NSW National Parks and Wildlife Service

Coastal hazard response plan

Sandon River campground, Yuraygir National Park

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Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

Artist and designer Nikita Ridgeway from Aboriginal design agency Boss Lady Creative Designs created the People and Community symbol.

Cover photo: Sandon River campground and Plover Island. John Fullerton/Hydrosphere Consulting 2022

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4WD	4-wheel drive (vehicles)
AEP	annual exceedance probability
AHD	Australian height datum (i.e. distance relative to sea level)
CHRP	coastal hazard response plan
CO_2	carbon dioxide
CMP	coastal management program
DECC	NSW Department of Environment and Climate Change
EP	exceedance probability
GSC	geotextile sand container
HHWSS	high high-water solstice spring (tide)
NPWS	NSW National Parks and Wildlife Service
SEPP	State environmental planning policy
SSP	shared socio-economic pathway

Executive summary

Sandon River campground within Yuraygir National Park is a significant feature within the coastal reserve system managed by the NSW National Parks and Wildlife Service (NPWS). The campground precinct is valued for the scenic beauty of its natural landscape, the recreational opportunities it provides and its cultural heritage, including sites of spiritual significance and contemporary importance to the Yaegl people as well as historic heritage sites. The high levels of biodiversity in the area reflect climatic conditions that support a diverse range of subtropical coastal communities.

Sandon Beach has experienced erosion and has receded over time (recession), impacting the sand dunes along the coast, pedestrian and 4-wheel-drive access to the beach, and the northern section of the campground. The road into the precinct, Sandon River Road, is sometimes inundated by high tides, which is expected to increasingly impact access to the campground. Although some measures to stabilise the dunes have been implemented in response to these erosion and inundation events, there has been no formal strategic approach to coastal management at Sandon River campground.

The coastal hazard response plan (CHRP) outlined in this report considers the predicted impacts of beach erosion, recession and inundation on the campground. The plan presents and assesses the suitability of potential options for managing the predicted extent of the coastal hazards in the short, medium and long term.

The community reference group established to assist in developing the CHRP included Aboriginal representatives, community representatives, site users, state government agencies, Clarence Valley Council and other interest groups.

The key considerations in the plan's development were:

- maintaining the facilities at Sandon River campground and the surrounding reserve areas for as long as economically and practically viable
- ensuring that management approaches are sympathetic to the area's natural coastal processes
- limiting artificial intervention, to protect the scenic beauty and natural landscape of the area.

The recommended approach to managing coastal hazards is an adaptive one that includes a range of measures implemented at different stages. The short-to-medium-term measures will stabilise the sand dunes and riverbanks in the campsite precinct. These include restoration of the sand dunes through fencing and revegetation of the area behind the dunes through planting, to provide protection from smaller erosion events. The long-term recommendation is to implement a strategic planned retreat of the campground and associated assets.

This adaptive management approach recognises that coastal processes will always impact the natural landscape and that intervention will not stop 'nature taking its course'. The proposed plan is designed to address risks while maintaining the functionality, safety and natural beauty of the campground area for as long as viable. To appropriately manage any risk to the natural environment and cultural heritage, planning for the long-term retreat of campground assets should begin in consultation with stakeholders.

1. Introduction

The New South Wales coastal zone contains sites of natural, cultural and socioeconomic value at regional, state and national levels. Approximately half of the coastline is managed within reserves by the NSW National Parks and Wildlife Service (NPWS) under the *National Parks and Wildlife Act 1974* (NSW).

Sandon River campground in Yuraygir National Park is a significant site and landscape feature within the NPWS coastal reserve system. Historically, the Sandon River campground precinct has experienced coastal erosion and Sandon Beach has receded over time (an event known as 'recession'). Climate change, particularly any associated rise in sea level, is expected to have a further impact on erosion and recession of Sandon Beach. The campground's proximity to the Sandon River estuary is also at risk of increased tidal and coastal inundation (flooding) in the surrounding area.

The study area for this coastal hazard response plan (CHRP) incorporates the Sandon River campground and surrounding areas, including entrance roads, tracks, operational facilities, and NPWS land and assets (see Section 4 and Appendix A: Maps). The coastline and estuary in the study area is the traditional land of the Yaegl people. The area is highly valued for its biodiversity, Aboriginal cultural heritage and recreational opportunities, all of which attract thousands of visitors each year, with many staying at the Sandon River campground. The community expects the NPWS to maintain the facilities at this precinct as long as possible. Although the NPWS has implemented some dune stabilisation measures to provide a degree of protection to the site against erosion, the predicted coastal hazards mean further measures are needed.

This CHRP considers the risks to natural, built and cultural assets within the Sandon River campground that are expected to result from the coastal hazards of beach erosion, recession and inundation. Detailed coastal hazard studies, an assessment and comparison of management options, and stakeholder engagement have informed the development of this plan. The recommended management approach includes measures to respond to erosion, recession and inundation over the short, medium and long term. The aim is to balance the expectations and values of the NPWS, the local community, traditional owners and visitors with the future safety and viability of the campground in the face of current and future coastal hazards.

2. Legislative and planning context

The principal legislation guiding the management of NSW national parks and reserves is the *National Parks and Wildlife Act 1974*. The *Coastal Management Act 2016* (NSW) and the *State Environmental Planning Policy (Resilience and Hazards) 2021* (*Resilience and Hazards SEPP*) establish the strategic framework for management of coastal issues in NSW. Development controls relating to coastal management are prescribed in the *Environmental Planning and Assessment Act 1979* (NSW), the *Resilience and Hazards SEPP* and the *State Environmental Planning Policy (Transport and Infrastructure) 2021*.

The NPWS undertakes coastal planning and management consistent with:

- the NSW Government's coastal management framework (NSW Environment and Heritage 2023)
- NPWS statutory land management responsibilities, as defined under the *National Parks and Wildlife Act 1974*.

The *Yuraygir National Park and Yuraygir State Conservation Area plan of management* (NPWS 2003) outlines how the study area will be managed.

This CHRP aligns with the requirement for sustainable coastal management and the objectives of the *Coastal Management Act 2016*, which are consistent with the conservation objectives of the *National Parks and Wildlife Act 1974*. The plan will contribute to better alignment of the coastal management and planning activities of the NPWS, other NSW government agencies and the Clarence Valley Council for the study area.

3. Project background

The study area is part of the Yuraygir National Park and is located within the Clarence Valley local government area. The majority of the coastline north and south of the Sandon River entrance is managed as national park or reserve. Recognising the extensive area of the coastal zone under its management, the NPWS collaborates with the Clarence Valley Council in the development of the coastal management program (CMP) for the Clarence Valley Open Coast.

A scoping study was completed in March 2021 as stage 1 of developing the Clarence Valley Open Coast CMP (Hydrosphere Consulting 2021). This study identified that the high risk of continuing coastal erosion and recession within the study area, combined with a lack of contemporary understanding of coastal hazards, required more detailed assessment. Stage 2 of the CMP development involved probabilistic modelling of coastal erosion and recession, and tidal/coastal inundation, for various likelihoods, planning horizons and climate scenarios (see Section 5.3 and Appendix C: Coastal hazard mapping). The coastal hazard mapping resulting from this modelling provides robust and contemporary information on the current and future risks that have been used for the development of this CHRP.

The development of this CHRP aligns with stage 3 of the Clarence Valley Open Coast CMP, developing and identifying coastal management strategies and actions for the Clarence Valley coastline. The plan is consistent with the relevant components of the *NSW Coastal Management Manual* (NSW Environment and Heritage 2018a, 2018b, 2019a, 2019b), which guides the preparation of CMPs.

The NPWS and the Clarence Valley Council intend to incorporate the outcomes of this CHRP as stage 4 actions in the Clarence Valley Open Coast CMP, to ensure a coordinated management approach.

4. The study area

The Sandon River camping reserve was established by the former Maclean Shire Council in the 1950s. In November 1983, the land on the north side of Sandon River was included in the Yuraygir National Park, including the cabins and the camping reserve (DECC 2009). Maps of the study area, including land ownership and management, are shown in Appendix A: Maps. The study area includes the Sandon River campground and surrounding areas, entrance roads, tracks and facilities, and Sandon village to the south of Sandon River. As there are multiple authorities responsible for infrastructure in the study area – the NPWS, Clarence Valley Council, Essential Energy and various state government agencies – a coordinated approach will be required to manage the site. The future management of the Sandon River campground site and facilities under NPWS control (Figure A.3) is the focus of this plan.

4.1 Campground location and layout

The campground is in the Sandon River precinct of Yuraygir National Park and is accessed from Brooms Head via Sandon River Road along the narrow peninsula between Sandon River and the Pacific Ocean. Sandon Beach is located to the north of the Sandon River campground and stretches approximately 10 km northwards to Cakora Point in Brooms Head. The beach is enclosed by the Cakora Point headland to its north and Plover Island and a tombolo (a spit of sand or shingle linking an island or rocky outcrop to the mainland) to the south. The southern section of Sandon Beach is a narrow spit of land that runs alongside the Sandon River and the Sandon River Road, with the Sandon River campground located at the southern tip adjacent to the river entrance. The campground occupies an area of approximately one hectare on a sandy peninsula between the Sandon River estuary and the beach. A narrow strip of coastal vegetation on either side of the peninsula separates the campground from the ocean and estuary (Photo 1).

The campground caters for short-term camping and includes unpowered campsites, toilet facilities and garbage services, sandy beach, rocky shores, shallow reefs and picnic areas (Photo 2). The campground allows direct access to Sandon River, Sandon Beach, the ocean and Plover Island via the tombolo.

Vehicle use of the beaches within the study area is restricted to an access trail north of the campground. A boat ramp within the campground provides access to the river and offshore via the river entrance. Regular campers are passionate about fishing and other recreational activities around and on the Sandon River.

The Solitary Islands Marine Park was established in 1998 below the mean high-water mark at Sandon River and is managed by the NSW Department of Primary Industries. The coastal features within the marine park have not been included in this response plan.

Access to Sandon village (located across the river, south of the campground) is by boat across the Sandon River from the campground or, during low tides, by 4-wheel-drive (4WD) vehicle along Sandon/Illaroo beach (south of the study area). During high tides, the ‘back track’, which runs parallel to Sandon/Illaroo beach, allows vehicles to access Sandon village from the south. Power is supplied to the village from Brooms Head via overhead power lines that follow Sandon River Road into the campground and over the river. No power is supplied to the campground.

Photo 1 Aerial view of Sandon River campground and Sandon River (looking west), 2020

Photo 2 Sandon River campground and picnic areas, 2022

4.2 Aboriginal cultural and historic heritage significance

The study area continues to hold special significance to the Yaegl people as a cultural landscape, containing sites, places, stories and resources that are essential in maintaining traditional and contemporary links to the land. The Yaegl people have occupied and managed the coastline and surrounding areas for thousands of years. The coastal areas continue to play a significant role in their daily lives, providing an abundance of natural resources for survival, ceremonial rituals and a deep social, cultural and spiritual connection. Numerous sites, areas and landscapes significant to the Yaegl people are located in the study area, including midden sites within the campground and a stone quarry site at Plover Island, as documented in previous investigations (e.g. Tuck 2007; DECC 2009; Collins 2001). These sites represent the high heritage value and archaeological sensitivity of the area. Throughout the campground, measures have been implemented to protect the remaining cultural heritage resources, including protective fencing, surface fill and restrictions on the future redevelopment of the site (Collins 2001).

The Yaegl people are the traditional owners and custodians of Yaegl Country, which encompasses the study area. The Yaegl people's ongoing use and relationship to country is recognised under native title determination NCD2017/003 – Yaegl People #2 (Part B) (National Native Title Tribunal 2017), which covers areas of Crown land within the lower Clarence Valley from Shark Bay in the north to Wooli in the south, including areas of Yuraygir National Park and parts of the study area (Figure A.2).

Yuraygir National Park has a long 'shared' history of both Aboriginal and European use, occupation and association. The early European history relates principally to the use of the coastline and hinterland as a recreational area, initially for camping, fishing and hunting in the late 19th century, and later for surfing and bushwalking as well. Commercial fishing operations included former oyster leases, an oyster processing site and the former commercial fishing cooperative and associated infrastructure (shed and boat slip). Sand mining was also undertaken in the area north of Sandon River campground. Sugar cane was the most recent farming activity to be undertaken in what is now the national park (Tuck 2007; DECC 2009).

The 13 huts along Sandon River Road and within the campground were constructed as dwellings between the 1930s and 1960s on Crown land under permissive occupancies granted by the former Lands Department, before this central section was part of Yuraygir National Park. The huts have been assessed and listed as significant local heritage items because of their place in the history of early coastal recreation and commercial fishing.

4.3 Biodiversity significance

Yuraygir National Park is located within the Macleay–Macpherson overlap, an ecological transition zone between the temperate southern areas of eastern Australia and the tropical north. The zone of overlap has significance for the number and diversity of both plant and animal species. The distribution of plant communities in the planning area is determined by the area's natural contours, water sources, soils, rock types and other aspects of the landscape, but is also influenced by natural coastal processes such as wind and tides. The climatic conditions support subtropical, coastal and temperate communities and species. Plant communities include wet and dry forests, woodland, shrubland, heathland, sedges and grasses. Animal species include reptiles, turtles, birds and mammals, migratory and resident shorebirds, and bats (NPWS 2003).

5. Development of the response plan

5.1 Stakeholder engagement

A community reference group was established for this project to assist in the development of the CHRP. The group included:

- campground users
- representatives from Sandon Ratepayers Association
- Clarence Valley Council
- NSW Department of Climate Change, Energy, the Environment and Water
- NSW Department of Primary Industries – Fisheries and Marine Parks divisions
- Yaegl Traditional Owners' Aboriginal Corporation (a Registered Native Title Body Corporate)
- Lower Clarence Deep Sea Fishing/Angling Club
- Sandon River Environmental Alliance
- the onsite caretaker of the campground
- representatives from Huts 9, 11, 13 and 14c.

The project team held 2 meetings with the community reference group.

- The first meeting introduced the project, presented information on coastal hazards and asset risks, determined community objectives and gathered information.
- The second meeting presented management options, obtained the group's input into the options, and discussed individual parts of the management plan.
- Biodiversity, Conservation and Science Group within the Department of Climate Change, Energy, Environment and Water provided a technical review of the management options and recommendations and reviewed the draft CHRP.

A separate meeting was also held with the Yaegl Traditional Owners' Aboriginal Corporation to present the project scope and provide additional context.

5.2 Key values, objectives and considerations

5.2.1 Values

The Sandon River campground is valued for its:

- scenic beauty
- recreational opportunities
- natural landscape
- cultural heritage significance.

5.2.2 Objectives

The *Yuraygir National Park and Yuraygir State Conservation Area plan of management* (NPWS 2003) outlines the following management objectives.

- Protect the planning area as part of the system of regionally important protected areas on the Clarence and Richmond coast of northern NSW.

- Promote appropriate land use planning and management among neighbours and other land use authorities which will afford the highest practicable protection for:
  - the natural condition of the planning area
  - the recreation setting provided by the planning area
  - the natural condition of adjacent lands.
- Emphasise within the local community, particularly neighbours of the planning area, the importance and purpose of management programs relating to the protection of the natural and cultural heritage and to the control of fire, weeds and feral animals.
- Protect Aboriginal cultural heritage and provide opportunities for the Aboriginal community to be involved in the management of their heritage within the planning area.
- Promote public awareness and appreciation of the planning area with emphasis on:
  - the importance of the planning area in the regional pattern of conservation areas
  - the geological evolution of the Clarence coast
  - the biological significance of the coastal environment for the conservation of native plants and animals
  - appropriate use of the recreation resources of the planning area, particularly the recreational use of its beaches.
- Ensure that the pattern of outdoor recreation in the planning area is appropriate, with emphasis on providing a range of low-key facilities and opportunities for alternative access to the coast.

The NPWS also has specific objectives for the ongoing management of the Sandon River campground. These include:

- acknowledgement of the campground's cultural heritage values and facilitation of the use and access to the area by native title holders
- safe and functional vehicular access
- safe and enjoyable visitor (camping and day use) experience
- preservation of scenic amenity
- maintenance of the surrounding beaches, foreshore and reserve areas to support the visitor experience, for as long as it is viable
- provision of opportunities for appreciation, understanding and enjoyment of the area
- maintenance of the economic viability of the campground
- preservation of habitat and ecosystem services in the surrounding area.

A key objective of this CHRP is to promote and achieve the objects of the NSW Government's coastal management framework under the *Coastal Management Act 2016*. Section 3 of the Act states that its objects are:

> to manage the coastal environment of New South Wales consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of the State, and in particular —
>
> (a) to protect and enhance natural coastal processes and coastal environmental values including natural character, scenic value, biological diversity and ecosystem integrity and resilience, and
>
> (b) to support the social and cultural values of the coastal zone and maintain public access, amenity, use and safety, and
>
> (c) to acknowledge Aboriginal peoples' spiritual, social, customary and economic use of the coastal zone, and
>
> (d) to recognise the coastal zone as a vital economic zone and to support sustainable coastal economies, and

(e) to facilitate ecologically sustainable development in the coastal zone and promote sustainable land use planning decision-making, and

(f) to mitigate current and future risks from coastal hazards, taking into account the effects of climate change, and

(g) to recognise that the local and regional scale effects of coastal processes, and the inherently ambulatory and dynamic nature of the shoreline, may result in the loss of coastal land to the sea (including estuaries and other arms of the sea), and to manage coastal use and development accordingly, and

(h) to promote integrated and co-ordinated coastal planning, management and reporting, and

(i) to encourage and promote plans and strategies to improve the resilience of coastal assets to the impacts of an uncertain climate future including impacts of extreme storm events, and

(j) to ensure co-ordination of the policies and activities of government and public authorities relating to the coastal zone and to facilitate the proper integration of their management activities, and

(k) to support public participation in coastal management and planning and greater public awareness, education and understanding of coastal processes and management actions, and

(l) to facilitate the identification of land in the coastal zone for acquisition by public or local authorities in order to promote the protection, enhancement, maintenance and restoration of the environment of the coastal zone, and

(m) to support the objects of the *Marine Estate Management Act 2014*.

5.2.3 Considerations in the development of the CHRP

- The community and the NPWS desire to maintain the facilities at Sandon River campground and the surrounding reserve areas for as long as economically and practically viable.
- Future management approaches and protection measures should be sympathetic to natural coastal processes.
- Artificial intervention should be limited so that the scenic beauty and natural landscape of the area are not substantially compromised.

