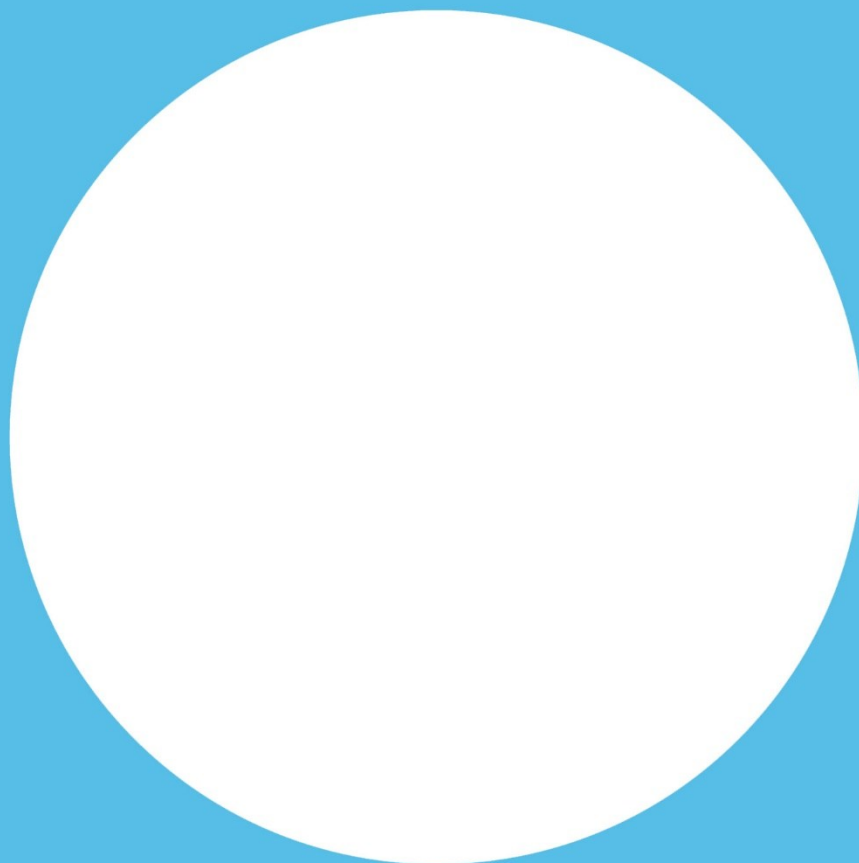


Helping local government
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Coastal Adaptation Actions Compendium

August 2025

Coastal Adaptation Actions Compendium

Revision	Date	Prepared by	Reviewed by
Rev.0	9/04/2025	Hatch Pty Ltd	CRC Program Management Group
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Prepared by HATCH for

LGA South Australia

In partnership with the Department for Environment and Water and the
South Australian Coast Protection Board

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1. Introduction

1.1. Purpose of this Guide

The Adaptation Action Compendium has been developed as a practical resource for adaptation planning in South Australia, providing coastal practitioners, policy makers, and decision-makers with a catalogue of adaptation actions to complement the Coastal Hazard Adaptation Planning (CHAP) Guidelines.

This guide aims to:

- Present a consolidated resource for adaptation actions in a South Australian context.
- Support local and state government agencies, policy makers, and coastal practitioners in decision-making.
- Provide a structured approach to adaptation based on the adaptation hierarchy.
- Showcase case studies from South Australia or elsewhere demonstrating real-world coastal adaptation strategies.
- Assist with implementation considerations, regulatory requirements, and trade-offs.

This guide is not intended to be a detailed design manual but rather a strategic resource that outlines adaptation options, considerations, and case studies.

1.2. How to Use this Guide

The compendium is structured according to the coastal adaptation hierarchy, helping users navigate options based on their specific adaptation needs. Each action follows a consistent format:

- Description and key function.
- Suitability in different coastal settings.
- Implementation considerations, including approvals and design factors.
- Challenges and trade-offs.
- Case studies relevant to South Australia.

By following this structured approach, users can identify the most appropriate adaptation measures for their context, while community members, educators, and researchers can use this resource to understand adaptation processes and outcomes.

1.3. Target Audience

This guide is primarily designed for coastal practitioners, policy makers, and decision-makers involved in coastal adaptation planning and implementation, with a secondary audience including community members and researchers.

Primary audience:

- Local government officers responsible for coastal planning and management.
- Policy and decision-makers shaping adaptation strategies.
- State government agencies overseeing coastal governance.
- Coastal practitioners implementing adaptation actions.

Secondary audience:

- Community members seeking to understand adaptation options and initiatives in their region.
- Educators and researchers studying coastal adaptation and resilience.

1.4. Adaptation Hierarchy

Adaptation actions in this compendium are structured according to the adaptation hierarchy, following the approach outlined in the CHAP Guidelines for South Australia. This hierarchy provides a framework for decision-making based on the level of intervention required to address coastal hazards. Adaptation actions are classified into four main categories as shown in Figure 1-1.

