	132
Sewer pump station	Major	No.				1			1			1			1			
Shelter	Minor	No.				1			2			3	6		6	1	1	
Stormwater pipe	Major	m										4	15	10	6	440	136	71
Stormwater pit	Major	No.											1		1	4		
Vehicular track	Major	m		47	12	5	29	29	10	5	55	19	4		78			
Water main	Major	m											82	55		981	245	85

Table 24: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario - Angourie

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Amenities/ toilet block	Major	No.												1	1			
Carparks	Major	m^2	182	104	57	13	270	84	48	31	360	159	68	15	1,248	62		
Council managed reserves	Major	ha	1.50	0.43	0.18	0.06	1.84	0.27	0.11	0.06	2.11	0.31	0.34	0.14	3.84	1.14	0.13	0.05
Fencing	Minor	m													48	19		
Platform/ walkway/ stairs	Minor	m^2	68				68				68				68			
Roads	Major	m														91	299	205
Sewer main	Major	m											28	20	129	215	388	82
Sewer pump station	Major	No.													1	2		
Playground	Moderate	m^2															67	30
Vehicular track	Major	m	90	9	4		98	5			102	1			103			
Water main	Major	m														24	22	18
Water pump station	Major	No.														1		

Table 25: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario - Brooms Head

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Amenities/ toilet block	Major	No.		1			1				1				1			
Caravan park buildings	Major	No.		2			2				2				2			
Boat ramp	Moderate	m^2	124				124				124				124			
Bridge	Major	No.			1			1			1				1			
Council managed reserves	Major	ha	1.83	3.82	5.24	5.58	3.73	1.58	0.65	0.16	5.70	0.53	0.45	0.22	7.0	1.91	2.20	1.22
Culverts	Major	No.															1	
Lighting	Minor	No,			1			1			1				1			
Beach access	Minor	No.	6				6				6				6			
Pathway	Moderate	m	18	12	18	170	32	144	76	22	282	63	26	44	490	156	45	13
Roads	Major	m			342	92		452	517	62	499	540	301	105	1,614	981	350	102
Sewer main	Major	m			33	30		37	130	7	61	118	23	11	218	53	59	20
Shelter	Minor	No.	2	3			5				5				5			
Playground	Minor	m^2	48	409			457				457				457			
Vehicular track	Major	m	12	30	27	8	87		5	18	87	46	37	6	175			
Water main	Major	m			359	194		594	300	305	665	648	480	2,906	5,631	3,903	975	298

Table 26: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario - Sandon

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Boat ramp	Moderate	m^2			4	27			68	18		83	4		87			
Council managed reserves	Major	m^2	20	35.6	43	45	33.7	10.8	6.5	2	55	25	7	3	99	13	6	2
Roads	Major	m				17			32	125		115	70	335	336	194	19	18
Vehicular track	Major	m											4	3	5	9.1	8.8	3

Table 27: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario - Minnie Water

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Carparks	Major	m^2	132	232	400	153	242	436	340	86	784	360	113	18	1,287			
Council managed reserves	Major	ha	2.7	2.1	1.3	0.5	4.2	1.7	1	0.4	6.1	1.4	0.6	0.3	9.6	1.1	0.6	0.1
Culverts	Major	No.									1	1			3	1		
Pathway	Moderate	m													10	34	26	6
Platform/ walkway/ stairs	Minor	m^2		10	11	5	7	13	10	4	23	16	81	5	210	41	11	3
Roads	Major	m	54	18	15	7	67	16	18	81	85	134	100	35	681	202	116	21
Shelter	Minor	No.	3				3				3				3			
Stormwater pipe	Major	m	24	17	11	4	36	15	10	4	50	20	15	4	110	21	19	3
Stormwater pit	Major	No.	2		1		2	1			3				4			
Vehicular track	Major	m	78	19	14	8	91	17	19	10	115	84	24		223			
Water main	Major	m												139	370	186	73	17

Table 28: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario – Diggers Camp

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
Amenities/ toilet block	Major	No.													1			
Carparks	Major	m^2	174	43	19	6	187	37	16	7	236	24	10		270			
Council managed reserves	Major	ha	2.6	0.4	0.1	0.12	2.7	0.3	0.2	0.08	3.2	0.2	0.2	0.012	5.1	0.3	0.2	0.02
Roads	Major	m	82	22	10	4	89	19	10	4	112	16	7	2	336	16	11	4
Shelter	Minor	No.													1			
Stormwater pipe	Major	m														7	6	2
Stormwater pit	Major	No.														1		
Vehicular track	Major	m	136	16	5	2	138	13	5	2	153	9	4	1	232	57	11	4

Table 29: Risk and exposure of Council assets with the various erosion/ recession scenarios and SSP2 climate change scenario - Wooli

Asset category, type, feature	Consequence (from Table 13)	Units	2023 Present Day				2043 (+20 years)				2073 (+50 years)				2123 (+100 years)			
			Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare	Frequent	Frequent to rare	Rare	Rare to very rare
BBQ/ fireplace	Minor	No.																1
Boat ramp	Moderate	m^2											102	7	107			7
Carparks	Major	m^2	17	251	46	19	233	73	47	23	348	324	144	19	845	876		
Council managed reserves	Major	ha	9.1	7.5	2.4	1.2	15	4	2	1	21	4	3	2	36	6	2	1
Culverts	Major	No.						1		1	1	5	5	1	17	17	7	
Fencing	Minor	m											51	13	74	47		
Lighting	Minor	No,														2		
Pathway	Moderate	m		10	7	3	10	8	7	4	24	141	205	65	768	460	238	28
Platform/ walkway/ stairs	Minor	m^2		160			132	28			160				160			
Roads	Major	m			124	159		39	388	162	347	1,673	127	443	3,182	2,228	807	245
Shelter	Minor	No.											1		1			3
Skate park	Moderate	No.															17	213
Stormwater pipe	Major	m											6	6	30	252	157	57
Stormwater pit	Major	No.											1		4	17	7	
Vehicular track	Major	m	9	2		10	11		155	146	90	365	197	37	1,106	604	118	40
Water main	Major	m										747	824	618	2,901	1,784	229	115
Water reservoir	Major	No.													1			

APPENDIX 7 DETAILED THREAT AND RISK ASSESSMENT

Methodology

The first - pass risk assessment included in the Stage 1 Scoping Study has been updated with new information available from Stage 2, including the detailed coastal hazard assessments and mapping which provide updated information on areas potentially impacted over time. The risk assessment process identifies credible risks, the likelihood of the threat occurring given existing controls, the consequences to environment, social and economic values, public safety and benefits should the event occur and applies a risk rating. The risk assessment is consistent with AS/NZS ISO 31000: *Risk Management - Principles and Guidelines*. The methodology uses the risk assessment process outlined in Table 30 to Table 32 which uses qualitative scales to assess the risk of identified issues impacting the values and assets of the study area under current management practices (based on the framework adopted for the TARA for the Marine Estate). For coastal hazards, the frequency descriptors (Table 11) have been as a surrogate indicator of likelihood.