5.3 Coastal hazards

This CHRP addresses the current and future coastal hazards in the study area, including:

- tidal and coastal inundation
- beach erosion
- coastal recession
- riverbank erosion in the context of waves, sea level and weather events (e.g. storms).

Other coastal hazards have not been considered in this report. For example, entrance instability. The Sandon River entrance is flanked by Plover Island and a linking tombolo to the north and a rocky headland to the south. Tidal currents in the river estuary move marine sands upriver, resulting in the formation of shoals in the lower estuary. River-related sedimentation does not greatly affect the estuary, and sand movement within the estuary is predominantly natural (Hydrosphere Consulting 2021).

5.3.1 Coastal processes

The ocean conditions and wave climate – that is, the distribution of wave characteristics averaged over a period of time and for a particular location – along the Clarence Valley coastline are influenced by both short-term weather and longer-term climatic conditions. Coastal processes and influences along the coastline include wind, wave direction, wave height, sediment movement and weather patterns, as described below (Hydrosphere Consulting 2021).

- **Wind**. Morning winds are typically light and from the west, with stronger winds from the south occasionally. Afternoon winds are usually stronger north-east and south-east winds. Wind direction and strength influence wind-related transport of sand and local wave conditions.
- **Wave direction**. The dominant swell direction along the Clarence Valley coastline is east-southeast (that is, waves travel from a direction that is between easterly and south-easterly). There is a seasonal trend in wave direction with swells predominantly east-southeast during summer, shifting further south in autumn, and south-east to south-southeast during winter. North-easterly winds can influence wave direction in the spring, but the predominant direction is still south-east. In summer, the largest swells come from the south-southeast, with a small portion of larger swells from the east.
- **Wave height**. Wave heights peak between March and April. Periodic weather events can result in large wave conditions that impact on shorelines.
- **Sediment movement**. The Clarence Valley coastline is a longshore drift coastline, which means that waves move sediments (such as sand, pebbles and shells) parallel to the coastline, resulting in coastal formations such as sandbars and spits (compartments). Overall sediment movement (in a northerly direction) is influenced by the predominant south-easterly swell. Longshore drift occurs within and between sediment compartments. There are other localised sediment movements, including onshore and offshore movements under different conditions.
- **Weather patterns**. The El Niño Southern Oscillation cycle is responsible for influencing weather patterns on the east coast and is a major driver of wave climate and associated coastal processes and conditions. The cycle drives the El Niño and La Niña weather phases. El Niño events are associated with reduced storminess, weaker easterly trade winds and a generally more southerly wave climate. La Niña events are associated with the opposite: increased storminess, stronger trade winds and a more easterly wave climate.

The ocean tides and wave climate along the Clarence Valley coastline have formed multiple scallop-shaped open bays in the shoreline such as the one at Sandon River campground. These natural coastal processes have also periodically resulted in erosion along Sandon Beach. More recently, a storm event in 2017 resulted in retreat of the shoreline to the north-east of the campground (see Figure B.6 and Figure B.7). Erosion of the riverbank has also occurred near Sandon village on the southern bank of the estuary entrance.

5.3.2 Current coastal management measures

Coastal management actions such as coastal erosion mitigation measures at Sandon River campground are currently implemented on a case-by-case basis in response to coastal erosion events. For example, in response to the 2017 storm event that resulted in coastal erosion of the sand dunes, the NPWS constructed sand-trap fences and revegetated the dune (Figure 1, Photos 3 and 4).

Figure 1 **Existing dune stabilisation works, Sandon River campground, 2024**

Photo 3 Dune rehabilitation area adjacent to Sandon River campground, 2022

Photo 4 Dune rehabilitation area adjacent to Sandon River campground, 2023

The upper beach area on the eastern side of the campground consists of dune fencing and revegetation areas covering approximately 3,000 square metres. Two designated pedestrian access tracks run through this area. Sand is slowly building up on the upper beach forming a relatively wide and flat accumulation of sand that is acting as an incipient dune (that is, a dune in its early stage of formation). This accumulated sand is currently relatively low in height. The area is well vegetated (approximately 70 to 80% cover) by predominantly beach spinifex (*Spinifex sericeus*) and goat's foot (*Ipomoea pes-caprae subsp. brasiliensis*, also known as beach morning glory). Both of these are colonising species that commonly establish in newly formed dune areas. These rehabilitation measures following erosion events appear to have been successful in restabilising the dune.

Directly behind the incipient dune area is a steep slope (scarp) from past erosion. The vegetation of this scarp varies along its length. Above the scarp is a narrow area that is fenced off from public access.

An array of dune fences has been installed on the upper beach to the west of the 4WD access along Sandon Beach (see Figure 1). Another incipient dune in this area is being colonised by beach spinifex, goat's foot and sea purslane (*Sesuvium portulacastrum*, also known as pigweed*)*.

On the western side of the peninsula, much of Sandon River Road is located close to the riverbank, where it is impacted by high tides and small waves that also cause bank erosion. A section of the road (approximately 150 m in length) has been armoured with rock revetment to prevent further riverbank erosion (see Figure 2 and Photo 5). With extreme high tides, the road can currently be inundated with water from the river rising above the banks.

Ad hoc rock walls have been built by landowners within Sandon village in an attempt to provide protection from erosion along the southern bank of the river entrance.

Figure 2 **Aerial view showing section of Sandon River Road armoured with rock protection, 2024**

Photo 5 Section of Sandon River Road armoured with rock protection, 2020

5.3.3 Coastal hazard assessments

Coastal hazard assessments and associated maps (JBP 2022, 2023) were prepared to support stage 2 of the development of the Clarence Valley Open Coast CMP. Coastal hazard mapping is provided in Appendix C. The coastal hazard assessments considered the hazards of coastal erosion, recession and inundation as defined by NSW Environment and Heritage (2019a):

- **Beach erosion** refers to the removal of beach materials by wave action, tidal currents, shore currents or wind. It is usually associated with storms or elevated water levels and can occur on the open coast and in estuaries. Beach erosion events are often combined with a beach recovery phase when sediment moves back onshore to rebuild the beach and dunes. The balance between sediment added and sediment removed from the coastal system (the 'sediment budget') is maintained in a closed sediment compartment (Figure 3).
- **Shoreline recession** refers to continuing landward movement of the shoreline or a net landward movement of the shoreline over a specified time.
- **Tidal inundation** refers to the flooding of land by tidal action under normal weather conditions. Tidal inundation includes brief incursions of seawater onto low-lying land during an elevated water level event (such as a 'king' tide) and more permanent flooding due to land subsidence, changes in tidal range or sea level rise. Any changes in mean sea level will directly affect the extent and severity of tidal inundation hazards.
- **Coastal inundation related to storm events** refers to the temporary flooding of a portion of land within the coastal zone when a combination of marine and atmospheric processes raises ocean water levels above normal elevations, causing it to flood low-lying areas or wash over dunes, structures and barriers (Figure 4). Coastal inundation is often associated with storms, where the elevated water level is called a storm surge.

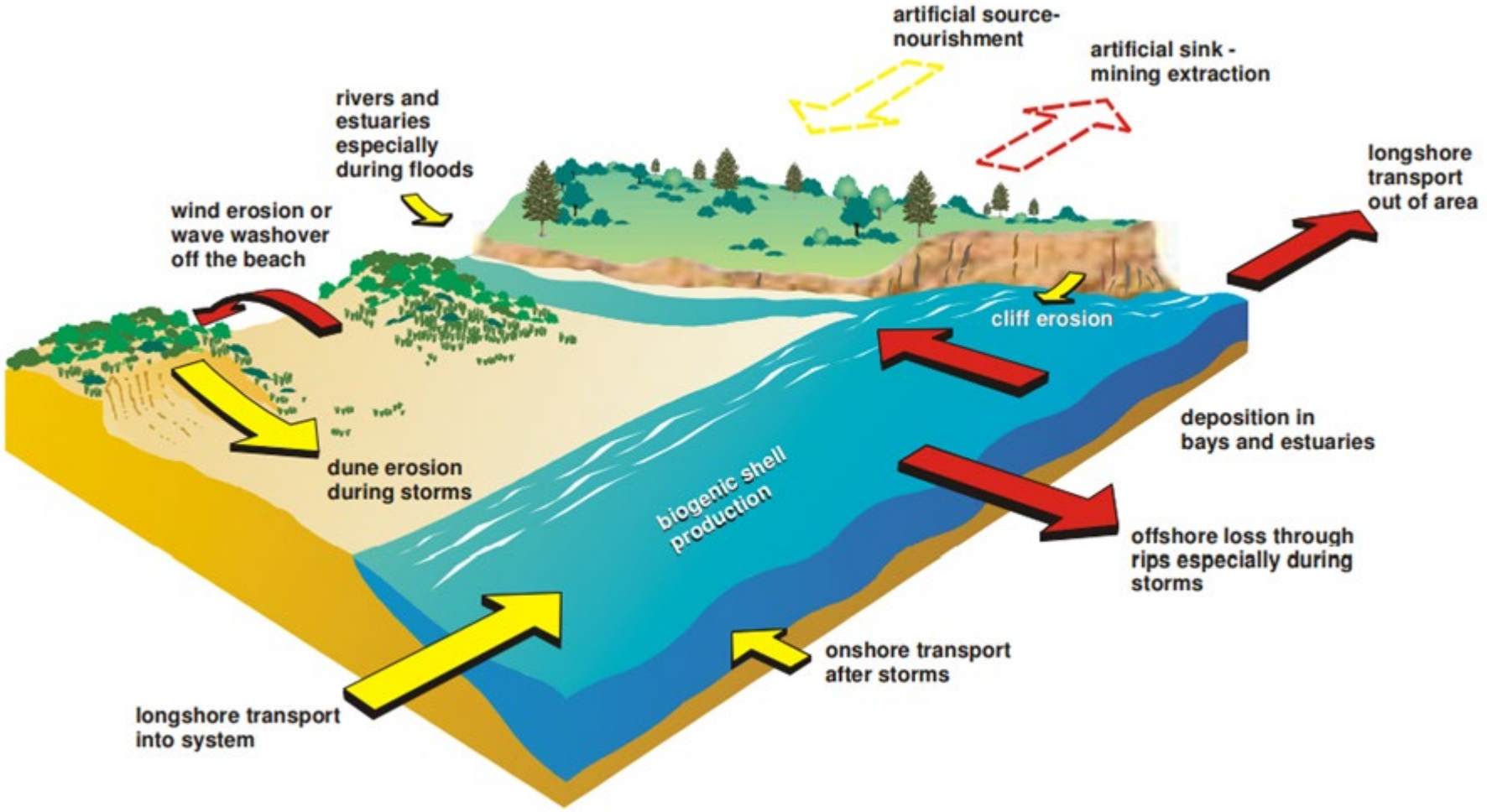

Figure 3 Components of the coastal sediment budget

Source: NSW Department of Land and Water Conservation (2001).

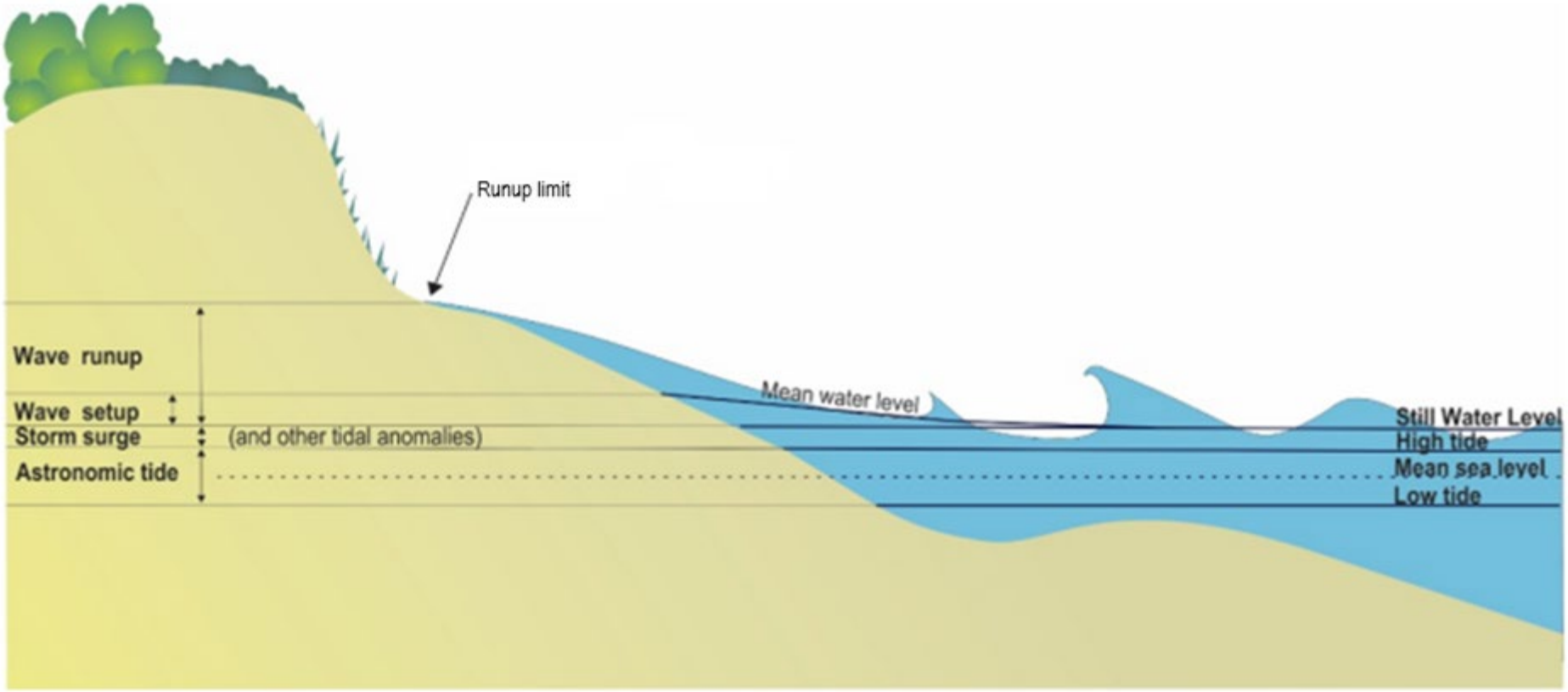

Figure 4 Different components that contribute to elevated water levels on the open coast

Source: NSW Environment and Heritage (2018c), Figure B2.13.

The coastal hazard assessments considered a number of scenarios for each of 3 categories of hazard – tidal inundation, coastal inundation, and beach erosion and shoreline recession – that would result from a combination of 3 factors: timeframe, event frequency and future climate scenario.

The definitions of event frequency were based on terminology used in flood management planning (Ball et al. 2019). The term **exceedance probability** (EP) means the probability that a particular event will be exceeded in a given period.

- For inundation events, the event frequency is the probability that a particular inundation event will be exceeded in a given year, that is, annual EP (AEP).
- For erosion and recession events, hazard projections are a combination of short-term and long-term probabilistic components, so scenarios are described in terms of likely EP. For a given planning horizon, erosion/recession maps indicate the probability, given as a percentage, that the hazard extent will be exceeded.

The future climate scenarios were drawn from the Intergovernmental Panel on Climate Change (IPCC) categories of shared socio-economic pathways (SSPs), which 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 (IPCC 2023). The assessment scenarios included allowances for sea level rise based on 2 SSPs, namely SSP2 and SSP5.

- SSP2 represents a pathway 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 staying at 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 triple by 2075. However, it also includes a pathway where competitive markets, innovation and participatory societies are able to produce rapid technological progress to achieve sustainable development over the long term.

The Clarence Valley Council commissioned a climate risk assessment which considers that SSP2 is more likely than SSP5 (Risk Frontiers 2021).

Table 1 shows the 64 scenarios considered in the coastal hazard assessments, in the following combinations:

- 8 tidal inundation scenarios, based on a high high-water solstice spring (HHWSS) tide, for:
  - 4 timeframes (2023, 2043, 2073 and 2123)
  - an AEP of more than one per year (very frequent)
  - 2 future climate scenarios (SPP2 and SPP5)
- 24 coastal inundation scenarios, based on extreme sea level rise, for the same 4 timeframes and same 2 future climate scenarios, but with 3 event frequencies:
  - 10% AEP (frequent to very rare)
  - 2% AEP (rare)
  - 1% AEP (rare to very rare)
- 32 beach erosion and shoreline recession scenarios, for the same 4 timeframes and same 2 future climate scenarios, but with 4 event frequencies:
  - 50% AEP (frequent)
  - 10% AEP
  - 2% AEP
  - 1% AEP.

Table 1 Coastal hazard assessment scenarios

Hazard	Planning timeframes	Event frequency*	Future climate scenarios
Tidal inundation (HHWSS tide)	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	> 1 per year	SSP2 SSP5
Coastal inundation (extreme sea level rise)	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	10% AEP 2% AEP 1% AEP	SSP2 SSP5
Beach erosion and shoreline recession	Present day (2023) +20 years (2043) +50 years (2073) +100 years (2123)	50% EP 10% EP 2% EP 1% EP	SSP2 SSP5

AEP = annual exceedance probability; EP = exceedance probability; HHWSS = high high-water solstice spring; SSP = shared socio-economic pathway, as defined by the Intergovernmental Panel on Climate Change (2023).

* Event frequency values are defined as: > 1 = very frequent; 50% = frequent; 10% = frequent to rare; 2% = rare; 1% = rare to very rare.