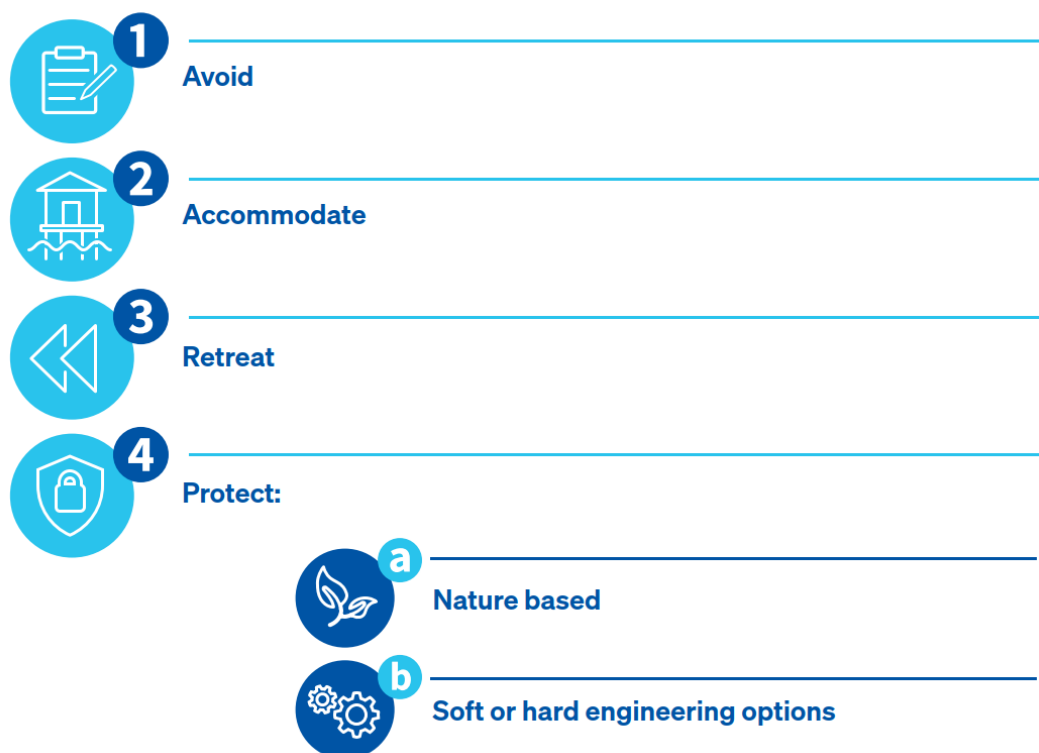


Figure 1-1: Adaptation hierarchy

1. Avoid - Identify future no-build areas and use planning tools to prevent new development in areas at risk.
2. Accommodate - Continue to use the land but accommodate risks by adopting risk-tolerant land uses, asset design and operations, and building methods.
3. Retreat - Withdraw, relocate or abandon assets that are at risk, allowing ecosystems to retreat landward.
4. Protect - Use hard structures such as seawalls or soft solutions such as dunes and vegetation to protect land from the sea.

Further to this, the following adaptation options are also considered within this compendium:

- No regrets - A temporary option that allows further time before implementing a specific adaptation action. This is often an appropriate approach when costly adaptation actions are being considered, and further detail is required before implementation.
- Do nothing - Assumes that risk is accepted and that no further action will be taken. This risk treatment option provides a basis for comparison of all other risk treatment options.

1.5. Coastal Hazard Definitions

Coastal hazards refer to natural processes and events that impact coastal environments, infrastructure, and communities. The adaptation actions in this compendium are designed to address a range of coastal hazards relevant to South Australia. These hazards are described in detail in the Coastal Hazard Assessment Compendium, which provides technical assessments of hazard risks, their drivers, and their potential consequences.

The key coastal hazards considered in this compendium include:

- Short-term erosion - loss of sediment from beaches, dunes and cliffs during extreme events such as storms and high waves.
- Long-term erosion - progressive retreat of the shoreline due to persistent wave action, sediment deficits, and sea-level rise.
- Cliff erosion - structural collapse and degradation of cliffs caused by wave energy, rainfall infiltration, and weathering processes.
- Accretion - accumulation of sediment over time, often occurring due to longshore drift, reduced wave energy, or river sediment delivery.
- Regular inundation - ongoing tidal flooding affecting low-lying areas below tidal benchmarks due to rising sea levels and tidal cycles.
- Storm tide flooding - temporary flooding of coastal areas caused by storm surges, tides, and wave setup during severe weather events.
- Terrestrial flooding - co-occurrence of coastal and riverine or rainfall flooding due to extreme rainfall and high river flows coinciding with storm surges.
- Saline intrusion - the intrusion of saltwater into freshwater systems, estuaries, and groundwater aquifers due to elevated water levels and reduced freshwater inflow.
- Coastal acid sulfate soils (CASS) - natural coastal sediments that contain iron sulfides and can produce sulfuric acid when disturbed or exposed to air.
- Sand drift - the movement and accumulation of sand by the wind, particularly in areas of active sand dunes and unconsolidated coastal sediments.