The risk assessment evaluates the current day risk and also considers how the risk level is likely to change in the future (i.e. over 20, 50 and 100 years). This includes assessment of how factors such as climate change, increasing development pressures and population increase will impact these risks. Where available, future risks to public assets have been assigned based on the asset risk and exposure assessment (Appendix 6). In other cases, a qualitative assessment has been undertaken considering the expected future changes.

The detailed risk assessment considers the risk to values from categories of issues and key threats for each location. The assessment typically focusses on the detrimental, rather than the beneficial impacts of the threat, unless otherwise indicated. In all circumstances, the potential highest consequence level to any asset or value was used for the assessment.

Table 30: Qualitative measures of consequence or impact

Consequence	Description
Catastrophic	Significant on-going and/or permanent negative impacts on the environmental, social or economic values, and where these values are endangered either permanently or irreversibly.
Major	Substantial measurable and/or ongoing negative impacts on the environmental, social or economic values.
Moderate	Measurable and/or on-going negative impacts on the environmental, social or economic values.
Minor	Discernible and/or temporary negative impacts on the environmental, social or economic values.
Insignificant	No or barely discernible negative impacts on the environmental, social or economic values.

Source: Adapted from MEMA (2015)

Table 31: Qualitative measures of likelihood under current management practices

Likelihood	Description
Almost certain	A very large certainty that this will occur in this situation within the timeframe.
Likely	Expected to occur in this situation within the timeframe.
Possible	Some clear evidence exists to suggest this is possible in this situation within the timeframe.
Unlikely	Uncommon, but has been known to occur elsewhere. Expected to occur here only in specific circumstances within the timeframe.
Rare	Never reported for this situation, but still plausible within the timeframe.

Source: Adapted from MEMA (2015)

Table 32: Qualitative risk estimation

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Minimal	Low	Moderate	High	High
Likely	Minimal	Low	Moderate	High	High
Possible	Minimal	Minimal	Low	Moderate	High
Unlikely	Minimal	Minimal	Minimal	Low	Moderate
Rare	Minimal	Minimal	Minimal	Low	Moderate

Assessment and analysis

The management issues and threats affecting the study area and results of the detailed threat and risk assessment are provided in Table 33 - Table 41.

Table 33: Detailed threat and risk assessment - coastal hazards

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts - Loss of beach and foredune, degradation or loss of assets and infrastructure, unsafe or loss of access to beach, increased frequency of flooding and inundation, loss of dune vegetation, migration of estuarine and riparian vegetation communities, loss of amenity, public safety risks, reduced tourism value, damage to cultural heritage sites, liability and legality issues, related social and economic factors.									
T1 - Beach erosion									
Ten Mile Beach	Appendix 4	NPWS	-	Moderate	Possible	Low	Moderate	High	High
Shark Bay	JBP (2023) - Appendix 3	NPWS	-	Moderate	Likely	Moderate	High	High	High
Woody Bay	JBP (2023) - Appendix 3	NPWS	Beach maintenance including removal of fallen trees.	Major	Likely	High	High	High	High
Woody Head campground	JBP (2023) - Appendix 3	NPWS	Seawall and artificial dune, asset relocation, signage.	Major	Likely	High	High	High	High
Iluka area (Bluff Beach, Back Beach)	Appendix 4	NPWS	-	Minor	Likely	Minimal	Minimal	Low	Low
Iluka Beach	Appendix 4	CVC managed Crown land, Crown land	-	Minor	Likely	Minimal	Minimal	Low	Low
Andersons Beach	-	Crown land	Sea wall	Minor	Possible	Minimal	Minimal	Low	Low
Whiting Beach	JBP (2023) - Appendix 3	CVC managed Crown land	Beach nourishment, geotextile sand container wall (eastern end)	Moderate	Likely	Moderate	Moderate	High	High
Turners Beach	Appendix 4	CVC managed Crown land, Crown land	-	Minor	Possible	Minimal	Minimal	Low	Low
Yamba Main Beach	-	CVC managed Crown land, Yamba SLSC	Seawall in front of surf club, planned relocation of SLSC	Major	Possible	Moderate	Moderate	Moderate	Moderate
Convent Beach	-	Residents, CVC managed Crown land	-	Major	Possible	Moderate	Moderate	Moderate	Moderate
Pippi Beach	JBP (2023) - Appendix 3	CVC managed Crown land, Crown land	-	Minor	Likely	Low	Low	Moderate	Moderate
Barri Beach	Appendix 4	Crown land	-	Minor	Likely	Low	Low	Low	Low
Spooky Beach	JBP (2023) - Appendix 3	CVC managed Crown land, Crown land	-	Moderate	Possible	Low	Low	Low	Low
Angourie area (Angourie Point Beach, Back Beach, Little Shelley Beach, Shelley Beach, Plumbago Beach, Red Cliff)	Appendix 4	NPWS, Crown land	-	Minor	Likely	Low	Low	Low	Low
Brooms Head (Main Beach)	JBP (2023) - Appendix 3	NPWS, Crown land	-	Minor	Likely	Low	Low	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Lake Cakora (Ocean Road properties)	JBP (2023) - Appendix 3	Residents	EASP, Ocean Road revetment (ad hoc, erodible)	Major	Possible	Moderate	High	High	High
Lake Cakora entrance	JBP (2023) - Appendix 3	CVC managed Crown land, Crown land		Major	Likely	High	High	High	High
Brooms Head (foreshore reserve)	JBP (2023) - Appendix 3	CVC managed Crown land, Crown land	EASP, foreshore reserve revetment	Major	Almost Certain	High	High	High	High
The Sandon	Appendix 4	NPWS, Crown land	-	Minor	Likely	Low	Low	Moderate	Moderate
Sandon campground	JBP (2023) - Appendix 3	NPWS	Dune stabilisation (vegetation, sand trap fencing)	Major	Likely	High	High	High	High
Sandon Village		Residents, CVC managed Crown land	Ad hoc revetment	Major	Possible	Moderate	Moderate	High	High
Sandon Beach	Appendix 4	NPWS	-	Minor	Possible	Minimal	Low	Low	Low
Illaroo campground	Appendix 4	NPWS	-	Moderate	Possible	Low	Moderate	High	High
Minnie Water Beach	JBP (2023) - Appendix 3	CVC managed Crown land	-	Moderate	Possible	Low	Moderate	Moderate	Moderate
Minnie Water Back Beach	Appendix 4	NPWS	-	Minor	Likely	Low	Low	Low	Low
Diggers Camp	JBP (2023) - Appendix 3	CVC managed Crown land	-	Moderate	Likely	Moderate	Moderate	High	High
Wooli Beach (north) - Yuraygir National Park	Appendix 4	NPWS	Beach and dune rehabilitation, revegetation and weed control	Minor	Possible	Minimal	Low	Moderate	Moderate
Wooli village (north)	JBP (2023) - Appendix 3	Residents, CVC managed Crown land	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Wooli village (south)	JBP (2023) - Appendix 3	Residents, CVC managed Crown land	Beach nourishment scheme, beach and dune rehabilitation, revegetation and weed control, EASP	Major	Almost Certain	High	High	High	High
Wooli Beach (south)	Appendix 4	CVC managed Crown land	Beach and dune rehabilitation, revegetation and weed control	Moderate	Almost Certain	Moderate	High	High	High
Jones Beach	Appendix 4	NPWS, Crown land	-	Minor	Likely	Low	Low	Low	Low
T2 - Shoreline recession									
Ten Mile Beach	Appendix 4	NPWS	-	Minor	Likely	Low	Low	Low	Low
Iluka Road (Shark Bay)	JBP (2023) - Appendix 3	CVC, NPWS	-	Moderate	Likely	Moderate	High	High	High
Shark Bay	JBP (2023) - Appendix 3	NPWS	-	Moderate	Likely	Moderate	High	High	High