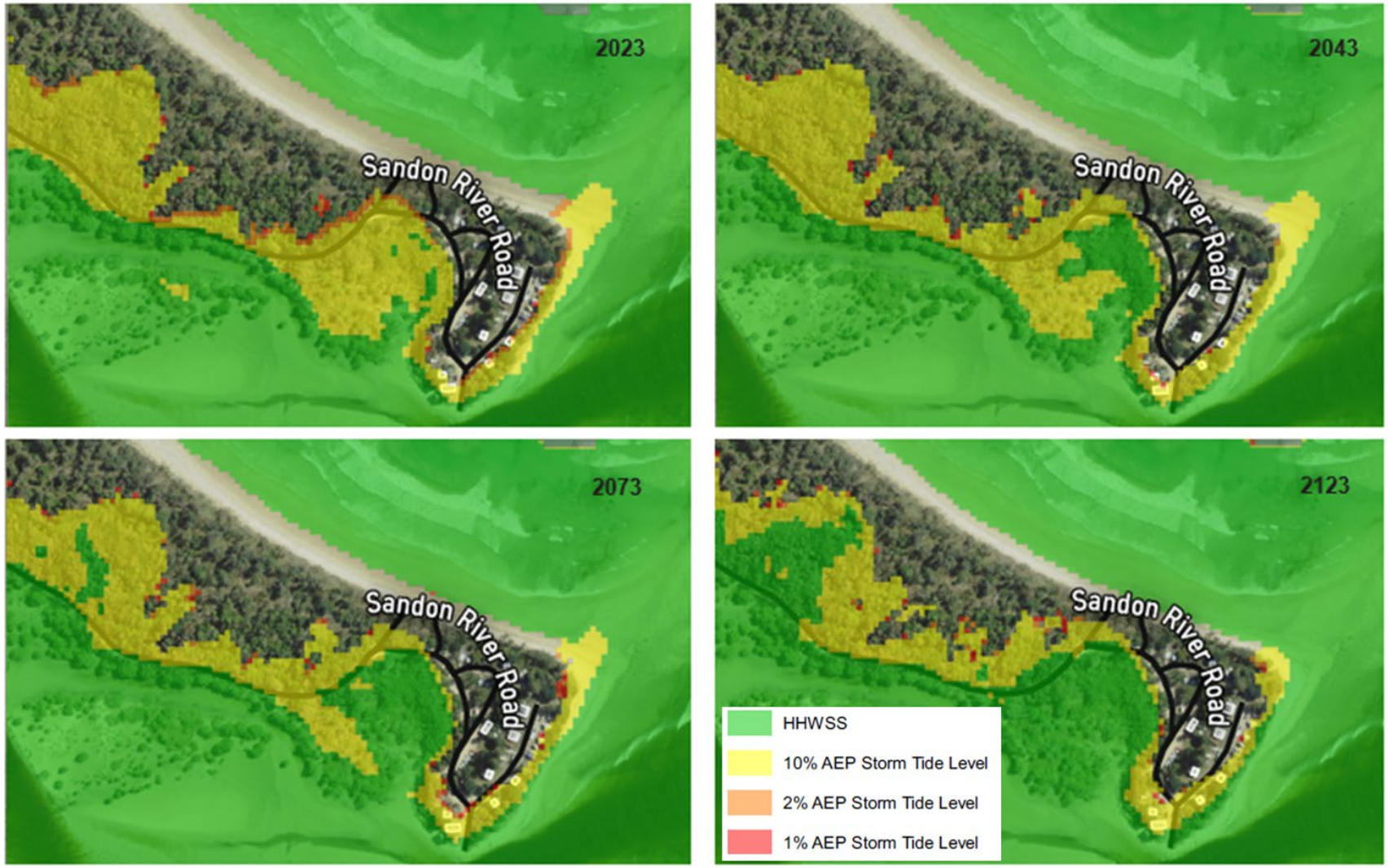

Figure 5 Projected Sandon River inundation extents in 2023, 2043, 2073 and 2123, based on shared socio-economic pathway scenario 2

HHWS: high high-water solstice spring; AEP: annual exceedance probability. Source: JBP (2022).

Tidal and coastal inundation hazard mapping

The detailed assessment of tidal and coastal inundation undertaken for Sandon River (JBP 2022) 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 Sandon River and coastline areas using hydrodynamic modelling and spatial projection methods. Each planning timeframe includes tidal inundation mapping based on a HHWSS tide, which occurs more than once each year, and coastal inundation (extreme sea level rise), shown in Table 1.

Periodic tidal inundation is predicted to impact the Sandon River campground, access road and surrounding national park with inundation extents increasing over time. Future coastal inundation from the ocean could extend into the campground areas, including the boat ramp and southern campsite areas, over the next 20 years. The depth of inundation varies at different locations along the road and depends on the combination of events as outlined in Table 1.

Campsites in the northern section are expected to be inundated by 2073. The inundation extents for the campground and surrounding areas for the present day and for 20, 50 and 100 years in the future, based on predicted changes to sea level under IPCC scenario SSP2, are shown in Figure 5.

Beach erosion and shoreline recession scenarios

Changes in the distribution of sediment between the nearshore, alongshore, beach face, foredune (frontal dune) and estuaries are considered in the assessment of potential beach erosion. Short-term changes in the shoreline are often quite dramatic and may mask long-term accretion or recession that occurs at much slower rates (Figure 6). As shoreline recession occurs, the beach fluctuation zone moves landward (Figure 7). 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 lose sediment from several sources. If the losses persistently exceed the gains, then the shorelines within that compartment will recede.

During a storm, sand is removed from the upper beach and dune profile and deposited below the intertidal zone to form a storm bar. The sand is not lost from the system and does not contribute to recession. Rather, such storm erosion is temporary, with the beach and dune usually accreting in the weeks, years or even decades after the storm event.

The detailed assessment of beach erosion and recession (JBP, 2023) provides information on the likelihood of beach erosion and shoreline recession over time. The erosion and recession assessment were undertaken for each planning horizon, event frequency and climate pathway (Table 1) and considered 5 factors:

- historic recession rate
- future variability in wave climate
- Impacts of potential rise in sea level
- storm (event-based) erosion
- other site-specific features of the landscape.

In other words, the future extent of erosion and shoreline recession will depend on the occurrence and severity of storms, future variability in wave climate, and impacts of sea level rise.

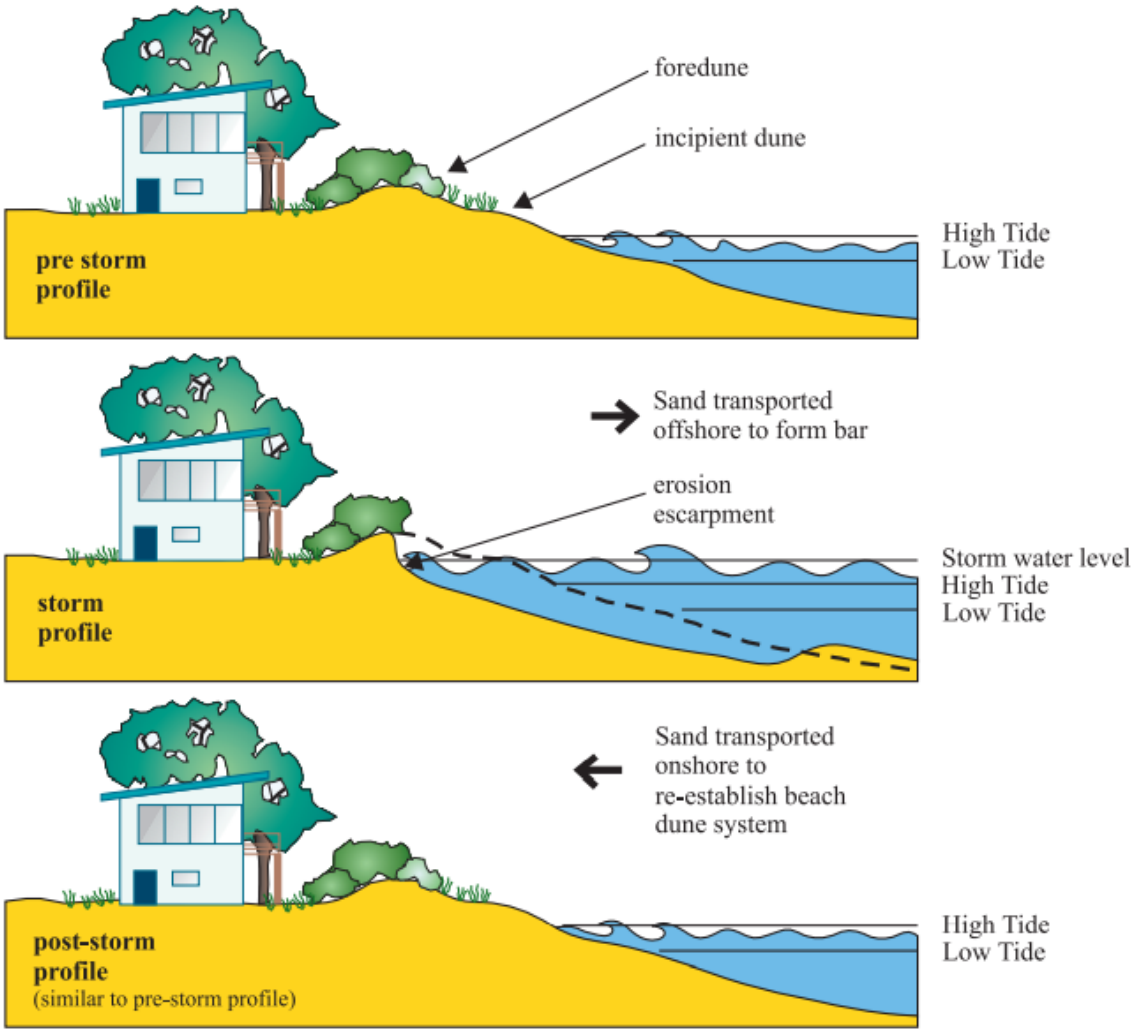

Figure 6 Beach erosion and accretion cycle with no permanent sand loss or shoreline retreat

Source: NSW Department of Land and Water Conservation (2001).

In the detailed assessment of beach erosion and recession (JBP 2023), historic recession was measured as the landward movement of the shoreline (in linear metres). The mean historic recession rate for the section of Sandon Beach adjacent to the campground is 0.08 m per year. Projected storm erosion and recession as a result of sea level rise was measured as the volume of sand lost from each metre along the length of the of beachfront (in cubic metres (m^3) per metre). Event-based erosion in the section of Sandon Beach adjacent to the campground was projected to be 181 m^3/m (1% AEP). Sea level rise impacts are expected to increase the rate of erosion. For the 2043, 2073 and 2123 timeframes, the additional erosion volume was projected to be, respectively, 30 m^3/m, 117 m^3/m and 381 m^3/m respectively (50th percentile values for a SSP2 climate scenario).

All erosion/recession scenarios have been created under different assumptions and may not be the limits of potential changes as the coastline may continue to evolve in an unforeseeable way. These scenarios provide guidance for strategic planning and potential approaches to manage the risks.

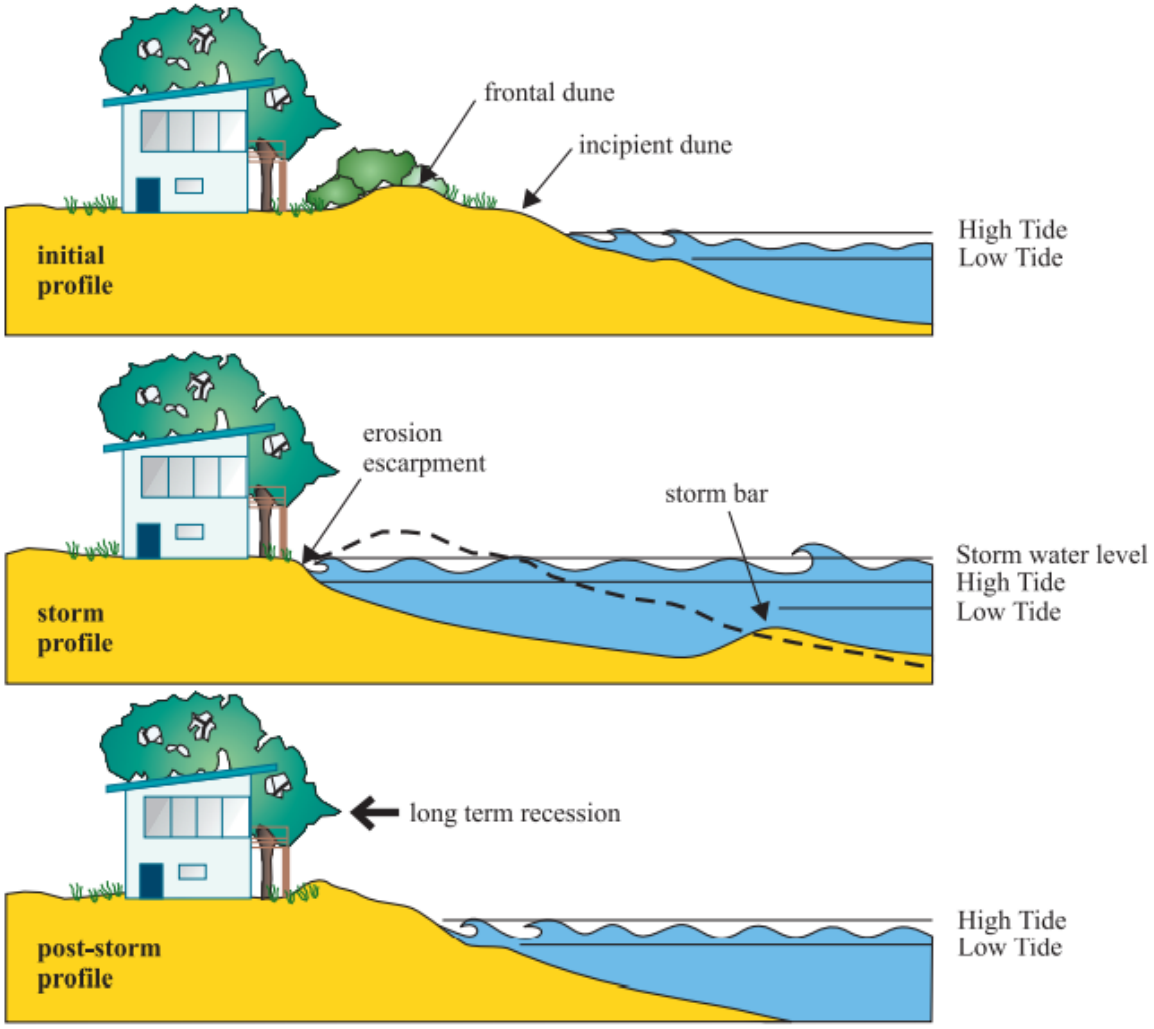

Figure 7 Long-term beach recession – landward displacement due to permanent sand loss

Source: NSW Department of Land and Water Conservation (2001).

The erosion hazard widths include an additional component for the zone of reduced foundation capacity, which is not an area where sediment is removed, but rather an area of instability (for building purposes) behind the eroded beach scarp. During an extreme storm event, erosion may extend the potential landward instability zone an additional 7.3 m inland (1% AEP).

JBP (2023) provides maps over different time horizons (reproduced in Appendix C: Coastal hazard mapping) which combine the upper values of the long-term recession rate, sea level rise impacts and storm erosion (EP).The assessments suggest that Sandon Beach is vulnerable to erosion at present, with Sandon River Road and the Sandon River campground at risk from rare (2% EP) erosion events and becoming more vulnerable in future. Coastal erosion may reach the Sandon River within 100 years, resulting in the complete loss of the Sandon peninsula.

Potential impacts of combined inundation, erosion and recession

The individual impacts of inundation, erosion and recession are exacerbated if combined. This could happen if severe erosion and inundation occur simultaneously or incrementally over time as recession progresses and inundation heights and frequency increase. The Sandon peninsula is threatened on its eastern side by coastal erosion and recession, and on

its western side by inundation from the estuary. Mapping indicates that there are 6 locations where erosion risk and inundation risk overlap (vulnerability zones 1 to 6 in Figure 8). These simultaneous events could result in a ‘break through’, where the ocean breaks through the peninsula on a longer-term or permanent basis, which could lead to the complete loss of land and assets within the area.

This type of impact occurred in 2022 on Bribie Island in Queensland. A combination of ongoing erosion and recession and coastal inundation led to the breakthrough of a narrow section of Bribie Island (Photo 6). This event created an area of significant exchange between the ocean and Pumicestone Passage and a channel resulting in broader geomorphic and tidal impacts.

Photo 6 Aerial view of ‘break through’ caused by natural coastal processes, Bribie Island, Queensland, 2022. Source: Blueys Photography

If a similar event occurred at Sandon River, it would not only impact assets within the direct footprint of the breakthrough but would prevent road access to any areas to the south of the break-through point.

A less drastic outcome of erosion and recession combining with inundation is the creation of an area where flooding or wave overtopping occurs intermittently during storms and other coastal inundation events. Historical aerial photographs show that the site of the campground was detached from the peninsula between 1942 (Figure B.1) and 1958 (Figure B.2). It is possible similar conditions could occur again.

Figure 8 **Coastal hazard vulnerability zones V1 to V5 (along Sandon River Road) and V6 (Sandon River campground area) for present day (2024) inundation and erosion events**

Note: 10% EP = exceedance probability risk of less than 10% (frequent to rare).

The campground would remain viable until its road access was significantly compromised, or the campground site and facilities were irreparably damaged. Modelling indicates that there is a present-day risk of a frequent to rare (10% EP) erosion event damaging the access road such that access may be available for 4WD vehicles only or restricted to limited tidal conditions. This would impact:

- campground users
- Sandon village residents who use the campground for boat access
- anglers who use the boat ramp to launch boats
- electricity infrastructure along the peninsula
- NPWS operations, including the ability to service campground facilities such as the toilets.

Over time, the viable area of campground is expected to reduce with increasing sea levels and impacts of beach erosion.

5.4 Development and assessment of management options

5.4.1 Strategic management approaches

This CHRP takes the strategic approach adopted in the NSW Environment and Heritage's *Coastal management manual* (2019b) of considering options to address identified risks and to manage any unacceptable risks, develop adaptation pathways over time and evaluate 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 with limited campground development only in low-risk locations
- **active intervention** – coastal management actions that seek to protect assets or accommodate change, while maintaining current systems and values
- **planning for change** – planning to relocate or redevelop assets to acknowledge the changing nature of the shoreline, timed to begin as opportunities arise or when thresholds of exposure, impact and risk are exceeded
- **emergency response** – actions to address residual risk in emergency situations.

These approaches recognise that natural coastal processes will impact the natural landscape over time and that interventions may not be able to stop 'nature taking its course'.

It is anticipated that the Sandon River campground will become unviable at some point in the future due to projected impacts of the coastal hazards identified in previous assessments. Because there is inherent uncertainty with the coastal hazard projections, the extent and timing of these impacts need to be considered in the selection of management options. The aim is to extend the timeframe over which the campground can remain in operation, through prudent and adaptive management.