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Woody Bay	JBP (2023) - Appendix 3	NPWS	Rock protection/ seawall and artificial dune, adaptive management (extension north as required), asset relocation, signage.	Major	Almost certain	High	High	High	High
Iluka area (Bluff Beach, Back Beach)	Appendix 4	NPWS	-	Minor	Possible	Minimal	Minimal	Low	Low
Iluka Beach	Appendix 4	CVC managed Crown land, Crown land	-	Moderate	Possible	Minimal	Minimal	Low	Low
Andersons Beach	Appendix 4	Crown land	Sea wall	Moderate	Possible	Low	Low	Low	Low
Whiting Beach	JBP (2023) - Appendix 3	CVC managed Crown land	Beach nourishment (initial campaign)	Moderate	Almost Certain	Moderate	Moderate	High	High
Turners Beach	Appendix 4	CVC managed Crown land, Crown land	-	Minor	Possible	Minimal	Low	Low	Moderate
Yamba Main Beach	-	CVC managed Crown land, Yamba SLSC	Seawall in front of surf club	Moderate	Possible	Low	Moderate	High	High
Convent Beach	-	Residents, CVC managed Crown land	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Pippi Beach	JBP (2023) - Appendix 3	CVC managed Crown land, Crown land	-	Minor	Likely	Minimal	Minimal	Moderate	Moderate
Barri Beach	Appendix 4	Crown Land	-	Minor	Possible	Minimal	Minimal	Low	Low
Spooky Beach	JBP (2023) - Appendix 3	CVC managed Crown land, Crown land	-	Moderate	Possible	Low	Low	Low	Low
Angourie area (Angourie Back Beach, Little Shelley Beach, Shelley Beach, Plumbago Beach)	Appendix 4	NPWS, Crown land	-	Moderate	Possible	Low	Low	Low	Low
Brooms Head (Main Beach)	JBP (2023) - Appendix 3	NPWS, Crown land	-	Minor	Almost Certain	Low	Moderate	High	High
Lake Cakora (Ocean Road properties)		Residents	Ocean Road revetment (ad hoc, erodible), localised beach scraping after storm events, design of extension of sea wall in progress.	Major	Almost Certain	High	High	High	High
Lake Cakora entrance		CVC managed Crown land, Crown land		Moderate	Almost Certain	Moderate	High	High	High
Brooms Head (foreshore reserve)		CVC managed Crown land, Crown land	Foreshore reserve revetment, vegetation management, localised beach scraping after storm events, monitoring.	Moderate	Almost Certain	Moderate	Moderate	High	High

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
The Sandon	Appendix 4	NPWS, Crown land	-	Moderate	Possible	Low	Low	Moderate	High
Sandon River campground	JBP (2023) - Appendix 3	NPWS	-	Moderate	Likely	Moderate	Moderate	High	High
Sandon village		Residents, CVC managed Crown land	Ad hoc revetment	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
Sandon Beach	Appendix 4	NPWS	-	Minor	Possible	Minimal	Low	Low	Low
Illaroo campground	Appendix 4	NPWS	-	Moderate	Possible	Low	Moderate	High	High
Minnie Water Beach	JBP (2023) - Appendix 3	CVC managed Crown land	-	Moderate	Possible	Low	Low	Moderate	High
Minnie Water Back Beach	Appendix 4	NPWS	-	Minor	Possible	Minimal	Low	Low	Low
Diggers Camp	Appendix 4	CVC managed Crown land	-	Moderate	Possible	Low	Low	Low	Low
Wooli Beach (north) - Yuraygir National Park	JBP (2023) - Appendix 3	NPWS	Beach and dune rehabilitation, revegetation and weed control	Minor	Possible	Minimal	Moderate	High	High
Wooli village	JBP (2023) - Appendix 3	Residents, CVC managed Crown land	Beach nourishment scheme, beach and dune rehabilitation, revegetation and weed control	Major	Likely	High	High	High	High
Wooli Beach (south)	JBP (2023) - Appendix 3	CVC managed Crown land	Beach and dune rehabilitation, revegetation and weed control	Moderate	Almost Certain	Moderate	High	High	High
Jones Beach	Appendix 4	NPWS, Crown land	-	Minor	Likely	Low	Low	Low	Low
T3 - Tidal/ coastal Inundation									
Ten Mile Beach	-	NPWS	-	Insignificant	Possible	Minimal	Minimal	Minimal	Minimal
Shark Bay	JBP (2022) - Appendix 2	NPWS	-	Minor	Possible	Minimal	Low	Low	Moderate
Woody Bay/ Woody Head	JBP (2022) - Appendix 2	NPWS	Seawall and artificial dune	Minor	Possible	Minimal	Minimal	Low	Low
Iluka Back Beach	JBP (2022) - Appendix 2	NPWS	-	Insignificant	Possible	Minimal	Minimal	Low	Low
Iluka Beach	JBP (2022) - Appendix 2	CVC managed Crown land, Crown land	-	Minor	Possible	Minimal	Minimal	Low	Low
Andersons Beach	JBP (2022) - Appendix 2	Crown land	Sea wall	Minor	Possible	Minimal	Minimal	Low	Low
Iluka	JBP (2022) - Appendix 2	NPWS, CVC managed Crown land, Crown land, private	-	Moderate	Possible	Low	Low	Moderate	Moderate
Whiting Beach	JBP (2022) - Appendix 2	CVC managed Crown land	-	Moderate	Likely	Moderate	High	High	High
Turners Beach	JBP (2022) - Appendix 2	CVC managed Crown land, Crown land	-	Minor	Unlikely	Minimal	Low	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Yamba Main Beach	JBP (2022) - Appendix 2	CVC managed Crown land, Yamba SLSC	Seawall in front of surf club	Moderate	Possible	Low	Low	Moderate	Moderate
Convent Beach	JBP (2022) - Appendix 2	Residents, CVC managed Crown land	-	Minor	Possible	Minimal	Minimal	Minimal	Low
Pippi Beach	JBP (2022) - Appendix 2	CVC managed Crown land, Crown land	-	Minor	Possible	Minimal	Low	Low	Low
Barri Beach	JBP (2022) - Appendix 2	Crown land	-	Minor	Possible	Minimal	Low	Low	Low
Spooky Beach	JBP (2022) - Appendix 2	CVC managed Crown land, Crown land	-	Minor	Possible	Minimal	Minimal	Minimal	Low
Angourie area (Angourie Back Beach, Little Shelley Beach, Shelley Beach, Plumbago Beach)	JBP (2022) - Appendix 2	NPWS	-	Insignificant	Possible	Minimal	Minimal	Minimal	Minimal
Brooms Head (Main Beach)	JBP (2022) - Appendix 2	NPWS, Crown land	-	Insignificant	Unlikely	Minimal	Minimal	Minimal	Minimal
Lake Cakora (Ocean Road properties)	JBP (2022) - Appendix 2	Residents	-	Major	Likely	High	High	High	High
Brooms Head (foreshore reserve)	JBP (2022) - Appendix 2	CVC managed Crown land, Crown land	Seawall	Moderate	Possible	Low	Low	Low	Moderate
Brooms Head (village)	JBP (2022) - Appendix 2	CVC managed Crown land, residents	-	Major	Likely	High	High	High	High
The Sandon	JBP (2022) - Appendix 2	NPWS, Crown land	-	Insignificant	Unlikely	Minimal	Minimal	Minimal	Minimal
Sandon campground and access road	JBP (2022) - Appendix 2	NPWS	-	Major	Likely	High	High	High	High
Sandon village	JBP (2022) - Appendix 2	Residents, CVC managed Crown land	-	Major	Possible	Moderate	Moderate	High	High
Sandon Beach	JBP (2022) - Appendix 2	NPWS	-	Insignificant	Unlikely	Minimal	Minimal	Minimal	Minimal
Illaroo campground	JBP (2022) - Appendix 2	NPWS	-	Moderate	Possible	Low	Moderate	Moderate	Moderate
Minnie Water Beach	JBP (2022) - Appendix 2	CVC managed Crown land	-	Moderate	Unlikely	Minimal	Low	Low	Low
Minnie Water Back Beach	JBP (2022) - Appendix 2	NPWS	-	Insignificant	Unlikely	Minimal	Minimal	Minimal	Minimal
Diggers Camp	JBP (2022) - Appendix 2	CVC managed Crown land	-	Moderate	Unlikely	Minimal	Low	Moderate	Moderate
Wooli Beach (north) - Yuraygir National Park	JBP (2022) - Appendix 2	NPWS	-	Insignificant	Unlikely	Minimal	Minimal	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Wooli village (north)	JBP (2022) - Appendix 2	CVC managed Crown land	-	Moderate	Likely	Moderate	High	High	High
Wooli village (south)	JBP (2022) - Appendix 2	Residents, CVC managed Crown land	-	Major	Likely	High	High	High	High
Jones Beach	JBP (2022) - Appendix 2	NPWS, Crown land	-	Insignificant	Unlikely	Minimal	Minimal	Minimal	Minimal
T4 - Entrance instability									
Clarence River	-	TfNSW - MIDO, Crown land	Breakwaters and estuarine training walls, dredging	Major	Unlikely	Low	Low	Low	Low
Lake Cakora	CZMP (SMEC, 2017) and Geotechnical Assessment (Royal HaskoningDHV, 2018b)	CVC managed Crown land, Crown land	Occasional informal opening	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
Lake Arragan/ Mara Creek	-	NPWS	No artificial intervention	Insignificant	Likely	Minimal	Minimal	Minimal	Minimal
Sandon River	CZMP (2012)	CVC managed Crown land, NPWS	Rocky headlands	Minor	Unlikely	Minimal	Minimal	Minimal	Minimal
Wooli Wooli River entrance	Royal HaskoningDHV (2018b)	CVC managed Crown land, Crown land	Breakwaters, estuarine training walls	Moderate	Possible	Low	Low	Low	Low
T5 - Slope instability/ landslip									
Headlands within Bundjalung National Park)	-	NPWS	-	Moderate	Unlikely	Minimal	Minimal	Minimal	Minimal
Headlands within Yuraygir National Park)	-	NPWS	-	Moderate	Unlikely	Minimal	Minimal	Minimal	Minimal
Pilot Hill	MHL (2003), JK Geotechnics (2017), FSG Geotechnics (2022)	CVC managed Crown land, residents	Monitoring program, stormwater improvements, emergency management plan	Catastrophic	Possible	High	High	High	High
Convent Beach	FSG Geotechnics (2022)	CVC managed Crown land, residents	-	Major	Possible	Moderate	Moderate	Moderate	Moderate
Yamba Point	Royal HaskoningDHV (2016)	CVC managed Crown land	Warning signs	Moderate	Possible	Low	Low	Low	Low
Pippi Beach	Royal HaskoningDHV (2016)	CVC managed Crown land	-	Moderate	Possible	Low	Low	Low	Low
Cakora Point	SMEC, 2012, FSG Geotechnics (2022)	CVC managed Crown land, Crown land	-	Moderate	Possible	Low	Low	Low	Low

Table 34: Detailed threat and risk assessment - bank erosion

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Bank instability, loss of land, erosion to and loss of riparian and estuarine vegetation and habitat, siltation, degraded water quality, navigation hazards, aquaculture/ oyster degradation, reduced amenity, reduced tourism value, liability and legality issues									
T6 - Erosion of foreshores (MEMS TARA priority threat)									
Lake Cakora	Observation	CVC	Repair works (bridge footings)	Major	Possible	Moderate	Moderate	High	High
Sandon River	EPS (GHD, 2011), CZMP (2012)	CVC managed Crown land, Crown land, NPWS, private landowners	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Wooli Wooli River	EMS (WBM, 2006)	CVC managed Crown land, Crown land, NPWS, private landowners	Ad hoc stabilisation in some locations	Moderate	Almost certain	Moderate	Moderate	High	High