5.4.2 Preliminary assessment of feasibility

A preliminary assessment of potential management options and their feasibility considered the following factors:

- consistency with management objectives (Section 5.2):
  - meeting the management objectives for the campground
  - promoting and achieving the objects of the NSW coastal management framework
  - complying with legislation and NPWS management plans
- the wider context and potential impacts, including:
  - environmental impacts (positive or negative) on the natural and built environment, taking account of environmental and sustainability objectives
  - social impacts, considering factors such as usability, access to the coastline, safety, aesthetics, recreational values, visitor experience and commercial activities
  - cultural heritage values
  - economic considerations such as anticipated costs (estimated initial and ongoing costs) and predicted benefits (campground income)
- feasibility as determined by effectiveness, technical viability, confidence in performance, constructability, and legal and approval risks
- viability of implementation as determined by availability of resources and expected commitment.

The results of the preliminary assessment of feasibility are provided in Table D. The potentially feasible management options and their feasibility assessment are further described in the following sections.

5.4.3 Potentially feasible management options

Option 1 – Planned retreat

Depending on the rate of shoreline recession over time, there may be a need to decommission and relocate the Sandon River campground facilities. Although the central campground is the least vulnerable to coastal hazards, the limited area available between the vulnerable areas adjacent to the beach and river mean there is little capacity to relocate facilities in the same area.

The campground currently caters for short-term camping and includes unpowered campsites and huts, toilet facilities and garbage services. Safe access by road is required to maintain these facilities. As the road access becomes compromised over time, some facilities will need to be removed. The campground could evolve into a more basic camping site without these facilities, potentially as a day-use area with access by 4WD vehicles at low tide only. The future configuration of the current campground – including retreat timing, impact thresholds and ongoing management implications – will need to be considered under this option.

There are 8 existing campgrounds within Yuraygir National Park, which provide a range of camping experiences along the coastline. Relocating the campground to a new site could be undertaken if a suitable site is found. The existing campground capitalises on the unique natural assets at Sandon River – headland, tombolo, sheltered bay, estuary access, ocean access, north-westerly views across water and boat-launching facilities. Alternative sites would provide a different camping experience.

Within the existing NPWS reserve estate (Yuraygir National Park) between Sandon River and Brooms Head, 4 alternative sites (sites A, B, C and D) within 500 m of the existing

shoreline were considered as possible relocation sites for the campground. Areas to the south of Sandon River were not considered because their restricted access makes them not feasible as relocation sites. To maximise the use of existing infrastructure and minimise disturbance and impact, only sites with existing road access or in close proximity to existing road access were considered. Also excluded as possible sites were areas within existing mapped coastal wetland areas or other low areas prone to flooding or future coastal inundation. The area has high cultural heritage significance and the Yaegl people's native title extends along the coastline (Figure A.2), so any future relocation options must be considered in consultation with the Yaegl people.

Figure 9 shows the constraints of potential new locations for the campground between Brooms Head and Sandon River. Sites A, B and C are located on Crown land with proximity to the Brooms Head village and are within 200 m of the beach. Access to the sites would be from Brooms Head via existing 4WD access roads to the areas. Existing pedestrian tracks to the beach are also present. These sites are on an elevated sand ridge (15 to 20 m above sea level) that is underlain by coffee rock. There are westerly views across Lake Cakora to the coastal range and vantage points to the east over the beach. The sites would not have access to an estuary, a protected bay, or boat-launching opportunities. With no existing facilities within the area, the sites would provide a very basic camping experience. Connection to existing utilities in Brooms Head may be possible.

Site D is located to the north-west of the current campground on a low ridge (6 to 8 m above sea level) near Toumbaal Creek, approximately 500 m from the beach. An existing vehicle track currently provides access to the site. The site has no direct access to the beach but does have estuary access. With no existing facilities, this site would also be a very basic campground. Boat-launching facilities could be added to provide an alternative boat access point for Sandon village for when the current boat ramp becomes inaccessible.

Detailed planning for retreat would need to include detailed investigation into the possible sites as well as considering the future management of the current campsite, including:

- transitioning the existing campground to a less frequently used day-use area accessed by 4WD, boat and on foot only at low tide
- the huts
- restrictions on access to the boat ramp and potential alternative boat ramp locations
- electricity supply to Sandon village.

Significant consultation and coordination of strategic retreat planning and implementation will be required.

This option need not be implemented in isolation but could be combined with other options in an adaptive approach that aims to improve natural and recreational values at the campground in the short term while planning for retreat in the longer term. For example, options 3B and 3C (dune stabilisation and revegetation) could provide a buffer against erosion and recession in the short-term to extend the life of the campground before full retreat becomes necessary.

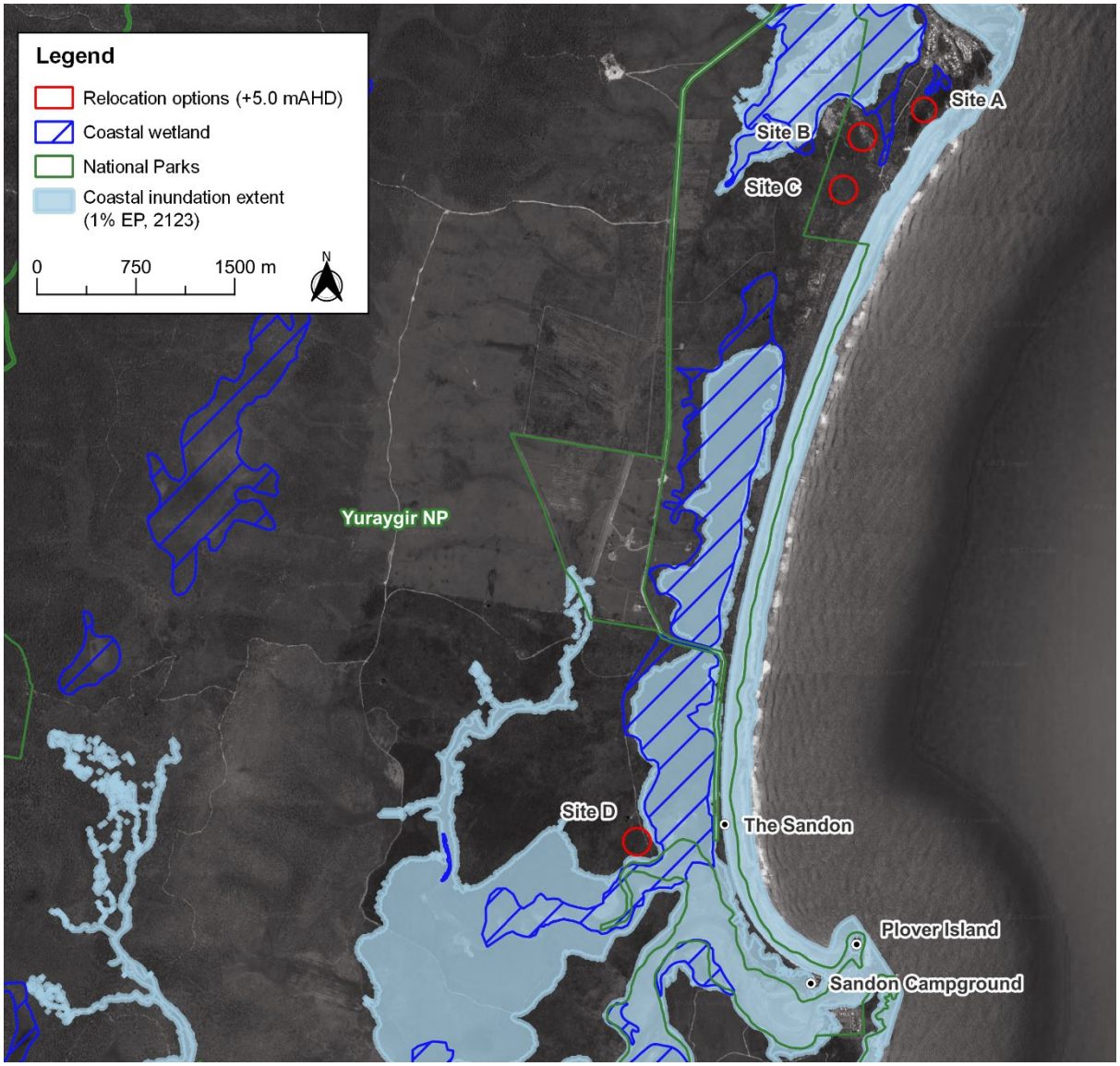

Figure 9 Potential campground relocation sites

Note: 1% EP = exceedance probability risk of less than 1% (rare); AHD = Australian height datum (i.e. distance relative to sea level); + mAHD = metres above sea level.

Option 2 – Coastal protection works

Coastal protection works could be constructed to reduce the impact of erosion around the shoreline frontage of the campground and access road. Up to 1,500 m of shoreline may require protection.

Option 2A – Short seawall to protect the campground

This option involves the construction of a seawall about 140 m in length along the northern perimeter of the campground (Figure 10), to protect the campground from beach erosion and recession. Erosion would still likely occur at the ends of the seawall, impacting not only the 4WD access track but also the campground access road directly to the west of the campground. The seawall could be extended a further 80 m to protect the road immediately to the west of the campground. Erosion and recession of the shoreline would continue to the north of the campground along Sandon Beach, impacting campground access.

Option 2B – Extended seawall to protect the campground and the vulnerable sections of the access road

Option 2B considers a seawall extending approximately 150 m north from the campground, along with several other seawall sections of varying lengths further north. These additional sections of seawall, totalling around 1,300 m, would protect the parts of the road that are at risk of erosion (Figure 10).

Seawalls are costly and may adversely impact the natural values of the area as well as the scenic amenity. Hard engineering structures would significantly affect natural coastal processes and potentially exacerbate erosion at the tombolo. While seawall options would provide erosion protection, they would not protect the campground and road from marine and estuary inundation unless they are constructed higher than current and projected inundation levels. Higher seawalls would further impact local amenity. More detailed modelling and analysis of coastal processes would be required if seawall options are pursued.

Figure 10 Aerial view of locations for proposed seawall to protect Sandon River campground (option 2A) and the campground and access road (option 2B)

Option 2C – Sand nourishment

Sand nourishment involves the importation of sand to a beach from a source external to the site. Sand nourishment can be used to bolster sand supplies and increase sand volumes to a beach and dune system. The aim is to replace lost sand on an ongoing basis and provide a buffer against future anticipated sand losses. The volume of sand required would depend on the level of protection to be provided and actual erosion that occurs. A rare to very rare (1% EP) erosion event would be expected to remove 181 m^3/m of sand (JBP 2023) over the 200 m of beach within the vicinity of the campground, resulting in sand loss of approximately 36,200 m^3 (the equivalent to about 14 Olympic swimming pools). The same volume of sand would be required to nourish the beach after such an event, and more sand would be needed to maintain this level of protection.

Sand nourishment can maintain or improve beach amenity and recreational use while mitigating the impacts of erosion and recession. It is important to note that sand nourishment would not be a one-time solution. The benefits of an initial nourishment campaign could be extended through repeat nourishment campaigns or beach scraping (option 3A).

Sand nourishment options for Sandon River campground include both targeted and large-scale areas.

- Targeted beach nourishment in the immediate area of the campground could mitigate beach erosion, improve beach amenity, and replenish or supplement dune restoration. This may be suitable to support dune restoration works (option 3) in low volumes and at low cost.
- Larger or wider scale nourishment could reduce recession of the beach to the west and north of the campground, prolong the life of the peninsula and protect the access road. This approach would require large volumes of sand at high cost.

It is important that sand from the source matches or has similar characteristics (grain size, texture, angularity, and composition) to the existing sand at Sandon Beach.

Commercially available sand from quarries is a potential source of sand for nourishment but is likely to be viable for small volumes only. Apart from the high costs, the constraints, and potential issues with using commercially available sand include:

- reliability and availability of the supply into the future – sand characteristics may change with extraction areas, quarry extraction licences may expire, and sand sources may become exhausted
- sustainability – quarry sand is a finite resource that is generally considered to be in short supply
- the impact of truck movements – the number of expected truck movements to deliver the sand will put extra pressure on roads, particularly Brooms Head Road and Sandon River Road, and will negatively impact amenity in the area.

Local sand sources would avoid the above issues but may have other constraints and issues. Potential sources include:

- sand dunes to the north of the campground – removal of sand from this area would reduce the coastal hazard protection available for the road and is unlikely to be supported due to the interference with natural dune processes
- offshore sand sources – although detailed sourcing studies and feasibility assessments have not been undertaken, the costs involved in offshore dredging are likely prohibitive for the volumes required for sand nourishment at this location
- material from navigational dredging – there is unlikely to be any navigational dredging undertaken locally (for example, in Sandon River) that would provide a logical source.

Sand nourishment is unlikely to be viable due to the high cost of external sand sources, frequency of nourishment required and likely high environmental impacts of locally sourced sand.

Option 3 – Dune rehabilitation

Dunes, particularly incipient and foredunes such as those within the rehabilitation areas, are transient – that is, they are not permanent features – and should be considered as temporary buffers. It is inevitable that coastal erosion events will intermittently remove sand and damage infrastructure in these areas. Maintaining an effective dune buffer by facilitating accretion of sand during dune-building periods will provide some protection.

Dune stabilisation and revegetation are sustainable, natural, and effective ways to improve the resilience of a beach dune system against beach erosion. Typically, the goal of dune stabilisation is to restore a dune system that resembles, as closely as practicable, the dunes that were present before the degradation. At Sandon River campground the goal is to stabilise and encourage the formation of dunes to provide a buffer against erosion. The goal of dune revegetation is to increase the area and diversity of vegetation, which facilitates further sand capture and dune building and helps stabilise the dunes. Other benefits include habitat creation and improved recreational and scenic values.

Option 3A – Beach scraping

Beach scraping and dune reprofiling (sometimes referred to as ‘nature-assisted beach enhancement’) is the movement, using mechanical means, of small to medium quantities of sand from the lower part of the beach system to the upper beach to create new dunes or rehabilitate existing dunes. Repeated beach scraping campaigns can speed up natural beach accretion following storm erosion and reduce the rate of localised recession but does not overcome long-term recession of a beach compartment suffering from a sediment budget deficiency.

At Sandon River campground, beach scraping could be used to provide a short- to medium-term buffer by creating or rehabilitating dunes adjacent to the campground.

For beach scraping to be viable, sufficient sand reserves need to be available on the lower beach to replenish the upper beach. The method of beach scraping varies according to beach conditions, available machinery and extent of dune building and finishing required. The general process is that sand is pushed or excavated from the lower beach and placed on the upper beach or dune zone. The machinery used depends on the scale of the operation. Costs for beach scraping also vary according to machinery used, access conditions, volume of sand to be scraped and the area to be scraped. Additional costs include dune fencing, dune maintenance and ongoing monitoring, needed to identify when the beach is in a state suitable for scraping to occur.

An indicative area to be scraped at Sandon Beach extends west from the north-eastern tip of the campground to approximately the extent of the current sand-trap fencing west of the 4WD access track, as shown in Figure 11. The placement area includes the vegetation, sand traps and inclusion fencing already installed. The likely availability of sand at Sandon Beach is currently unknown.

Analysis of historic beach profiles, a feasibility assessment, a strategy for beach scraping and environmental assessment would be required before scraping could commence. The feasibility assessment would determine whether sufficient sand reserves would become available, and how and when scraping could occur, including triggers for each scraping event. Monitoring and a construction methodology including detailed costings need to be completed.

Figure 11 Aerial view showing location of potential beach scraping area to protect against erosion

Sand won from a single scraping campaign may provide a buffer from a small erosion event. If multiple scraping campaigns could be undertaken in relatively quick succession – that is, with no erosion in between – larger volumes of sand could be accumulated to provide a buffer against more significant erosion events. This option could temporarily extend the life of the campground and provide a buffer to facilitate retreat options.

Although beach scraping may be considered as a short-term solution to buffer against erosion – subject to further investigation and assessment of suitability – it is not recommended as a long-term solution to prolong the life of the campground and the protection works already in place.

Option 3B – Maintenance of existing dune rehabilitation areas

Maintenance of existing dune rehabilitation areas could include repairing and rebuilding sand traps, fences, and pathways. While continued dune stabilisation work would be beneficial, no new sand traps or dune building is required.

Sand-trap fencing. An inspection of the existing sand-trap fencing to the south of the 4WD track indicates that some improvements to these structures could be undertaken to increase effectiveness.

The current sand-trap fencing was installed between late 2021 and early 2022. There are 10 shade mesh fences approximately 6.5 m in length. The fences are aligned in a north-east direction, perpendicular to the existing dune system, and are situated approximately 11 m apart. The fences are approximately 1.2 m in height above the current dune surface. A post and wire fence is located around the perimeter of the sand traps to prevent public access. This perimeter fence also extends further north to provide exclusion from a shorebird nesting area.

In February 2023, the fences appeared to be in relatively good condition, with little sign of deterioration (Photo 7 and Photo 8). Most fence bases were below the current dune surface, with some erosion occurring in sections. The far eastern fences had a small accumulation of sand, possibly from some sand being moved in a cross-shore direction by strong south-east winds. However, there is very little evidence that sand is accumulating around the western sand-trap fencing, possibly because of the alignment of the fences (Figure 12).

Typically, sand-trap fencing for dune restoration is placed perpendicular to the dominant sand-transporting wind. This is because the fences function as wind shadows, creating a sheltered zone on the downwind side of the fence. This allows wind-blown sand to settle, effectively ‘trapping’ the sand and initiating dune formation. This occurs on both the windward and lee sides of the fence (Figure 13). The predominant strong onshore wind directions (that is, those most likely to transport sand shoreward) at Sandon River are from the north-east in spring to early autumn and from the south and south-east in winter (Figure 12).

To improve their effectiveness, the fences should be re-aligned to be perpendicular to the predominant north-east winds and parallel to the beach to maximise sand trapping efficiency (Figure 14).

Another key factor to consider is the ‘fetch’ over which dry sand is exposed to wind and is subject to wind-borne transport. For example, if the fence is located too low on the beach front, close to the high-water mark, there may not be a sufficient fetch across dry sand. This would limit the degree of wind-borne transport, reduce the sand-trap fencing’s effectiveness and result in limited dune building. In such situations, it is advantageous to remove, or not install, any fencing lower on the beach front.

During periods of higher sand availability and exposure on the beach, which typically occurs during spring and summer, sand-trap baffles can be moved downslope to provide additional room for dune building without significantly compromising the available sand fetch.