Table 35: Detailed threat and risk assessment - biodiversity

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Reduced habitat availability, loss of biodiversity, water quality impacts, reduced amenity, reduced stabilising dune vegetation, increased erosion risk, increased nutrient load to estuary, fauna mortality, risks to shorebird and turtle nesting, displacement of native species, alteration of fauna habitats, reduced recruitment of native riparian vegetation, poor water quality, related social and economic factors									
T7 - Historic clearing of riparian vegetation and adjacent habitat (MEMS TARA priority threat)									
Wooli Wooli River	EMP (BMT WBM (2009), EPS (WBM, 2006)	CVC managed Crown land, Crown land, NPWS, private landowners	-	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
Sandon River	EPS (GHD, 2011), CZMP (2012)	CVC managed Crown land, Crown land, NPWS, private landowners	-	Minor	Possible	Minimal	Minimal	Minimal	Minimal
T8 - Foreshore development (MEMS TARA priority threat)									
Yamba-Angourie coast	Community consultation	CVC	LEP and DCP	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
Sandon Village	DPI - Marine Parks	CVC	DPI - Marine Parks regulations	Minor	Almost certain	Low	Low	Low	Low
Smaller villages (Brooms Head, Sandon, Wooli)	Various	CVC	LEP and DCP	Minor	Likely	Low	Low	Low	Low
T9 - Invasive weeds (e.g. Bitou bush, Lantana)									
Coastline north of Clarence River estuary (Bundjalung National Park)	NPWS (1997), OEH (2012a, 2012b)	NPWS	National Park Plan of Management, NPWS Regional Pest Management Strategies	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Yamba-Angourie coast	Community consultation	CVC	Reserve plans of management	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Brooms Head (Northern Beach)	CZMP (SMEC, 2017)	CVC	Brooms Head Reserve Vegetation Management Plan, dune revegetation and rehabilitation	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Yuraygir National Park	-	NPWS	National Park Plan of Management, NPWS Regional Pest Management Strategies	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Sandon River	EPS (GHD, 2011), CZMP (2012)	CVC, NPWS	National Park Plan of Management, NPWS Regional Pest Management Strategies	Minor	Possible	Minimal	Minimal	Minimal	Minimal
Wooli Beach	Royal HaskoningDHV (2018)	CVC	Beach and dune rehabilitation, revegetation and weed control	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Wooli Wooli River	EPS (WBM, 2006)	CVC, NPWS		Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
T10 - Uncontrolled stock access to and grazing within the riparian zone									
Wooli Wooli River	EMP (BMT WBM (2009)	Private landowners	-	Moderate	Possible	Low	Low	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
T11 - Seagrass decline									
Sandon River (particularly Toumbaal Creek)	CEMC	DPI-Fisheries	-	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Wooli Wooli River	DPI-Fisheries	DPI-Fisheries	-	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
T12 – Estuarine vegetation (mangrove, saltmarsh, seagrass) damage									
Sandon River	EPS (GHD, 2011), CZMP (2012)	DPI-Fisheries	DPI - Marine Parks regulations	Minor	Possible	Minimal	Minimal	Minimal	Minimal
Wooli Wooli River	DPI - Marine Parks	DPI-Fisheries	DPI - Marine Parks regulations	Minor	Possible	Minimal	Minimal	Minimal	Minimal
T13 - Unauthorised clearing of reserves for views									
Wooli Beach	Royal HaskoningDHV (2018)	CVC	Council vegetation management policy	Minor	Possible	Minimal	Minimal	Minimal	Minimal
Yamba	Community consultation	CVC		Minor	Possible	Minimal	Minimal	Minimal	Minimal
T14 - Overfishing, non-compliance with fishery regulations									
Lake Cakora	CZMP (SMEC, 2017)	DPI-Fisheries	DPI-Fisheries regulations	Minor	Likely	Low	Low	Low	Low
Sandon River	CZMP, GHD (2012)	DPI-Fisheries		Minor	Likely	Low	Low	Low	Low
All areas (not specified)	Community survey	DPI-Fisheries		Minor	Likely	Low	Low	Low	Low
T15 - Anthropogenic barriers (i.e. physical barriers, land use and planning constraints) to migration of vegetation communities with sea level rise									
Lake Cakora	CZMP (SMEC, 2017)	DPI-Fisheries	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Sandon River	CZMP, GHD (2012)	DPI-Fisheries	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Wooli Wooli River	-	DPI-Fisheries	-	Minor	Possible	Minimal	Low	Moderate	Moderate
T16 - Uncontrolled dog access									
Brooms Head	CEMC, community consultation	CVC, NPWS	Dogs banned in caravan park. Off-leash area north of the Lake Cakora 4WD access. Dogs prohibited south of 4WD track.	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
National Parks (e.g. Shark Bay)	NPWS	NPWS	Dogs banned in National Parks	Moderate	Possible	Low	Low	Low	Low
T17 - 4WD/ motorbikes on beaches									
Shark Bay (Bundjalung National Park)	NPWS	NPWS	PoM	Major	Likely	High	High	High	High
Barri Point	Community consultation	CVC	2018 Beach Access Policy	Moderate	Likely	Moderate	Moderate	Moderate	Moderate

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Brooms Head	CZMP (SMEC, 2017), CEMC, community consultation	CVC	2018 Beach Access Policy, 4WD access north of Lake Cakora	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
Sandon Beach	Community consultation, NPWS	NPWS, Crown land	PoM	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
Wooli Beach	Royal HaskoningDHV (2018)	CVC	2018 Beach Access Policy, gate at breakwall	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
T18 - Predation and invasion by introduced animals (e.g. pigs, cane toads, foxes, rabbits)									
Bundjalung National Park	NPWS (1997), OEH (2012a,b)	NPWS	Bundjalung National Park Plan of Management, Regional Pest Management Strategies	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Brooms Head	CZMP (SMEC, 2017)	CVC, NPWS		Minor	Likely	Low	Low	Low	Low
Yuraygir National Park	NPWS, (2003), OEH (2012a,b)	NPWS	Yuraygir National Park Plan of Management, Regional Pest Management Strategies	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Sandon River	CZMP, GHD (2012)	CVC, NPWS		Minor	Likely	Low	Low	Low	Low
Wooli Wooli River	EPS (WBM, 2006)	CVC, NPWS		Minor	Likely	Low	Low	Low	Low
T19 - Insufficient protection for marine animals									
All areas	Community consultation	NPWS	Legislation	Minor	Possible	Minimal	Minimal	Minimal	Minimal
T20 - Illegal (freedom) camping									
All areas (particularly Spooky Beach, Angourie Back Beach car park, Green Point, Angourie Point, Iluka Beach, Shark Bay, Sandon)	Community consultation, DPI - Marine Parks	CVC, NPWS	Policy, Council working party, no parking signs in high impact areas, ranger patrols, free camping excluded within 10km of coast.	Minor	Almost certain	Low	Low	Low	Low
T21 - Spear fishing									
All areas	Community consultation	DPI-Fisheries	DPI-Fisheries policy and legislation	Minor	Possible	Minimal	Minimal	Minimal	Minimal
T22 – Modification of coastal wetland habitat due to coastal hazards									
Bundjalung National Park	JBP (2022), JBP (2023), Appendix 4	NPWS	-	Major	Possible	Moderate	Moderate	High	High
Hickey Island	JBP (2022), JBP (2023)	CVC managed Crown land	-	Major	Possible	Moderate	Moderate	High	High
Brooms Head north	JBP (2023)	NPWS, Crown land	-	Major	Possible	Moderate	Moderate	High	High

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Lake Cakora	JBP (2022)	CVC managed Crown land, Crown and	-	Major	Possible	Moderate	Moderate	High	High
Yuraygir National Park and surrounds	JBP (2022), JBP (2023), Appendix 4	NPWS, DPI – Marine Parks	-	Major	Possible	Moderate	Moderate	High	High
Minnie Water Beach	JBP (2023)	CVC managed Crown land	-	Major	Possible	Moderate	Moderate	High	High
Wooli Wooli River	JBP (2022)	CVC managed Crown land, Crown land	-	Major	Possible	Moderate	Moderate	High	High

Table 36: Detailed threat and risk assessment - water quality

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Suspended solids, sedimentation, nutrient export, high biological oxygen demand, eutrophication, fertiliser/pesticide contamination, faecal contamination, shellfish/aquaculture contamination, oyster industry closures									
T23 - Urban stormwater pollution (MEMS TARA priority threat)									
Lake Cakora	CZMP (SMEC, 2017),	CVC	-	Minor	Likely	Low	Low	Low	Low
Sandon River	CZMP, GHD (2012)	CVC	-	Minor	Possible	Minimal	Minimal	Minimal	Minimal
Wooli Wooli River	EMP (BMT WBM (2009)	CVC	-	Minor	Likely	Low	Low	Low	Low
T24 - Pollution from on-site wastewater systems									
Brooms Head/ Lake Cakora (caravan park)	CZMP (SMEC, 2017)	CVC	Upgrade of on-site sewerage system	Moderate	Possible	Low	Low	Low	Low
Lake Cakora (residential properties)	CZMP (SMEC, 2017)	CVC, residents	Ongoing inspection program	Moderate	Possible	Low	Low	Low	Low
Wooli village	EMP (BMT WBM (2009)	CVC, residents		Moderate	Possible	Low	Low	Low	Low
Sandon village	CZMP, GHD (2012)	CVC, residents		Moderate	Possible	Low	Low	Low	Low
Sandon campground	CZMP, GHD (2012)	NPWS	NPWS maintenance	Moderate	Possible	Low	Low	Low	Low
T25 - Poor flushing of ICOLLs									
Lake Cakora	CZMP (SMEC, 2017), Ryder *et al*., (2014)	CVC, NPWS	No formal management	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Lake Arragan	Ryder *et al*., (2014)	NPWS	No formal management	Moderate	Possible	Low	Low	Low	Low
T26 - Sea level rise increasing salinity within the estuary									
Lake Cakora	CZMP (SMEC, 2017)	CVC, NPWS	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Sandon River	CZMP, GHD (2012)	CVC, NPWS	-	Minor	Possible	Minimal	Low	Moderate	Moderate
Wooli Wooli River	EMP (BMT WBM (2009)	CVC, NPWS	-	Minor	Possible	Minimal	Low	Moderate	Moderate
T27 - Climate warming and extreme temperatures									
Study area	Various	CVC, NPWS	-	Minor	Possible	Minimal	Low	Moderate	Moderate
T28 - Increased storminess and changed rainfall patterns									
Study area	Various	CVC, NPWS	-	Minor	Possible	Minimal	Low	Moderate	Moderate
T29 - Land/ waterway contamination									
Estuaries (e.g. chemical/fuel spills)	Various	CVC, NPWS	-	Minor	Possible	Minimal	Minimal	Minimal	Minimal
Sandon (tarring oyster sticks)	DPI - Marine Parks	CVC, NPWS	-	Minor	Likely	Low	Low	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Angourie Blue and Green Pools	-	CVC	Monitoring	Minor	Almost certain	Low	Low	Low	Low
T30 - Forestry activities									
Sandon River and Wooli Wooli River catchments	Mapping	Forestry Corporation	Harvest operations planning, monitoring, environmental management system	Moderate	Possible	Low	Low	Low	Low

Table 37: Detailed threat and risk assessment - shoaling and estuary hydraulics

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Siltation, navigational impacts, boating safety, community perception/satisfaction									
T31 - Shoaling and sediment movement within estuaries									
Clarence River entrance	Port Authority	Port Authority	Periodic maintenance dredging	Major	Likely	High	High	High	High
Sandon River	EPS (GHD, 2011), CZMP (2012)	DPE - Crown Land	-	Minor	Likely	Low	Low	Low	Low
Wooli Wooli River	EMP (BMT WBM (2009), community consultation	DPE - Crown Land	-	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
T32 - Erosion and sedimentation affecting navigation									
Clarence River entrance	Port Authority	Port Authority	Periodic maintenance dredging	Major	Likely	High	High	High	High
Wooli Wooli River	EMP (BMT WBM (2009), community consultation	DPE - Crown Land	-	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
T33 - Estuary entrance modifications (MEMS TARA priority threat)									
Clarence River entrance	-	TfNSW - MIDO	Breakwalls, training walls for safe navigation, periodic maintenance dredging	Moderate	Possible	Low	Low	Low	Low
Wooli Wooli River	-	TfNSW - MIDO	Breakwalls, training walls for safe navigation	Moderate	Possible	Low	Low	Low	Low