As sand builds up within the vicinity of the sand-trap fencing, the exclusion fencing should be moved seaward to fence off newly accumulated sand. This will exclude public access and allow colonisation of vegetation to occur and further secure this sand. The best location of the fencing, to maximise the north-east fetch of the fences while providing sufficient space for dune formation, would be subject to the beach profile at the time.

For this reason, adaptive management, including monitoring of sand accumulation, is most likely to yield the best results.

Photo 7 North-easterly alignment of existing sand-trap fencing, Sandon Beach, 2023

Photo 8 Close-up view of a sand-trap fence, Sandon Beach, 2023

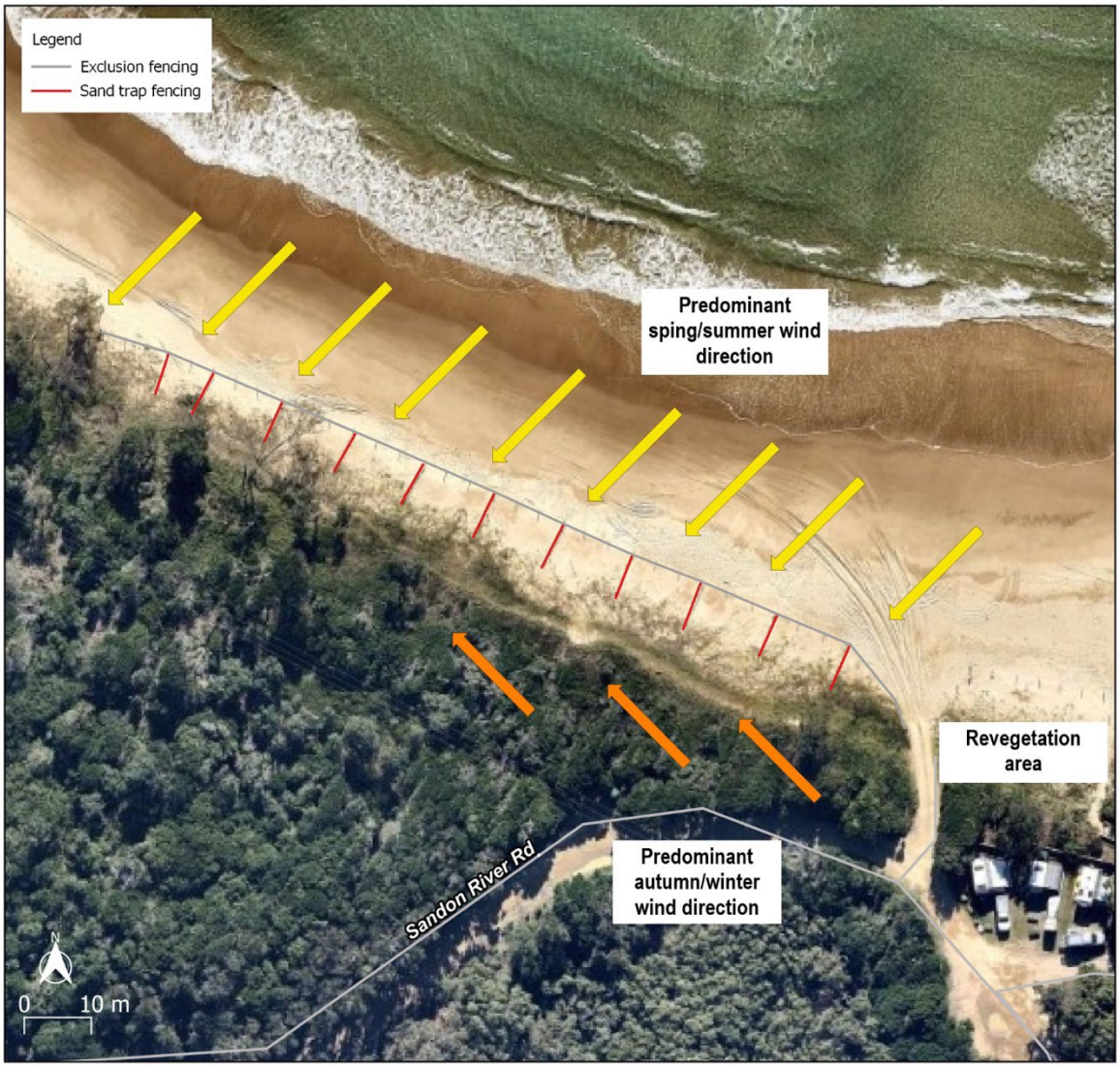

Figure 12 Aerial view of the layout of the existing sand-trap fencing array and predominant wind directions, Sandon Beach, 2024

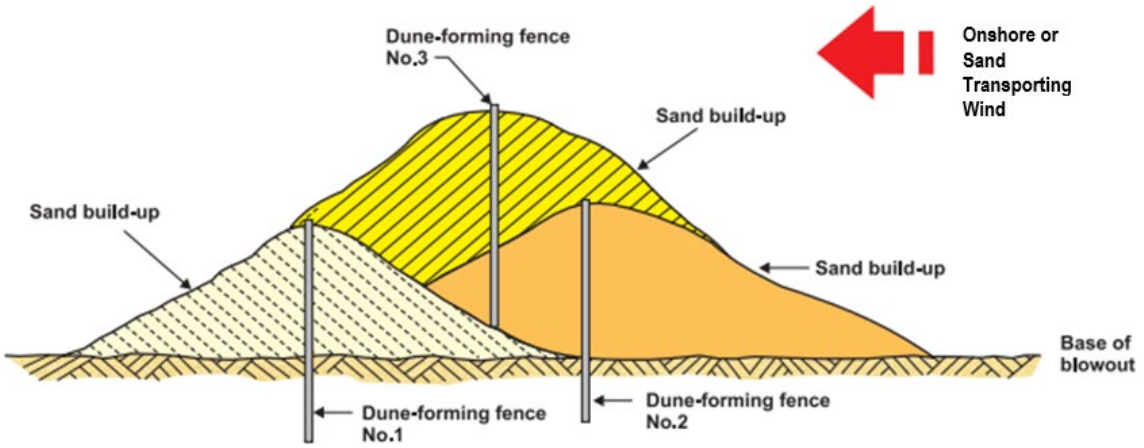

Figure 13 Diagram showing how fencing forms sand dunes

Source: NSW Department of Land and Water Conservation (2001).

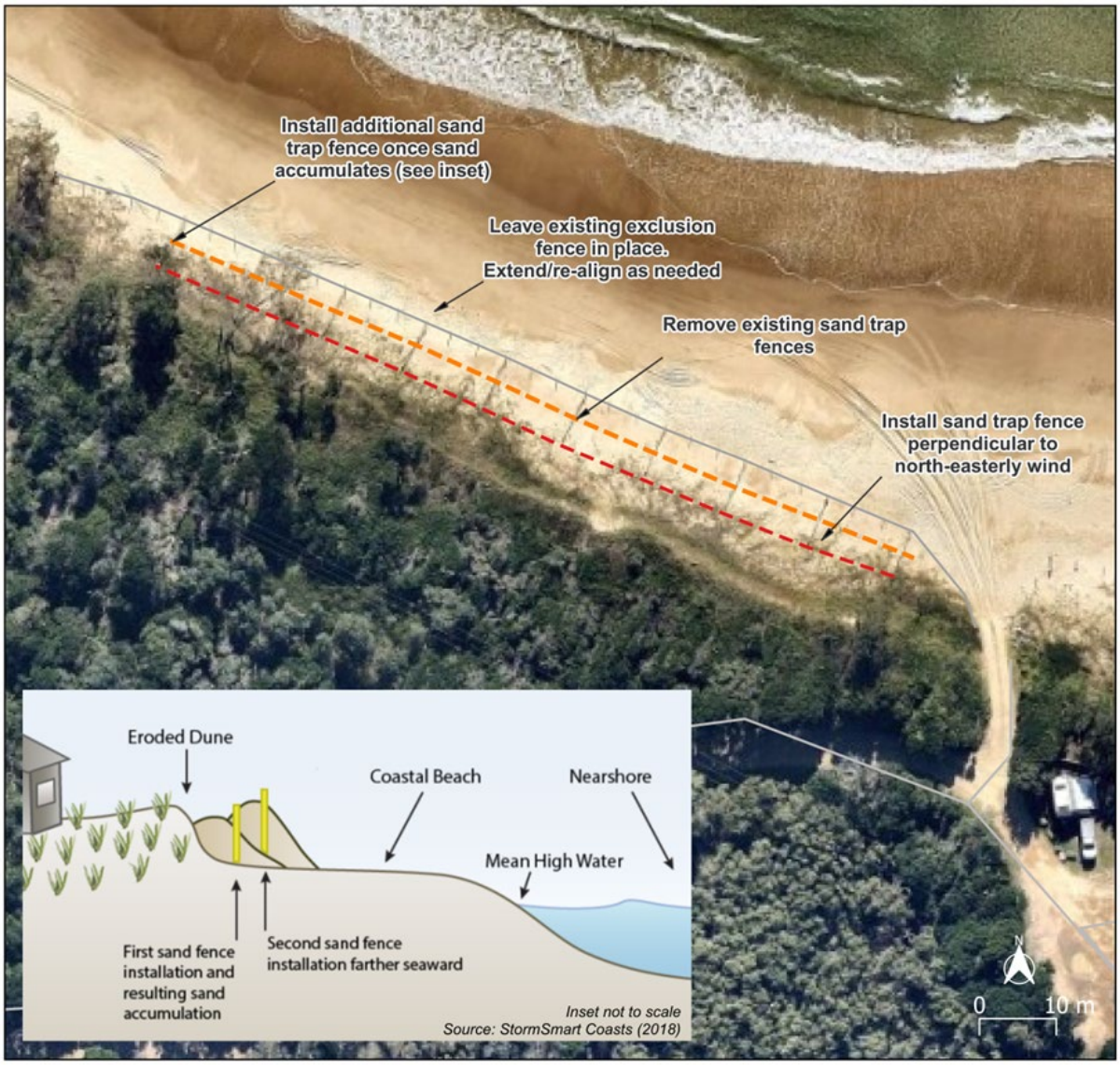

Figure 14 Aerial view showing proposed realignment of sand-trap fencing, Sandon Beach, with inset showing diagram of sand-trap fence positioning

Dune area revegetation. Revegetation works have been undertaken next to the north of the campground, east of the 4WD access track (Figure 1). These areas should be improved and maintained with further infill plantings to increase the diversity and stability of the area.

A concept planting plan is shown in Figure 15. Previously this area would have been in the hind dunes, as shown by the elevation, historic erosion scarp and the dead or dying hind dune tree species such as banksias. The loss of sand from the narrow area between the campground and the lower newly formed incipient dune area, within the fenced-off beach area, has exposed this area to north-east winds, salt, and mobile sand. These are the environmental characteristics of a foredune, so revegetation in this area should include foredune species. Mousley (2012) provides a guide for appropriate species selection, subject to availability and project timeframes. All plants should be of local provenance, where available. Preserving the view from the campground sites to the beach is also a consideration in species selection.

Figure 15 Aerial view of proposed revegetation plan for Sandon River campground, 2024

Option 3C – Manage river entrance erosion

Erosion of the riverbank is occurring intermittently along approximately 60 m of bank on the eastern perimeter of the campground (Figure 16). The erosion appears to be caused by high water events with increased wave action scouring out sand from above the cobble rock layer (Photo 9, Photo 10, Photo 11 and Photo 12). The toe of the bank is gradually being undermined, causing a section of bank above and associated vegetation to slip.

Campsite fencing is situated at least 3 to 5 m landward of the erosion. The erosion assessment indicates that the campsites and a section of the internal road is at immediate risk (JBP 2023). This location is underlain with cobblestones and contains vegetation, both of which provide minor protection against erosion although exposed tree roots suggest there is erosion in this area (Photo 9, Photo 10 and Photo 11).

The riverbank along this section is well fenced along the perimeter of campsites. A formalised access point includes a set of stairs for public access. Ad-hoc public access does not appear to be contributing to erosion.

Figure 16 Aerial view showing the location of intermittent erosion (red dash line) of the eastern riverbank, Sandon River campground

Photo 9 Riverbank erosion occurring 10 metres south of access stairs, Sandon River campground, 2023

Photo 10 Riverbank erosion occurring immediately north of access stairs, Sandon River campground, 2023

Photo 11 Riverbank erosion occurring approximately 15 metres north of access stairs, Sandon River campground, 2023

Photo 12 Riverbank erosion occurring near the sand dune fencing, 45 m north of access stairs, Sandon River campground, 2023

Potential options to address the river entrance erosion occurring include:

- hard protection such as rock revetments or gabion baskets (usually wire mesh containers filled with stones)
- geotextile sand container (GSC) revetments
- cobble scraping
- revegetation.

Hard protection options. Rock revetments or gabion baskets would remedy existing erosion and provide protection against future erosion by stabilising and armouring the riverbank. Works would need to be keyed into the toe of the bank and constructed to a sufficient height to provide protection against large wave action and sea level rise. Materials would need to be transported to the site via the 4WD beach access and placed by excavator. These hard protection options would have significant costs and potential adverse impacts. For example, the structure would cause end effect erosion, lead to loss of the sandy beach in front of the structure, and detract from the natural amenity of the area. Due to the significant cost and potential impacts, hard protection options are not recommended.

Geotextile sand container revetments. GSC revetments protect the riverbank in the same way as hard protection but are used where a structure 'softer' than rock is required. GSC revetments are unsuitable for long-term protection as they typically have a relatively short life (5 years), are vulnerable to damage and vandalism, and are a synthetic structure that could detract from the natural amenity of the area.

Cobble scraping. This approach is similar to beach scraping, using the layer of cobble (smoothed rock, < 250 mm in size) located at the erosion site (visible in Photos 9 to 12). The extent of the layer is unknown but aerial photography suggests it may extend down into the lower beach profile. Some of this cobble material located on the lower beach could be moved up the beach by excavator and placed directly in front of and on the erosion scarp. This would form a wave barrier and provide some protection against the main erosion mechanism, which is the erosion by waves and destabilisation of the sandy toe above the cobble layer. The benefits of this approach are use of local resources and costs being limited to machinery and time costs. Cobble scraping is not a typical methodology but is likely to be technically feasible. Like all options, it requires further evaluation, environmental assessment, and approvals.

Revegetation. Established mature natural vegetation exists along the length of the riverbank, forming relatively solid canopy that shades the ground. Any vegetation planted along here would be difficult to establish, apart from understorey species that are unlikely to provide much stability. Similarly, any species likely to survive in the erosion sites are unlikely to provide any significant stability. Some contribution to stability, however insignificant, would also improve amenity. Some planting has already been undertaken on the landward side of the existing vegetation near the camp sites. Infill planting in other areas should be undertaken when the opportunity arises, for example in areas that are currently open, where a tree dies, or where vegetation is removed for another reason.

Option 4 – Access road modifications

Sandon River Road is currently vulnerable to periodic flooding of the lower-lying sections of the road, restricting access. This inundation will become more frequent and, over time, damage the road so that it eventually becomes unusable by most vehicles. In the present day 10% EP scenario, approximately 1,500 m of road needs to be modified to protect against coastal inundation now, by raising the level of the road above the height of inundation. The length of road needing such protection will increase into the future.

Roadwork programs required to raise the road level include:

- ground preparation, including removal or redistribution of existing materials and drainage works
- installation of road drainage such as culverts, causeways, and bridges
- transport to the site of significant volumes of fill material (approximately 10,200 m^3 for every 0.5 m raising)
- road surfacing.

The required height of the road would depend on the timeframe and inundation scenario. The cost of these works is significant, and roadworks may have impacts on surface water and groundwater systems, vegetation, cultural heritage, and amenity. Road-raising works would need to include erosion protection for the road but would not provide any protection to the campground against erosion and recession.

Summary of options

The Sandon River campground and access road are at significant risk from erosion, recession and inundation, and any works to protect the road and campground would:

- be large in scale
- incur significant environmental and cultural impacts
- be likely to impact natural coastal processes
- require significant financial investment, as well as time and resources.

The management options assessed as being potentially feasible are summarised in Table 2.

Table 2 Management options for Sandon River campground

Hazard	Management approach	Description
Erosion and inundation	1. Planned retreat	Decommission and retreat. Allow natural processes to occur.
Erosion and inundation	Adaptive management: 1. Planned retreat plus 3. Dune rehabilitation options 3B and 3C	Natural defence through stabilising dunes (option 3B) and managing riverbank erosion (option 3C) in the short term. Plan for retreat (option 1) in the long term.
Erosion only	2. Coastal protection works option 2A	Short seawall (140 m length)
Erosion only	2. Coastal protection works option 2B	Extended seawall (700 m length)
Erosion only	2. Coastal protection works option 2C	Buffer erosion through sand nourishment
Erosion only	3. Dune rehabilitation option 3A	Buffer erosion through beach scraping
Inundation only	4. Access road modification	Raise sections of Sandon River Road (1.5 km length)

The coastal protection works options (option 2) and access road modifications (option 4) do not provide significant benefits or fully address the coastal hazards (Table 3). Dune rehabilitation (option 3B) and management of river entrance erosion with revegetation (option 3C) would facilitate an adaptive approach to address risks and maintain functionality and safety of the campground, until long-term retreat of campground assets (option 1) becomes essential.

Table 3 Effectiveness of management options for each vulnerability zone

Vulnerability zone*	Coastal hazard	Timeframe	Options that enable natural processes (no protection)	Low regrets/ natural defence erosion buffer options	Protection options against erosion/ recession	Protection options against inundation	Comments
V1 – Sandon River Road (north)	Inundation from the estuary	Present day onwards	1, 2A, 2B, 2C, 3A, 3B, 3C, 4	nil	n/a	nil	nil
V2 – Sandon River Road (north)	Coastal erosion Inundation from the estuary	Present day onwards	1, 2A, 2C, 3A, 3B, 3C, 4	nil	2B	nil	nil
V3 – Sandon River Road (mid)	Inundation from the estuary Coastal erosion	Inundation – present day onwards Erosion – 2073	1, 2A, 2C, 3A, 3B, 3C, 4	nil	2B	nil	nil
V4 – Sandon River Road (mid)	Inundation from the estuary Coastal erosion, with potential for breakthrough	Inundation – present day onwards Erosion – 2073	1, 2A, 2C, 3A, 3B, 3C, 4	nil	2B	nil	nil
V5 – Sandon River Road (south)	Coastal erosion Inundation from the estuary	Present day onwards	1, 2A, 2C, 3A, 3B, 3C	nil	2B	4	2A – Potential end erosion effect Extreme inundation events may still impact the road
V6 – Sandon River campground	Coastal erosion from the north-east (Sandon beach) and south-east (river entrance) Inundation from the river (particularly southern sections of campground)	Present day onwards	n/a	1, 3A	2A, 2B, 2C, 3B + 3C	2A, 4	Extreme inundation events may still impact the road

* Locations of vulnerability zones are shown on the map in Figure 8.

5.4.4 Assessment of management options

Qualitative assessment

Options 1 to 4, which were assessed as being potentially feasible, were evaluated through a comparison of benefits and costs (Table D.). Qualitative assessment of environmental, social, and cultural factors was undertaken to outline the key considerations for each option.

Multi-criteria analysis

The NPWS assessed the range of potential management options using a multi-criteria analysis (MCA), based on Infrastructure Australia (2021) methodology, which is designed to support an analysis of coastal management options within the NSW national park estate.

The NPWS previously identified a planned retreat (option 1) as the long-term option. Therefore, planning for retreat is included in all management options. The planned retreat option is a stand-alone management option that will immediately decommission the campground. The adaptive management approach combines the long-term option 1 with shorter-term options.

Three primary criteria form the basis of the MCA:

- environmental and cultural considerations
- recreational considerations
- financial considerations.

Each primary criterion has numerous indicators (sub-criteria) that represent the key values identified from stakeholder consultation in 2022 and 2023. Some indicators are specific (for example, heritage items) while others relate to multiple park values (for example, avoid damage to watercourses and waterbodies relates to environmental, cultural, and recreational values). No weighting was applied to criteria or indicators. Details of how the criteria and indicators were applied in the MCA to arrive at the rankings are in Appendix D.

The results of the MCA are shown in Table 4.

Table 4 Results of multi-criteria analysis of the management options for Sandon River campground

Option	Option number	Description	MCA rank*
Planned retreat	1	Decommission and retreat Allow natural processes to occur	4
Adaptive management	1 + 3B + 3C	Plan for retreat in the long term Dune and riverbank stabilisation in the short term	1
Coastal protection works	2A	Short seawall (140 m length)	6
	2B	Extended seawall (700 m length)	6
	2C	Sand nourishment	3
Dune rehabilitation	3A	Beach scraping	2
Access road modifications	4	Raise sections of road (1.5 km length)	5

MCA = multi-criteria analysis

* MCA rank is a score out of 10, where 1 is the highest (best) score. For calculations, see Appendix D.

All options returned low overall scores, reflecting the risky position of Sandon River campground. That is, all options to protect the campground are either cost-prohibitive, have unacceptable environmental impacts, or do not adequately address the coastal hazards.

Options 2A and 2B both ranked 6, reflecting their high negative impacts on natural coastal processes, visual amenity, and recreational values.

Option 4 ranked 5, reflecting its high cost and negative impact on the environment.

Option 1 ranked 4, reflecting its low environmental impact, but reduced campground lifespan.

Option 2C ranked 3, reflecting the increase in recreational and environmental values, but high cost and uncertainty.

Option 3A ranked 2, reflecting the increase in recreational and environmental values, but high uncertainty on sand availability.

The adaptive management approach (options 1 + 3B + 3C) received the highest overall score of 55% and is ranked 1. This approach scored highest in protection of environmental values, particularly enhancing habitat connectivity, and protecting biodiversity. Its recreational values scored slightly above that of option 2C because of improved visual amenity and community support, based on a slightly increased campground lifespan (while still financially viable) and its use of nature-based solutions.

Recommendation

Based on the MCA, the recommended management option for Sandon River campground is **adaptive management – options 1 + 3B + 3C: Planned retreat with dune and riverbank stabilisation**.

6. Recommended management approach

6.1 Adaptive management

The preferred option for the management of Sandon River campground is an **adaptive management approach** that includes long-term strategic retreat of the campground infrastructure and assets, combined with dune stabilisation, fencing and revegetation as shown in Figure 17. The recommended measures are sympathetic to natural coastal processes and aim to balance the natural and recreational values of this area. Any short-term actions will need to be compatible with the long-term planned retreat strategy. The key risks, strategic responses and recommended management approaches for present and future scenarios are detailed in Table 5 and Table 6 respectively. Table 7 lists the suggested timing and costs for each of the required implementation actions – planned retreat, dune and riverbank stabilisation and emergency response measures, as described below.

6.1.1 Planned retreat

Strategic planning for retreat is the recommended long-term solution for Sandon River campground. The timing of planned retreat will depend on the actual rates of erosion and recession experienced in the future, and the actual impacts of erosion, recession and inundation on accessibility, safety, and the visitor experience. The rates and impacts of the coastal hazards need to be closely monitored for this purpose.

Coastal hazard risk thresholds and triggers for response will need to be developed to determine when retreat actions are required. Consideration will need to be given to the risk to and condition of the access road in retreat planning. For example, if the access road becomes severely compromised, the plan will need to consider how best to remove assets.

Consultation with all stakeholders will be required throughout the retreat planning and implementation stages. Removal of campground assets and infrastructure, electricity infrastructure, the boat ramp, huts, and heritage items should be developed in consultation with stakeholders to appropriately manage the risk to assets and cultural heritage.
A coordinated approach between Clarence Valley Council, the NPWS and other asset owners (for example, Essential Energy) will be required.

6.1.2 Dune and riverbank stabilisation

Infill planting with suitable low growing species of the area to the north of campground between the campsites and existing dune restoration area is recommended. This will improve stability of the hind dune area and provide some protection from small erosion events as they become more frequent. Some infill planting could also be done along the eastern perimeter of the campground to restore the eroded riverbank.

Maintenance of the existing dune restoration area should be undertaken on a regular basis. This would include maintenance and repair of fencing and access areas, and weeding and vegetation management, as required. To improve the effectiveness of the existing sand-trap fences to the west of the 4WD access point, the fences should be realigned. The erosion along this foreshore should be monitored along with opportunities for revegetation. Any further vegetation in this area will improve stability and general amenity.

6.1.3 Emergency response measures

Emergency response measures for the Sandon River campground will be addressed in the coastal zone emergency action subplan being prepared by the Clarence Valley Council as part of the Clarence Valley Open Coast CMP.

Table 5 Potential adaptive management actions for each strategic response stage to present day (2023) risks

Stage	Potential actions
Alert	• Targeted revegetation of northern and eastern borders of campground • Maintenance of existing dune restoration areas • Re-configuration of existing sand-trap fencing • Development of a coastal hazard monitoring plan and monitoring of the extent and impacts of coastal hazards • Development of cultural heritage management plans • Periodic re-assessment of long-term coastal hazards as additional information becomes available • Ongoing maintenance of beach and campground areas in response to coastal hazards • Engagement with traditional owners • Ongoing campground user and visitor surveys and engagement • Ongoing community awareness and education
Avoid future impact	• Maintenance of existing campground facilities with limited expansion or upgrade
Planning for change	• Retreat planning that includes development of actions required to protect natural and cultural heritage values and of triggers for retreat actions • Consultation and co-ordination of stakeholders in retreat planning
Emergency response	• Preparation and implementation of emergency response measures for the campground in response to coastal hazard events.

Note: Key present-day risks include:

- erosion and recession potentially impacting the northern and eastern areas of Sandon River campground and various sections of Sandon River Road
- erosion periodically impacting pedestrian and 4WD beach access
- infrequent inundation occurring along sections of Sandon River Road during high water events, restricting access.

Table 6 Potential adaptive management actions for each strategic response stage to future (2043 and beyond) risks

Stage	Potential actions
Alert	• Continued revegetation and dune restoration and maintenance as required • Periodic re-assessment of long-term coastal hazards as additional information becomes available • Ongoing monitoring of the extent and impacts of coastal hazards • Ongoing maintenance of beach and campground areas in response to coastal hazards • Engagement with traditional owners • Ongoing campground user and visitor surveys and engagement • Ongoing community awareness and education
Avoid future impact	• Maintenance of campground assets to preserve natural and recreational values until triggers for planned retreat have been met • Maintenance of existing campground facilities with limited expansion or upgrade
Planning for change	• Ongoing consultation and co-ordination of stakeholders regarding retreat planning • Implementation of retreat actions required to protect natural and cultural heritage values once triggers for planned retreat have been met
Emergency response	• Implementation of emergency response measures as required

Note: Key future risks include increased erosion, recession and inundation impacts on Sandon River campground and Sandon River Road.

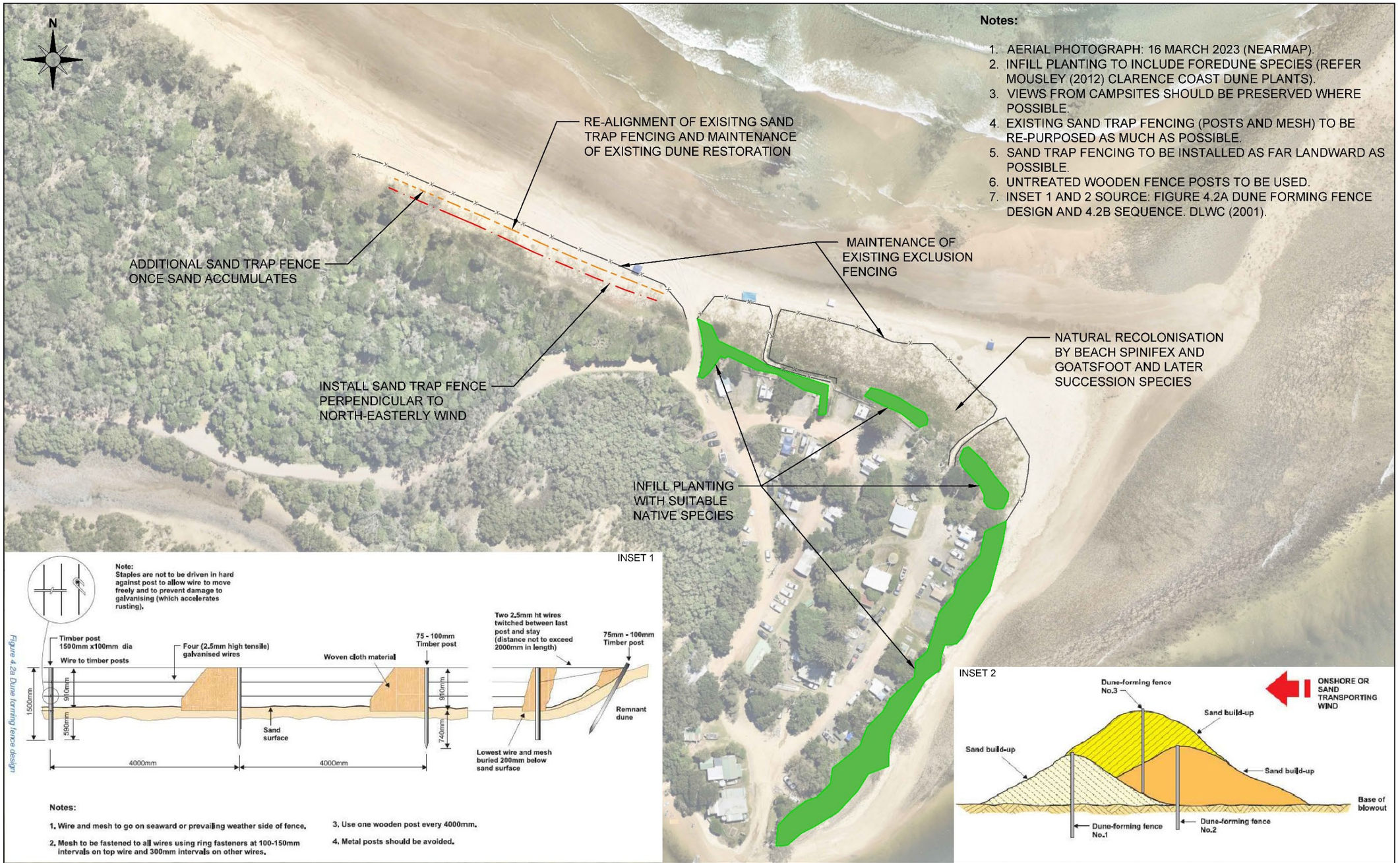

Figure 17 Proposed dune stabilisation and revegetation under adaptive management approach for Sandon River campground (note that Figure 17 is available as a separate PDF)

Table 7 Sandon River coastal hazard response plan – cost estimates for adaptive management implementation actions over 10 years

No.	Recommended action	Description	Estimated 10-year cost (2023 $)	Year 1 cost ($)	Year 2 cost ($)	Year 3 cost ($)	Year 4 cost ($)	Year 5 cost ($)	Year 6 cost ($)	Year 7 cost ($)	Year 8 cost ($)	Year 9 cost ($)	Year 10 cost ($)
1	**Planning**												
1a	Coastal hazard monitoring	Develop a coastal hazard monitoring plan including ongoing inspection and monitoring requirements and responses	**60,000**	15,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
1b	Coastal hazard assessment	Periodic review of coastal hazard assessment and mapping (align with CMP)	**30,000**	0	0	0	0	0	0	0	0	0	30,000
1c	Campground user surveys	Determine user satisfaction with campground facilities and management response	**20,000**	0	0	0	0	10,000	0	0	0	0	10,000
1d	Community awareness/ education	Update education/interpretive signage with latest information and management response	**20,000**	10,000	0	0	0	0	10,000	0	0	0	0
1e	Aboriginal heritage	Investigate Aboriginal heritage protection requirements	**60,000**	60,000	0	0	0	0	0	0	0	0	0
1f	European heritage	Investigate European heritage protection requirements for historic heritage sites	**60,000**	0	0	0	0	0	0	30,000	30,000	0	0
2	**Implementation**												
2a	Reconfiguration of sand trap fences	Reconfigure sand fence trap into single north-east facing fence. Install additional seaward fence as required	**10,000**	10,000	0	0	0	0	0	0	0	0	0
2b	Initial infill revegetation	Infill revegetation of northern and eastern areas of campground with suitable endemic coastal species	**10,000**	10,000	0	0	0	0	0	0	0	0	0
2c	Site relocation investigations	Investigate potential campground relocation options	**100,000**	0	0	0	0	0	0	0	0	50,000	50,000
2d	Retreat planning	Develop strategic plan including actions and thresholds. Engage with Yaegl traditional owners to develop ongoing management requirements. Develop strategic retreat planning actions with stakeholders. Monitor satisfaction with management response.	**100,000**	0	0	0	0	0	0	0	0	0	100,000
3	**Maintenance**												
3a	Dune and beach maintenance	Maintain revegetation area and manage weeds	**90,000**	0	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
		Totals	**560,000**	**105,000**	**15,000**	**15,000**	**15,000**	**25,000**	**25,000**	**45,000**	**45,000**	**65,000**	**205,000**

CMP = coastal management program (specifically, the Clarence Valley Open Coast CMP).

6.2 Ongoing strategic planning

Ongoing strategic planning is required to support the adaptive management approach including:

- monitoring
- re-assessment
- stakeholder engagement
- community awareness and education
- emergency planning.

Specific actions that contribute to management of environmental impacts and cultural heritage through preparedness and responsible coastal management in a dynamic environment are set out below. These actions may be resource-intensive once assets and values are at imminent risk.

- **Early warning systems and preparedness**. The state of the beach and campground area and forecast ocean and weather conditions need monitoring for triggers to initiate emergency response measures. Monitoring requirements and response measures are recommended as part of a coastal hazard monitoring plan.
- **Monitoring of beach profile**. Change in the beach profile – such as the position of the shoreline and condition of sand-trap fencing – should be monitored regularly and following coastal events. Triggers for intervention should be identified as part of a trigger-based planning approach.
- **Monitoring campground use and visitor satisfaction** Monitoring of visitor numbers and surveys of campground users and visitors as to their satisfaction with access and amenity are recommended.
- **Monitoring safety and ease of access**. Periodic monitoring and event-based monitoring (e.g. following large tides or swell) of the condition of the boat ramp and of access for vehicles, 4WD vehicles and pedestrians is recommended for inclusion in the Coastal Hazard Monitoring Plan.
- **Review of coastal hazard assessments**. Coastal hazard assessments need to be updated with further knowledge of climate change impacts to assess the effectiveness of the management approach. As part of the CMP implementation stage, review of coastal hazards and of management approach is recommended every 10 years. More frequent review may be required if coastal hazards are more severe than predicted.
- **Community awareness and education programs**. Interpretive and educational signage at the campground should be updated and added to, with input from the Yaegl people as traditional custodians, to provide information on campground values, coastal hazards, and the management approach.