Table 38: Detailed threat and risk assessment - use and access

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Restricted public access, public safety risks, reduced amenity, reduced tourism value, erosion, damage to incipient dune, noise disturbance, user conflict, construction of unauthorised access points, conflict between campers, day trippers, residents and land managers									
T34 - Limited pedestrian access									
Brooms Head (Northern Beach)	CZMP (SMEC, 2017)	CVC	-	Minor	Likely	Low	Low	Low	Low
Wooli Beach (Scope Street, Braithwaite Lane, Cenotaph)	Royal HaskoningDHV (2018)	CVC	Renewal of Cenotaph access steps	Minor	Likely	Low	Low	Low	Low
All areas	-	Various	-	Minor	Likely	Low	Low	Low	Low
T35 - Informal pedestrian access									
Wooli Beach	Royal HaskoningDHV (2018)	CVC	Planned renewal of access steps	Minor	Likely	Low	Low	Low	Low
All areas	-	Various	-	Minor	Likely	Low	Low	Low	Low
T36 - Population increase and visitor pressure increasing demand on services and environment and conflict between users									
Woody Head campground	Hydrosphere Consulting (2023)	NPWS	Campground capacity limitations	Minor	Likely	Low	Low	Low	Low
Sandon campground	EPS (GHD, 2011), CZMP (2012)	NPWS	Campground capacity limitations	Minor	Likely	Low	Low	Low	Low
T37 - Bushfire damage to access									
Yuraygir National Park	NPWS	NPWS	NPWS asset replacement	Minor	Likely	Low	Low	Low	Low
T38 - Limited boating access									
Wooli Wooli River (upper estuary)	EMP (BMT WBM (2009)	CVC, NPWS	-	Minor	Likely	Low	Low	Low	Low
T39 - Poor condition of public facilities (boat ramps etc.)									
Wooli Wooli River	EMP (BMT WBM (2009)	CVC	-	Minor	Likely	Low	Low	Low	Low
All areas	-	Various	-	Minor	Likely	Low	Low	Low	Low
T40 - Unauthorised access points									
Wooli Wooli River	EMP (BMT WBM, 2009)	Residents	-	Minor	Likely	Low	Low	Low	Low
T41 - Competing uses of the estuary/ coastal zone									
Sandon River	EPS (GHD, 2011), CZMP (2012)	CVC, NPWS	Signage	Minor	Likely	Low	Low	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
T42 - Unstable/unsafe bar crossing									
Wooli Wooli River	EMP (BMT WBM, 2009)	DPE - Crown Land	Signage	Minor	Likely	Low	Low	Low	Low
Sandon River	EPS (GHD, 2011), CZMP (2012)	DPE - Crown Land	Signage	Minor	Likely	Low	Low	Low	Low
T43 - Damage to beach access points									
Shark Bay	CEMC, CVC, community consultation	NPWS	-	Moderate	Almost certain	Moderate	High	High	High
Yuraygir National Park beach areas (e.g. Diggers Camp)		NPWS	-	Moderate	Almost certain	Moderate	High	High	High
Other beach areas - e.g. Iluka, Yamba, Angourie (Spooky Beach), Minnie Water, Brooms Head, Wooli		CVC	-	Moderate	Almost certain	Moderate	High	High	High
T44 - Stormwater erosion at beaches/ estuaries									
Minnie Water	Community consultation	CVC	-	Minor	Almost certain	Low	Low	Low	Low
T45 - Insufficient access for commercial fishers									
Red Cliff/ Lake Arragan	Community consultation	NPWS	-	Minor	Almost certain	Low	Low	Low	Low
T46 - Inadequate boat launch facilities									
Brooms Head	Community consultation	CVC	Boat ramp (shallow)	Minor	Likely	Low	Low	Low	Low
T47 - Reduced accessible beach at high tide due to coastal protection works									
Woody Bay	Hydrosphere Consulting (2023)	NPWS	-	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
Brooms Head	Observation	CVC	-	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
T48 - Insufficient emergency services access									
All areas	Community consultation	CVC, NPWS, SES	Emergency access roads and beach ramps in some areas	Major	Unlikely	Low	Low	Low	Low
T49 - Inadequate parking (boat trailers)									
Brooms Head	Community consultation	CVC	Car parking bay at boat ramp (too small for trailers).	Minor	Likely	Low	Low	Low	Low

Table 39: Detailed threat and risk assessment - governance

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Complex mix of landowners/managers, lack of alignment of plans/policies, lack of collaboration, cooperation and resource support, differing opinions, values, policies and management approaches, conflict and delays in implementing management approaches									
T50 - Multiple land managers									
Sandon River	CZMP, GHD (2012)	CVC, DPI - Crown Lands, NPWS, DPI - Marine Parks, private landowners	Management Plans, collaboration during CMP development	Moderate	Possible	Low	Low	Low	Low
T51 - Inadequate action on coastal protection (due to difficulties gaining community consensus, high cost of implementation and stringent approval requirements)									
All areas (not specified)	Community consultation	CVC, DPI - Crown Lands, NPWS, DPI - Marine Parks, private landowners	CMP development, coastal protection works.	Moderate	Possible	Low	Low	Low	Low
Woody Bay	NPWS	NPWS	Seawall, asset relocation, PoM, Coastal Hazard Response Plan for Woody Head Campground	Moderate	Possible	Low	Low	Low	Low
Yuraygir National Park	NPWS	NPWS	PoM, Coastal Hazard Response Plan for Sandon Campground	Moderate	Possible	Low	Low	Low	Low
T52 - Inaccurate or incomplete mapping of coastal management areas									
CWLRA	CM SEPP mapping, CVC LEP	CVC, NPWS, DPE - Crown Lands	CM SEPP mapping of CUA, CEA, CWLRA	Major	Possible	Moderate	High	High	High
CVA				Major	Possible	Moderate	High	High	High
CUA and CEA				Minor	Possible	Minimal	Minimal	Minimal	Minimal
T53 - Inadequate land use planning and development controls									
All areas	-	CVC	2011 LEP, DCPs	Major	Possible	Moderate	Moderate	Moderate	Moderate

Table 40: Detailed threat and risk assessment - heritage

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Loss of or damage to items of heritage significance or cultural heritage values, lack of protection of Aboriginal/Native Title rights.									
T54 - Lack of protection/ management of former oyster leases									
Sandon River (Tooumbaal Creek)	CEMC	Heritage NSW	-	Minor	Likely	Low	Low	Low	Low
T55 - Inadequate consultation with Aboriginal land managers									
Study area	CEMC, CVC	CVC, Aboriginal representatives, NPWS	Cultural heritage mapping, consultation during CMP development, development of Indigenous Land Use Agreement with Yaegl TOAC	Moderate	Possible	Low	Low	Low	Low
T56 - Damage to cultural heritage items/ sites									
Study area	Community consultation, NPWS	Heritage NSW	NPWS PoM, Cultural heritage mapping, legislative requirements	Major	Possible	Moderate	Moderate	Moderate	Moderate

Table 41: Detailed threat and risk assessment - amenity

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
Potential impacts: Public safety risks, odour, visual impacts, reduced tourism value.									
T57 - Fish cleaning waste									
Minnie Water	CEMC, community consultation	CVC, DPI-Fisheries	-	Minor	Almost certain	Low	Low	Low	Low
T58 - Beached or deceased whales on/ near beaches									
Marine areas	NPWS, CEMC	NPWS	NPWS review into management of deceased whales in NSW (2019)	Minor	Almost certain	Low	Low	Low	Low
T59 - Shark activity									
All beaches	Community consultation	DPI-Fisheries	NSW Government shark mitigation strategy	Moderate	Possible	Low	Low	Low	Low

Threats (use, activity or stressor) and location	Source of information	Management responsibility	Current management approach	Present day risk			Future Risk		
				Consequence	Likelihood	Current Risk	20-year	50-year	100-year
T60 - Fallen/ dangerous trees on eroded beaches									
Woody Bay	Observation	NPWS	Warning signs, tree/debris removal	Moderate	Almost certain	Moderate	Moderate	Moderate	Moderate
T61 - Marine debris and kelp following storm event									
Brooms Head foreshore	CZMP (SMEC, 2017)	CVC	-	Minor	Likely	Low	Low	Low	Low
T62 - Litter									
All areas (terrestrial)	Community consultation	CVC, NPWS	Rubbish bins.	Moderate	Likely	Moderate	Moderate	Moderate	Moderate
All areas (marine e.g. Jones Beach)	DPI - Marine Parks	NPWS, DPI - Marine Parks	NPWS and community clean-up days	Moderate	Likely	Moderate	Moderate	Moderate	Moderate

APPENDIX 8 DPI - FISHERIES BREAKWATER AUDIT OUTPUTS FOR CMP STUDY AREA

Clarence River Breakwater (North)

-29.424S
153.367W

Responsible authority:	NSW State Government
Built:	1874–1903
Modified:	Lengthened 1280 m in the 1960s
Primary purpose when first built:	Trained entrance for coastal shipping
Current uses:	– Ocean access for coastal shipping and boating – Fishing spot – Forms an estuarine wave-trap beach used by mullet fishers
Regulatory matters:	– Native Title (determined) – *Heritage Act 1977*
Multi-use features:	– Partial walking pathway – Stabilises a wave-trap beach used by mullet haulers – Shipwreck heritage HMAS Waree
Eco-features:	– Fauna refuge in the eastern most 250 m of the breakwater – Estuarine intertidal inlets

The breakwater is accessible with nearby parking.