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Appendix A: Maps

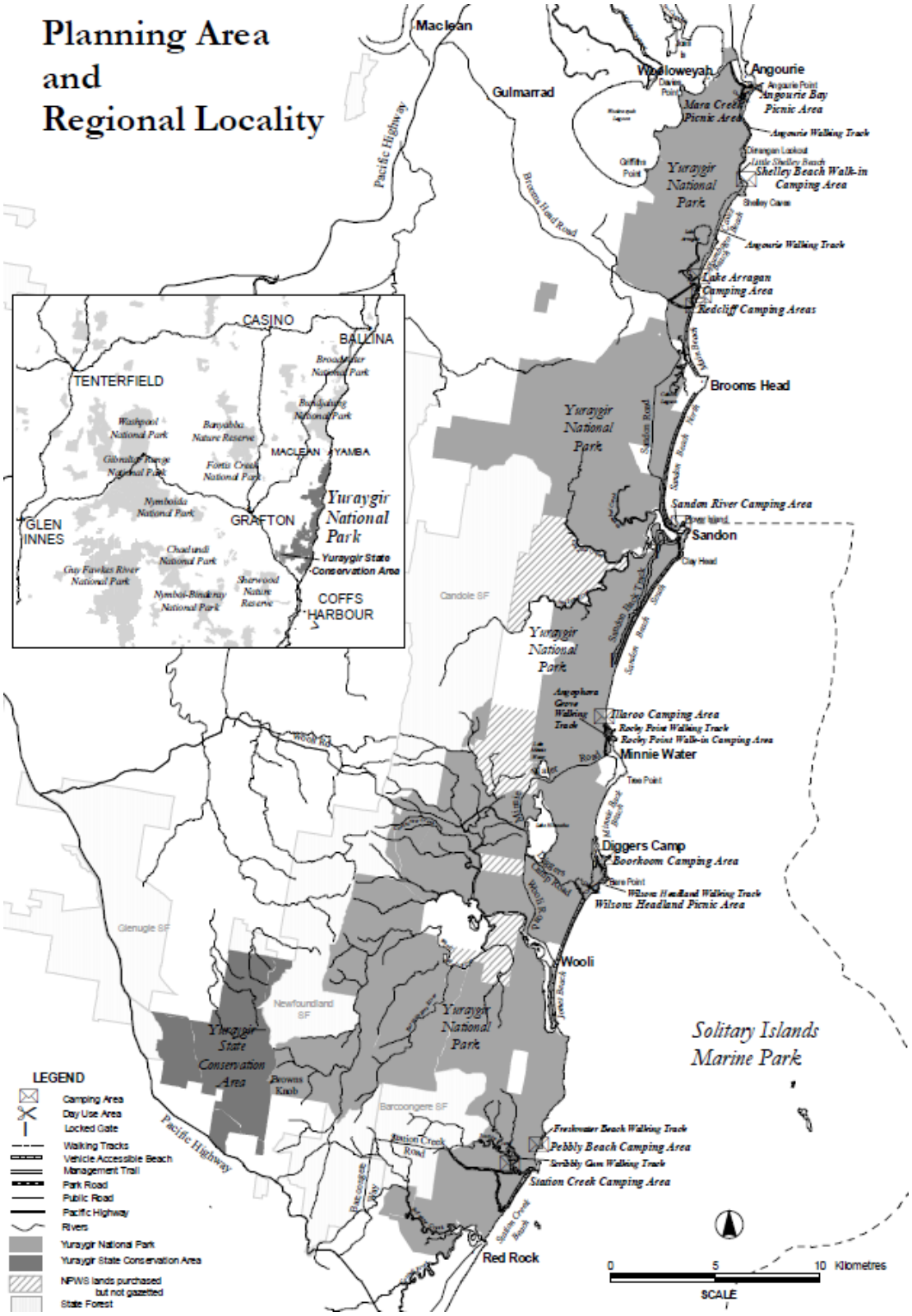

Figure A.1 Map of Yuraygir National Park. Source: National Parks and Wildlife Service (2003)

Figure A.2 Map of the land ownership and management in the study area

Sources: NSW Department of Primary Industries (2016) 'NSW Marine Protected Areas', accessed August 2023; NSW Spatial Services (2023) 'Clip & ship', accessed August 2023; National Native Title Tribunal (2023).

Figure A.3 Aerial view of Sandon River campground showing site plan

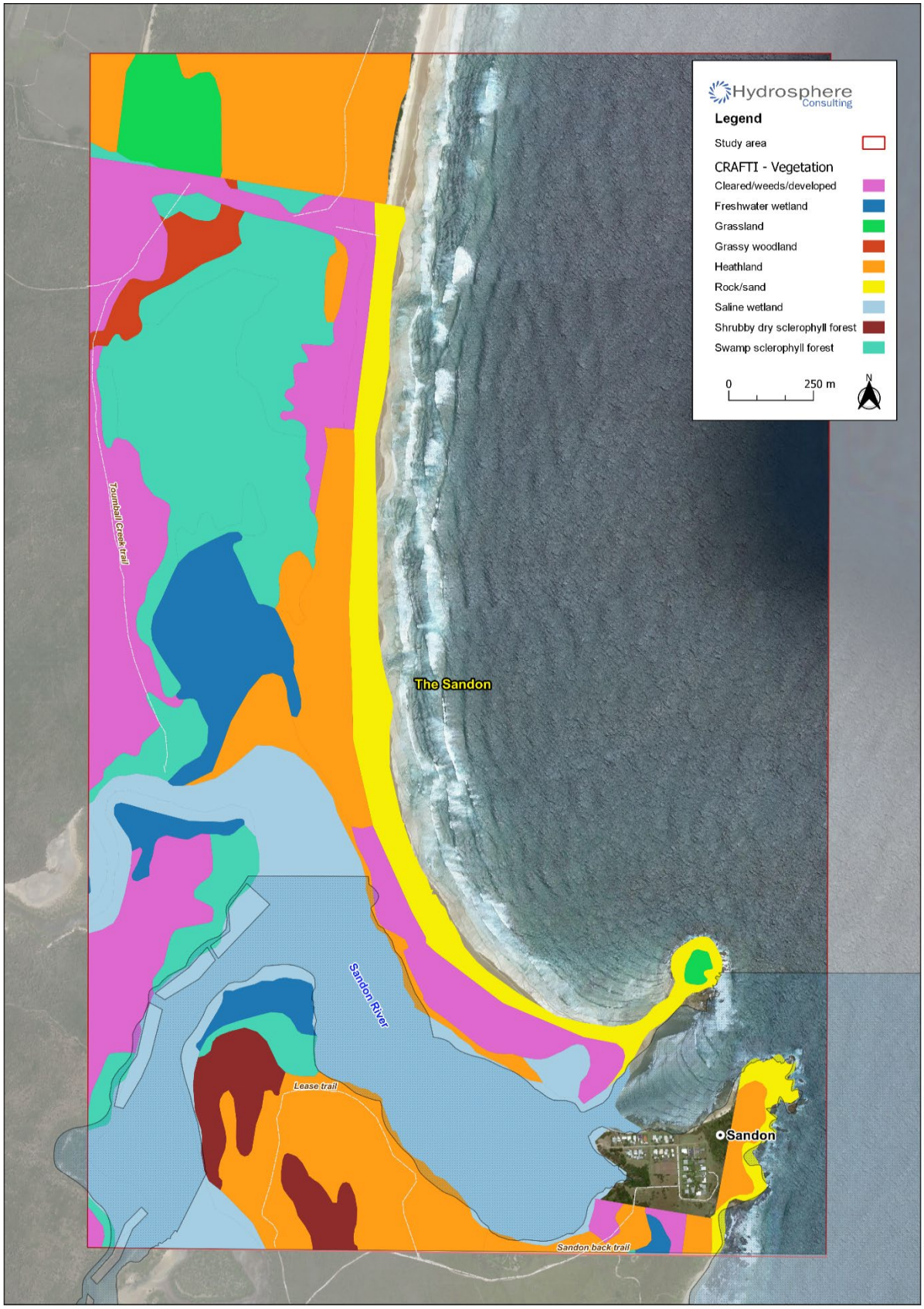

Figure A.4 Map of vegetation types in the study area

Source: State Government of NSW and NSW Department of Climate Change, Energy, the Environment and Water 2010, *CRAFTI Upper North East Floristics VIS 1108*, accessed from The Sharing and Enabling Environmental Data Portal.

Appendix B: Historical aerial photographs

Figure B.1 1942 – showing potential wave overwash at 2 locations and substantial sand accretion along Sandon Beach and within Sandon River

Source: N Johnston.

Figure B.2 1958 – showing potential wave overwash at one location and substantial sand accretion along Sandon Beach and within Sandon River

Source: NSW Spatial Services (n.d.) *Historical Imagery Viewer*, accessed August 2023.

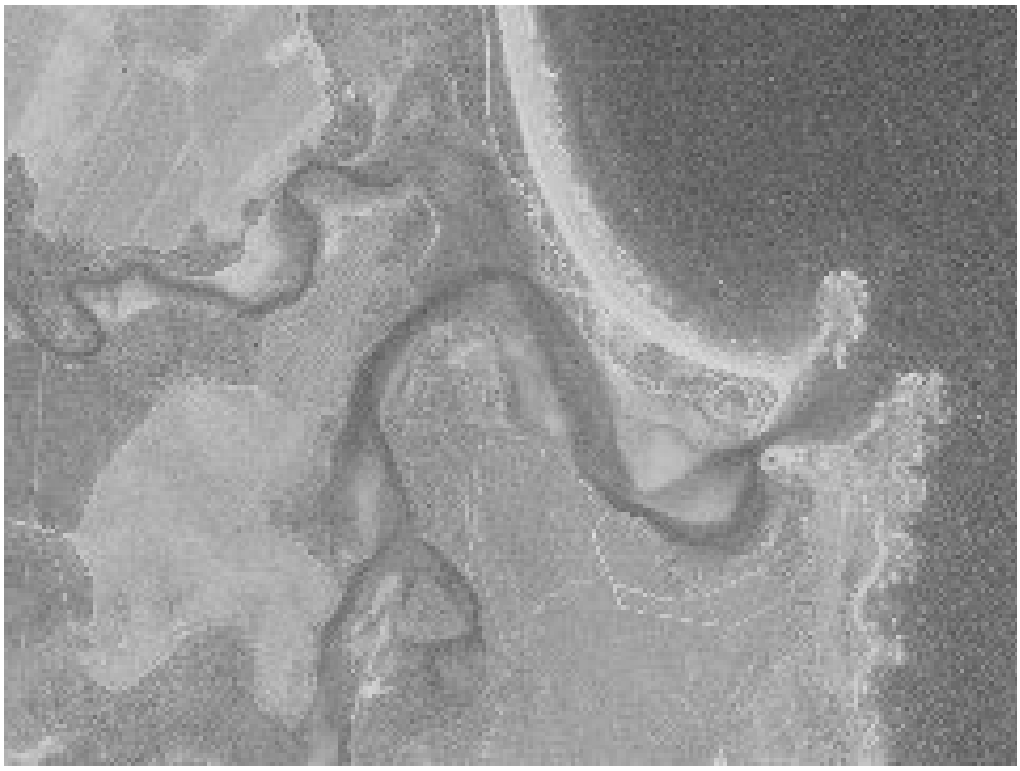

Figure B.3 1979 – expanded area of vegetation at the western end of Sandon River campground area

Source: NSW Spatial Services (n.d.) *Historical Imagery Viewer*, accessed August 2023.

Figure B.4 1993 – Sandon River campground established and expanded area of vegetation along Sandon River Road

Source: NSW Spatial Services (n.d.) *Historical Imagery Viewer*, accessed August 2023.

Figure B.5 June 2004 – aerial view of Sandon River campground and surrounds

Source: NSW Spatial Services (n.d.) *Historical Imagery Viewer*, accessed August 2023.

Figure B.6 November 2015 – vegetation along northern section of Sandon River campground

Source: Google © 2024. Google Earth Pro (2015) *Sandon River campground*, 18 November 2015.

Figure B.7 December 2017 – loss of dune and vegetation along northern section of Sandon River campground

Source: Google© 2024 CNES/Airbus. Google Earth Pro (2017) *Sandon River campground*, 14 December 2017.

Figure B.8 June 2022 – aerial view of Sandon River campground, June 2022

Source: Nearmap (2022) 'Aerial map of Sandon River campground', accessed August 2023.

Appendix C: Coastal hazard mapping

Detailed coastal hazard assessments and mapping are provided in JBP (2022, 2023). Additional mapping is also available to view and download on the Clarence Valley Council website:

- Clarence Valley coastline and estuaries plans and studies

Appendix C is available as 2 separate PDFs:

Appendix C Sandon River campground inundation mapping:

- Sandon inundation extents – present day (2023)
- Sandon inundation extents – 2043 SSP2
- Sandon inundation extents – 2073 SSP2
- Sandon inundation extents – 2123 SSP2

Appendix C Sandon River campground erosion-recession mapping:

- Sandon erosion and recession zones – present day (2023)
- Sandon erosion and recession zones – 2043 SSP2
- Sandon erosion and recession zones – 2073 SSP2
- Sandon erosion and recession zones – 2123 SSP2

Appendix D: Assessment of potential management options

D.1 Preliminary assessment of feasibility

The preliminary assessment of potential management options for each strategic management approach (alert, avoid, active intervention, planning for change and emergency response) and their feasibility is provided in Table D.1. A comparison of the benefits and costs associated with the potentially feasible options involving active intervention or planning for change is provided in Table D.2.

Table D.1 Preliminary assessment of potential coastal hazard responses

Potential response	Expected outcomes	Management objectives	Environmental context	Social context	Cultural heritage values	Costs	Benefits	Feasibility	Viability	Comments on feasibility
Alert										
Enhance dune and foreshore vegetation	Rehabilitation of dune and foreshore vegetation surrounding the campground to provide additional protection against erosion and wave impact	Consistent	Contributes to enhanced biodiversity values	Contributes to enhanced social values (visual amenity, visitor experience)	Contributes to management of cultural heritage impacts through restoration activities	Low – requires ongoing maintenance	Can slow the rate of recession and impacts of erosion although unlikely to be effective against major storm events	Feasible	Ongoing commitment to maintenance required	Revegetation of the southern and eastern boundaries of the campground is recommended. This would improve amenity, biodiversity and dune stability. It is recommended that natural colonisation of the dune stabilisation areas is allowed to take place.
Enhance sand dune through beach scraping	Renourish dune/upper beach profile to provide resilience against erosion and recession	Consistent for the short-term if benefits can be demonstrated	Impacts on beach and dune require assessment but are expected to be minimal and temporary	Temporary impacts during nourishment phase but improved access, safety and aesthetic appeal following completion of each scraping event	Impacts at the scraping and placement areas require assessment but are expected to provide protection to Aboriginal and historic heritage sites landward of the placement area	Moderate – requires ongoing maintenance and management	Can slow the rate of recession and impacts of erosion with sufficient nourishment volumes, although unlikely to be effective against major storm events	Feasibility depends on sufficient sources of sand being available – likelihood currently unknown Would be undertaken on an opportunistic basis but is feasible from a construction perspective	Would be undertaken on an opportunistic basis Likelihood of available sand unknown Ongoing resources and commitment likely to be required	Not recommended at this stage. Could be investigated further if additional protection against erosion is required.
Manage 4WD and pedestrian beach access	Restore beach access (4WD, pedestrian paths) in response to erosion and inundation (regrading, removal of debris)	Consistent	No impacts	Contributes to enhanced social values (safety, access to the coastline, visitor experience)	Unlikely to impact cultural heritage values if current footprint is maintained	Moderate – requires ongoing maintenance	Maintains safety and accessibility	As shoreline changes over time, existing access may not be viable and alternative locations or approaches may be required	Ongoing commitment to maintenance is likely to be required	Likely to be required in response to monitoring of safety and access. Response should be developed as part of a Coastal Hazard Monitoring Plan.
Protect Aboriginal cultural values and sites	Management decisions consider impacts on cultural heritage values and management approaches preferred by traditional custodians	Consistent	Impacts require assessment but are expected to be acceptable with best practice controls	Contributes to enhanced social values (visitor experience)	Expected to enhance Aboriginal cultural heritage values through collaboration and development of integrated management approaches	Low for consultation activities	Enhanced collaboration with Aboriginal communities and development of culturally sensitive management approaches	It is expected that feasible options can be developed	Requires ongoing commitment from all stakeholders	Ongoing liaison with Yaegl traditional owners to identify values, areas at risk and potential management approaches is recommended.
Protect other cultural values and sites	Relocation or modification of cultural sites in high-risk areas	Consistent	Impacts require assessment but are expected to be acceptable with best practice controls	Unlikely to impact social values	Expected to enhance historic heritage values through preservation	Potentially moderate – high	Historical heritage values are preserved	Over the longer timeframes, relocation of sites expected to be required as campground is unlikely to be viable. Further assessment of alternative sites required	Ongoing commitment to maintenance and/or relocation is likely to be required	Cultural heritage management plans should be prepared for heritage sites to adequately plan for protection of sites and potential relocation or removal as part of retreat of campground.

Potential response	Expected outcomes	Management objectives	Environmental context	Social context	Cultural heritage values	Costs	Benefits	Feasibility	Viability	Comments on feasibility
Update POM	Update POM to incorporate coastal hazard information and response actions	Consistent (sections 73B and 79A of the *National Parks and Wildlife Act 1974* (NSW)	No impacts	No impacts	No impacts	Low	Consistent with legislative requirements and best-practice management	Feasible	NPWS resources and commitment are likely to be required	The POM should be updated with the adopted coastal hazard response measures.
Coastal management program	Integrate the coastal hazard information and response actions into the Clarence Valley Open Coast CMP	Consistent with NSW Government coastal management framework	No impacts	No impacts	No impacts	Low	Consistent with integrated coastal management approach	Feasible. NPWS collaborated with Clarence Valley Council on Stages 1 and 2 of the Clarence Valley Open Coast CMP development. The preparation of this response plan is consistent with Stage 3.	NPWS resources and commitment are likely to be required	Incorporating the adopted coastal hazard response measures in the Clarence Valley Open Coast CMP will formalise the management approach and contribute to an integrated coastal management approach for the Clarence Valley coastline.
Avoid future impact										
Identify areas where campground redevelopment is not acceptable	Zoning of campground areas to identify future areas at risk	Consistent	Unlikely to impact environmental values	Increasing social impacts (loss of access, usability) as planned retreat is implemented	Unlikely to impact cultural heritage values	Low Campground revenue would be reduced with reduced capacity	Contributes to planned retreat approach and facilitates safe use of the campground precinct	Feasible	Minimal resources and commitment required	There is limited potential for campground development and therefore this option would not provide beneficial outcomes.
Relocate existing campground infrastructure to low-risk areas	Zoning of campground areas to identify future areas at risk and lower risk areas for campground reconfiguration	Consistent	Unlikely to impact environmental values	Increasing social impacts (loss of access, usability) as planned retreat is implemented	Due to high density of cultural sites within campground, impact on Aboriginal cultural heritage values is likely	Campground revenue would be reduced with reduced capacity	Contributes to planned retreat approach and facilitates safe use of the campground precinct	Limited low-risk areas available Relocation of roads likely to be unviable May be viable in the short- to medium-term for relocatable assets (e.g. cabins, tent sites) Will result in reduced campground capacity	Minimal resources and commitment required	There is limited potential for campground development and therefore this option would not provide beneficial outcomes.
Identify design standards for assets in areas where coastal risks are anticipated to change over time	Raised floor levels above inundation depth for new campground infrastructure Limited application for erosion risks.	Consistent	Unlikely to impact environmental values	Contributes to enhanced social values (visitor experience, recreational values, access)	Unlikely to impact cultural heritage values	Potentially moderate to high	Contributes to longer-term viability of campground but access to campground will continue to be an issue Not considered to be beneficial in isolation of coastal protection works	Unlikely to be feasible over the longer term due to increasing risks	Ongoing commitment is likely to be required	Not recommended due to scale of risks to the campground and access road.

Potential response	Expected outcomes	Management objectives	Environmental context	Social context	Cultural heritage values	Costs	Benefits	Feasibility	Viability	Comments on feasibility
Modifications to internal campground roads	Relocation or modification (raising, drainage, armouring) of internal campground roads	Consistent for the short term if benefits can be demonstrated	Impacts require assessment but are expected to be acceptable with best-practice controls	Contributes to enhanced social values (visitor experience, recreational values, access)	Likely to impact Aboriginal cultural heritage values Impacts require assessment and consultation with traditional custodians	Moderate	Contributes to longer-term viability of campground	Unlikely to be successful over the longer term (>50 years) due to increasing hazards and impacts on access road	Ongoing resources and commitment are likely to be required	Not recommended as this option would not provide beneficial outcomes.
Active intervention										
Enhance sand dune and beach through sand nourishment	Build up beach profile artificially to slow down recession	Consistent for the short term if benefits can be demonstrated	Impacts at sand source and placement site would require assessment but are expected to be acceptable with best-practice controls	Temporary impacts during nourishment phase, but improved access, safety and aesthetic appeal over the longer term	Impacts at potential sand source and placement site require assessment and consultation with traditional custodians Can provide protection to Aboriginal and historic heritage sites landward of the nourishment area	High – significant volumes required to maintain coastline position and alignment, as well as ongoing maintenance and replenishment as sand is lost to natural erosion processes	Can slow the rate of recession and impacts of erosion with sufficient nourishment volumes, although unlikely to be effective against major storm events	Limited sand available within close proximity to Sandon Commercial sand sources likely to be too costly Potential for offshore sources but unlikely given marine park status and costs unlikely to be feasible due to relatively small volumes Nearby navigational dredging unlikely to occur and unlikely to be feasible	Availability of suitable/cost-effective sand sources considered to be unlikely	Sand nourishment is a potentially feasible approach to provide protection.
Raising campground access road (Sandon River Road)	Raising of Sandon River Road above inundation levels	Maintenance of vehicular access is consistent for the short term if benefits can be demonstrated Major infrastructure development is unlikely to be acceptable with approval risks due to potential impacts on reserve values	Impacts require assessment but may be manageable with best-practice controls	Contributes to enhanced social values (access) Likely to detract from natural amenity	Likely to impact Aboriginal cultural heritage values Impacts require assessment and consultation with traditional custodians	Very high	Contributes to longer-term viability of campground	Long lengths of potentially impacted road Unlikely to be feasible in the long term without implementation of coastal protection works	Ongoing resources and commitment likely to be required	Potentially feasible if continuing to provide campground facilities in the current location is desired.
Installation of bridges on campground access road (Sandon River Road)	Installation of bridges on Sandon River Road to raise road above areas of inundation	Maintenance of vehicular access is consistent for the short term if benefits can be demonstrated Major infrastructure development is unlikely to be acceptable with approval risks due to potential impacts on reserve values	Impacts require assessment but are expected to be acceptable with best-practice controls	Contributes to enhanced social values (access) Likely to detract from natural amenity	Likely to impact Aboriginal cultural heritage values Impacts require assessment and consultation with traditional custodians	Very high	Contributes to longer-term viability of campground	Long lengths of potentially impacted road Unlikely to be feasible in the long term without implementation of coastal protection works	Ongoing resources and commitment likely to be required	Not considered to be feasible due to high cost and impacts.

Potential response	Expected outcomes	Management objectives	Environmental context	Social context	Cultural heritage values	Costs	Benefits	Feasibility	Viability	Comments on feasibility
Hard protection of campground e.g. seawall	Placement of non-erodible materials to reduce extent and impact of erosion and beach fluctuations and to realign the foreshore to an acceptable configuration to protect campground (e.g. seawall to the north of campground) Unlikely to protect against inundation, depending on wall height	Consistent for the short term if benefits can be demonstrated – contributes to ongoing viability of the campground but artificial intervention may compromise natural values of the reserve NPWS considers that hard engineering options should only be a last resort to protect key assets	Potential negative impacts on biodiversity values and natural coastal processes	Contributes to enhanced social values (visitor experience, recreational values, access) once implemented, but impacts on social values are expected during construction Likely to detract from natural amenity	Likely to impact Aboriginal cultural heritage values Impacts require assessment and consultation with traditional custodians	High	Contributes to long-term viability of campground	Can limit landward recession and protect campground Unlikely to be feasible in the long term without protection of the access road	Ongoing resources and commitment are likely to be required	Feasible but not recommended due to high cost and impacts.
Hard protection of campground and access road e.g. seawall	Placement of non-erodible materials to reduce extent and impact of erosion and beach fluctuations and to realign the foreshore to an acceptable configuration to protect campground and access road (e.g. seawall along Sandon Beach, groynes, offshore breakwaters and artificial headlands) Unlikely to protect against inundation, depending on wall height	Consistent for the short term if benefits can be demonstrated – contributes to ongoing viability of the campground but artificial intervention may compromise natural values of the reserve NPWS considers that hard engineering options should only be a last resort to protect key assets.	Potential impacts on biodiversity values	Contributes to enhanced social values (visitor experience, recreational values, access) once implemented, but impacts on social values are expected during construction Likely to detract from natural amenity	Likely to impact Aboriginal cultural heritage values Impacts require assessment and consultation with traditional custodians	Very high	Contributes to long-term viability of campground	Can limit landward recession and protect campground and access road Structure needs to span approximately 700 m of beach to sufficiently protect Sandon River Road Unlikely to be feasible in the long term without raising of the access road	Ongoing resources and commitment are likely to be required	Feasible but not recommended due to high cost and impacts.
Planning for change										
Identify alternative sites for campground	Campground relocated to low-risk area	Consistent with NSW Government coastal management framework	Potential impacts on biodiversity values	Contributes to enhanced social values (visitor experience, recreational values, access) but potentially reduced visitor experience in alternative location	Potential impacts on cultural heritage values	Moderate to high (depending on location and infrastructure requirements)	Provides compensation for future loss of campground facility	Limited suitable land available within national park	Ongoing resources and commitment are likely to be required	May be considered in retreat planning if feasible alternative sites are identified.

Potential response	Expected outcomes	Management objectives	Environmental context	Social context	Cultural heritage values	Costs	Benefits	Feasibility	Viability	Comments on feasibility
Planned retreat	As risks increase over time, the campground facilities are withdrawn, allowing natural processes to proceed unhindered	Consistent with current coastal management strategy	Ongoing maintenance of remaining reserve areas would be required to protect biodiversity values as far as possible	Loss of social values	Ongoing maintenance of remaining reserve areas would be required to protect cultural heritage values as far as possible	Low to moderate for relocation activities Significant reduction in reserve revenue	Acknowledges impacts of natural processes Eliminates need for ongoing investment in coastal protection works	Feasible	Ongoing resources and commitment are likely to be required	Due to the high risk of erosion and shoreline recession and resulting impacts to campground access roads, planned retreat is likely to be required in the long term. However, the timing will depend on the actual future rates of erosion and recession experienced and on impacts of erosion and inundation on accessibility and the visitor experience.
Emergency response										
Emergency management plan	Emergency response measures identified	Consistent	May require emergency coastal protection works to facilitate removal of damaged infrastructure, which may have a significant impact on environmental values and coastal processes	No impacts	No impacts	Low	Provides for appropriate management in response to impacts of natural processes	Feasible	Ongoing resources and commitment are likely to be required	Preparation of an emergency response plan (potentially part of the Coastal Zone Emergency Action Subplan to be prepared by Clarence Valley Council through the Clarence Valley Open Coast CMP). The plan will outline the roles and responsibilities of all public authorities in responding to emergencies immediately preceding or during periods of coastal hazard events.

4WD = 4-wheel drive (vehicle); CMP = coastal management plan; NPWS = NSW National Parks and Wildlife Service; POM = plan of management, referring to the *Yuraygir National Park and Yuraygir State Conservation Area plan of management* (NPWS 2003).

Table D.2 Comparison of benefits and costs associated with the potentially feasible options involving active intervention or planning for change

Option	Description	Environmental	Social	Cultural	NPV benefits ($)[1,3]	NPV costs ($)[2,3]	BCR	Recommendation
1 – Planned retreat	Immediate retreat planning and retreat within 2 years	Allows natural coastal processes to continue which would result in the loss of coastal vegetation to the north of the campground to recession.	Closure of the campground would result in loss of valued recreational opportunities. As the shoreline recedes and inundation becomes more frequent, the amenity value of the former campground area and therefore visitation are expected to reduce.	Historic and Aboriginal cultural heritage within the campground and shoreline areas would be directly impacted by coastal hazards.	$29,000	$535,000	0.05	As more cost-effective low-key options have been identified, this option is not recommended in isolation of 'no regrets' (alert) options.
2A – Short seawall to protect the campground	Construct a rock seawall on Sandon Beach along the northern perimeter of the campground (approximately 140 m).	Shoreline vegetation landward of the structure would be protected. End effect erosion would occur impacting vegetation and downdrift erosion and recession may be exacerbated, destabilising the foreshore further and increasing coastal hazards in other areas. Temporary construction related impacts.	The amenity and recreational value of the campground would be protected. The seawall would detract from amenity value of the beach and campground. Access to the campground would still be impacted by erosion and inundation.	Historic and Aboriginal cultural heritage within the shoreline area would be impacted. However, historic and Aboriginal cultural heritage within the campground area landward of the structure would be protected.	$240,000	$3,481,000	0.07	This option would be cost prohibitive, and campground access would still be compromised by erosion/recession and inundation. This option is not recommended.
2B – Extended seawall to protect the campground and the vulnerable sections of the access road	Construct a rock seawall on Sandon Beach north from campground (approximately 1,100 m).	Shoreline vegetation landward of the structure would be protected. End effect erosion would occur impacting vegetation and downdrift erosion and recession may be exacerbated, destabilising the foreshore further and increasing coastal hazard to other areas. Temporary construction related impacts.	The amenity and recreational value of the campground would be protected. The seawall would detract from amenity value of the beach and campground. Access to the campground would still be impacted by erosion and inundation.	Historic and Aboriginal cultural heritage within the shoreline area would be impacted. However, historic and Aboriginal cultural heritage within the campground area landward of the structure would be protected.	$297,000	$12,241,000	0.02	This option would be cost prohibitive, and access would still be compromised by inundation. This option is not recommended.
2C – Sand nourishment	Importation of sand to restore eroded areas, replenish dune system and protect the shoreline. Beach nourishment repeated every 2 years.	Environmental impacts of the sand sourcing and placement would need to be assessed. Shoreline vegetation landward of nourishment areas would be protected. Temporary construction related impacts.	Increased beach amenity. Nourishment would preserve (temporarily) the recreational value of the campground. Access to campground would still be impacted by inundation and erosion. Temporary construction related impacts.	Historic and Aboriginal cultural heritage within the campground and shoreline areas would be protected.	$270,000	$2,017,000	0.13	Suitable and cost effective commercial, land based, offshore or navigation dredging sand sources are unlikely. This option is not recommended.
3A – Beach scraping	Redistribution of sand from lower beach with machinery to upper beach. Beach scraping repeated every 2 years.	Minor temporary impacts on beach infauna. Provides protection to dune vegetation. Temporary construction related impacts.	Increased beach amenity. Beach scraping would preserve (temporarily) the recreational value of the campground. Access to campground would still be impacted by inundation and erosion. Temporary construction related impacts.	Historic and Aboriginal cultural heritage within the campground and shoreline areas would be protected.	$270,000	$1,063,000	0.25	Sufficient sand volumes on the lower beach may become available when prevailing conditions permit, although this requires further investigation. Given the uncertainty about the viability of sand scraping to prolong the life of the campground and the protection works already in place in this location, it is not recommended as a long-term option.
3B – Maintenance of existing dune rehabilitation areas 3C – Manage river entrance erosion	Maintenance of existing dune restoration areas (upgraded sand trap fencing). Revegetation of areas landward of dune restoration and eastern area of campground. Revegetation of riverbank to mitigate erosion along the northern entrance banks.	Revegetation options would improve dune biodiversity.	Improved amenity and community involvement/ownership of campground area. Protection provided will preserve the amenity and recreational value of the campground. Access to campground would still be impacted by inundation and erosion.	Historic and Aboriginal cultural heritage within the campground would be protected during moderate events.	$218,000	$549,000	0.40	Options 3B and 3C would be undertaken together as a low cost, no regrets approach that will improve dune and riverbank stability, provide some protection against small erosion events and improve amenity of campground. Revegetation options are unlikely to be effective in mitigating erosion over the long-term. This option is recommended.

Option	Description	Environmental	Social	Cultural	NPV benefits ($)[1,3]	NPV costs ($)[2,3]	BCR	Recommendation
4A – Raise short section of Sandon River Road	Raise low lying sections of Sandon River Road vulnerable to inundation (approx. 1.5 km in length) by 0.5 m.	Potential impacts to surface and groundwater hydrology. Vegetation clearing would be required to incorporate larger road footprint with batters. Potentially increased flooding of surrounding areas depending on drainage design.	Would protect access into campground from inundation however would not protect against erosion.	Historic and Aboriginal cultural heritage potentially impacted.	$302,000	$3,556,000	0.08	This option would be cost prohibitive and likely to cause unacceptable environmental impacts. Additional raising may also be required with increased sea level rise depending on the final road level. This option is not recommended.

BCR = benefit–cost ratio; NPV = net present value.

1. 50-year net present value of campground net income at 7% discount rate, initially $29,000 per year (average income in 2016–2023, excluding 2020 due to COVID), reduced with expected decreasing visitation where campground amenity is reduced.

2. 50-year net present value of budget capital and operating/maintenance costs.

3. Retreat is assumed to be implemented in year 2 (2026) for option 1, year 11 (2035) for option 3B + 3C, year 16 (2040) for options 2A, 2C and 3A, and year 26 (2050) for options 2B and 4.

D.2 Multi-criteria analysis

Table D.3 describes the indicators for each of the 3 criteria in the multi-criteria analysis (MCA).

Table D.3 Description of criteria and associated indicators in the multi-criteria analysis

Criterion	Indicators
Environmental and cultural considerations	• Protect Aboriginal cultural heritage • Protect European historic heritage • Allow natural coastal processes • Protect threatened flora species and ecological communities • Protect fauna species • Protect flora species • Maintain habitat connectivity • Avoid damage to watercourses and waterbodies • Avoid damage to marine parks and wildlife
Recreational considerations	• Protect recreational values of fishing (land based) • Protect recreational values of camping • Protect beach values for recreational activities • Protect or enhance nature-based activities (e.g. birdwatching) • Maintain access for boating (powered) • Maintain access for boating (unpowered) • Protect/maintain road access to campground • Protect access to beach • Maintain access to river • Community support for option (gauged from community workshops) • Protect visual amenity value
Financial considerations	• Provide a cost-effective management option (benefit–cost ratio) • Maintain viability of campground lifespan • Provide a viable management option considering NPWS budget (i.e. the ability to pay/fund)

MCA = multi-criteria analysis; NPWS = NSW National Parks and Wildlife Service.

Environmental/cultural and recreational indicators scoring

For the environmental and cultural criterion and the recreational criterion, each indicator is given a score out of 10 (Table D.4).

Table D.4 Multi-criteria analysis score for individual indicators

MCA measure	MCA score*	Impact on indicator	Example
Very strong positive	10	Very strong positive impact, long-term improvement	Large increase of listed species habitat
Strong positive	9	Strong positive impact, long-term improvement	Increase in habitat size (not large)
Medium Positive	8	Medium positive impact	Medium-term habitat improvement
Slight positive	7	Slight positive impact	Allows natural processes to occur
Very slight positive	6	Minimal positive impact	Buries and preserves cultural heritage in the short term
Neutral (no impacts)	5	No positive or negative impact	Retreat does not directly disturb tangible cultural items, so there is no negative impact, but it does not protect, so there is no positive impact.
Very slight negative	4	Very slight negative impact, short-term	Road works impact result in slight impact to cultural heritage related to construction activities
Slight negative	3	Slight negative impact (usually short-term)	Raising road causes minor impact to visual amenity
Medium negative	2	Medium negative impact, medium-term	Building seawall on nesting shorebird habitat
Strong negative	1	Strong negative impact, long-term	New road footprint clears native vegetation
Very strong negative	0	Very strong irreversible (permanent) negative impact	Seawalls prevent 4WD access and impacting endangered ecological community

4WD = 4-wheel drive (vehicle); MCA = multi-criteria assessment.

* Scores from 1 to 4 indicate a ***negative*** consequence. Scores from 6 to 10 indicate a ***positive*** consequence. A score of 5 indicates a ***neutral*** consequence.

Financial indicator scoring

The costs for each option are total construction costs and include all components to deliver the option, including planning and design, environmental approvals, stakeholder engagement, procurement and delivery, as well as long-term retreat planning.

Planning, investigation, and implementation costs for planned retreat (option 1) are included in all management options, but the timeframe in which the costs are incurred differs for each option.

The indicators used and method of scoring for the financial considerations criterion of the MCA is outlined below.

Benefit–cost ratio values from Table D.2 were used to produce a 'normalised' score out of 10 – that is, the highest benefit–cost ratio received the highest score of 10. These are calculated scores and not a subjective assessment.

Campground lifespan is an estimated measure of the benefit (in years) from the management option. This benefit is assigned a score between 0 and 10 based on the descriptions in Table D.5.

Table D.5 Campground lifespan indicator score

Score	Description
0	Option does not alter lifespan of campground
5	Option has a moderate impact on lifespan of campground
10	Option allows the maximum increase in lifespan of campground

Financial viability refers to the ability of the NPWS to fund the option. These scores are based on historical budget allocations and the likely funding to be available. Historically, the NPWS receives modest funding for coastal protection works and this funding reality is reflected in the scores detailed in Table D.6. The lower the funding range of the option, the higher the financial viability score.

Table D.6 Financial viability score for funding ranges of management options

Funding range ($million)	Score
0–0.19	**10**
0.2–0.49	**8**
0.5–0.99	**5**
1.0–2.99	**3**
3.0+	**0**

Assumptions

The options were developed using high-level conceptual designs and available information, rather than detailed scoping and data. Assumptions have been made to reflect the high-level nature of the options. Details of the assumptions are detailed in full in Section 5.4.

Final scores

A total score out of 10 was calculated for each primary criterion by averaging the respective indicators.

The final overall score for the management option was calculated by adding all 3 primary criteria scores out of 10 to produce an overall score out of 30.

The final score calculation for each option is:

Criterion 1 (x/10) + Criterion 2 (y/10) + Criterion 3 (z/10) = Total (T/30)