An estuarine training wall network extends upstream for 6.4 km and includes the Iluka Bay Boat Harbour precinct. Other inlets support seagrass, mangrove, saltmarsh, and wader and migratory bird habitats.

Recommendations for possible inclusion in future maintenance or upgrade works

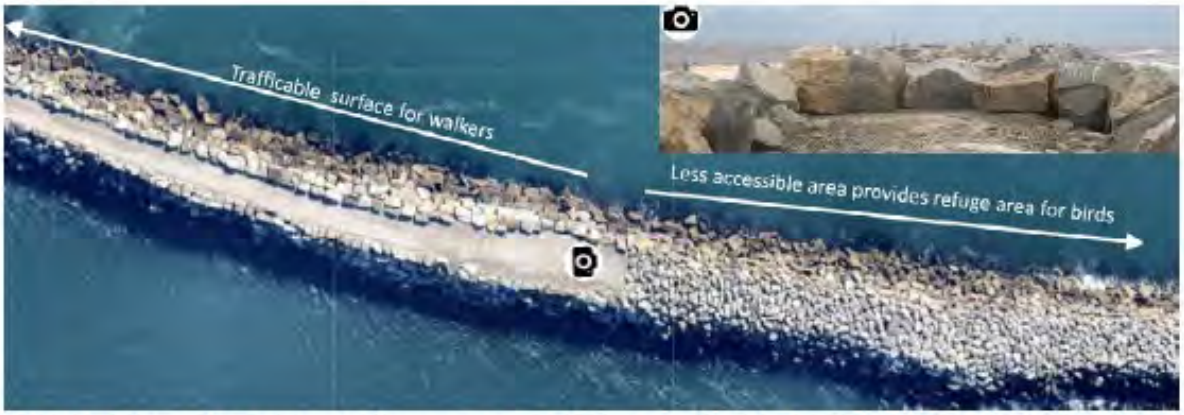
Future multi-use features

- Maintain existing pedestrian walkway surface
- Rock placement for emergency safety stairs
- Time works to avoid the mullet haul season in autumn

Future eco-features

- Maintain breakwater fauna refuge area
- Adjacent osprey tower
- Increase submerged habitat complexity
- Key fish habitat enhancement along training wall

Clarence Northern breakwater, showing the (1) northern breakwater; (2) Shipwreck HMAS Waree; (3) mullet haul beach
Credit: nearmap



The last 250 metres of the breakwater is inaccessible, and this creates a refugee for breakwater fauna
Credit: nearmap

Clarence River Breakwater (South)

-29.428S
153.366W

Responsible Authority:	NSW State Government
Built:	1862–1903
Modified:	Lengthened by 1.1 km in 1960s
Primary purpose when first built:	Trained entrance for coastal shipping
Current uses:	– Ocean access for coastal shipping and boating – Fishing spot – Forms Turners surf beach
Regulatory matters:	– Native Title (determined)

Multi-use features:
- Walking pathway
- Angel Ring
- Stabilises Turners beach

Eco-features:
- Estuarine intertidal inlets

The breakwater is accessible. It is close to parking, amenities and greenspace. An estuarine training wall extends upstream by about 5.5 km and includes the Yamba Harbour precinct. Other inlets support seagrass, mangrove, saltmarsh, and wader and migratory bird habitats.

Recommendations for possible inclusion in future maintenance or upgrade works

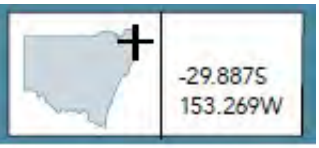
Future multi-use features
- Maintain pedestrian walkway surface
- Rock placement for seating and fishing opportunities
- Rock placement for emergency safety stairs

Future eco-features
- Adjacent osprey tower
- Increase submerged habitat complexity
- Key fish habitat enhancement along training wall

Clarence River Breakwater: (1) the southern breakwater; (2) Turners Beach; (3) interpretative signage acknowledging the engineering heritage of the Port of Clarence breakwater infrastructure *Credit: Six Maps*

The view back to land from the end of the Clarence River southern breakwater provides a unique perspective as sea birds arc and dive for fish. The first two-thirds of the breakwater has a smooth, tar-finished trafficable surface and the last third is a coarser gravel.

Wooli River Breakwater (North)



Responsible Authority:	NSW State Government
Built:	1973
Primary purpose when first built:	Trained entrance for boats used for fishing and tourism
Current uses:	– Ocean access for boating – Popular coastal walkway – Fishing spot
Regulatory matters:	– Native Title (determined) – Solitary Islands Marine Park
Multi-use features:	– Walking pathway
Eco-features:	– Estuarine intertidal inlet and the breakwater rubble surface supports areas of oyster reef

The breakwater is accessible. It is close to parking and green space.

Recommendations for possible inclusion in future maintenance or upgrade works

Future multi-use features

- Maintain existing pedestrian walkway surface
- Install CoastSnap photo point
- Rock placement for emergency safety stairs

Future eco-features

- Key fish habitat enhancement along training wall

Aerial photo of the Wooli estuary showing (1) northern breakwater; (2) southern breakwater; (3) wave-trap beach

Wooli breakwater rubble has been colonised by oysters to create a valuable oyster reef habitat

Credit: Charlie Jenkins

Wooli River Breakwater (South)

-29.888S
153.269W

Responsible Authority:	NSW State Government
Built:	1973
Primary purpose when first built:	Trained entrance for boating, commercial fishing and tourism
Current uses:	– Ocean access for boating – Forms an estuarine wave-trap beach
Regulatory matters:	– Solitary Islands Marine Park

Multi-use features: – Creates a wave-trap beach

Eco-features: – Fauna refuge

The breakwater is not accessible.

Recommendations for possible inclusion in future maintenance or upgrade works

Future multi-use features

Nil

Future eco-features

– Key fish habitat enhancement along training wall

The Wooli River southern breakwater does not have a smooth surface for walking *Credit: nearmap*

The trained entrance of the Wooli River estuary showing (1) the southern breakwater, the wave-trap beach and the lack of access to the southern breakwater *Credit: nearmap*