Each adaptation action in this guide is linked to one or more of these coastal hazards, providing targeted solutions for hazard mitigation and management. For detailed hazard descriptions, refer to the Coastal Hazard Assessment Compendium.

1.6. Approvals and Agency Engagement

Adaptation actions along the South Australian coast may require approvals, permits or advice from a range of local, State and Commonwealth agencies. The specific requirements depend on the location, nature and scale of the proposed works. Early engagement with the relevant authorities can help streamline planning, ensure alignment with legislation and policy, and avoid delays during implementation.

Common triggers include development in the Coastal Areas Overlay, disturbance of native vegetation, impacts to marine or estuarine systems, construction of coastal protection structures, or works affecting watercourses or cultural heritage sites. Development approvals are typically assessed under the *Planning, Development and Infrastructure Act 2016*, but other legislation such as the *Aboriginal Heritage Act 1988*, *Landscape South Australia Act 2019* and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) may also apply.

The Coast Protection Board plays a key role in this process as a statutory referral body for developments within the Coastal Areas Overlay. The Board provides technical advice and recommendations based on its policy, which outlines hazard assessment requirements for erosion, storm tide inundation and sea level rise. All adaptation proposals should be assessed against the Coast Protection Board Policy and supporting guidance documents to ensure consistency with state objectives for coastal hazard management.

Table 1-1: Key agencies and their likely roles

Agency	Focus areas or likely triggers for involvement
--------	--

Department for Environment and Water (DEW)	General interest in all development within the coastal zone. It has a statutory role in assessing impacts on native vegetation, threatened species, heritage sites and activities within marine parks.
Coast Protection Board (CPB)	CPB responsibilities? are defined by the <i>Coast Protection Act 1972</i> and its approved policies. The Board seeks to protect, maintain and restore the coastal environment against coastal hazards, inappropriate development and active misuse.
Landscape Boards	Water affecting activities, catchment management, revegetation, land condition
Department of Primary Industries and Regions SA (PIRSA)	Aquatic reserves, fisheries, aquaculture, biosecurity
Environment Protection Authority (EPA)	Pollution control, stormwater discharge, water quality, groundwater protection, site contamination, marine ecosystem health (including seagrass) and aquaculture.
Department for Infrastructure and Transport (DIT)	Coastal and marine infrastructure, ports and harbours, road upgrades, public access structures

Indicative approval pathways and agency engagement considerations are outlined for each adaptation option within this compendium. However, these must be reviewed and reconsidered each time an adaptation action is proposed to ensure site specific compliance and appropriate implementation.

1.7. Adaptation Actions Summary

The adaptation actions included in this compendium are summarised in Table 1-2 below.

Table 1-2: Summary of adaptation actions presented in this compendium

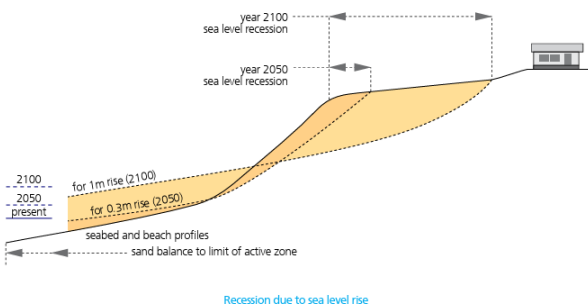
Adaptation Hierarchy	Adaptation Actions	Short-term erosion	Long-term erosion	Cliff erosion	Accretion	Storm tide flooding	Regular inundation	Terrestrial flooding	Saline intrusion	CASS	Sand drift
Avoid	Setbacks	✓	✓	✓		✓	✓	✓		✓	✓
	Planning change	✓	✓	✓		✓	✓	✓		✓	✓
	Planning overlay	✓	✓	✓		✓	✓	✓		✓	✓
Accommodate	Upgrade to more resilient infrastructure	✓				✓	✓	✓	✓	✓	✓
	Upgrade drainage network (including non-return valves)					✓	✓	✓			
	Upgrade roads	✓				✓	✓	✓			
Retreat	Land acquisition	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Removal of assets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Protect - nature based solutions	Mangrove forests & Saltmarsh	✓	✓			✓	✓	✓		✓	
	Seagrass meadows	✓	✓			✓	✓				
	Dune management	✓	✓			✓					✓
	Use of on-site materials	✓									✓
	Shellfish reefs	✓	✓								
Protect - soft engineering solutions	Beach nourishment, configuration dredging and beach scraping	✓	✓			✓					✓
	Sand bypassing	✓	✓		✓						✓
Protect - hard engineering solutions	Vertical seawalls	✓	✓			✓	✓				
	Rock revetments	✓	✓	✓		✓	✓				
	Geobags	✓	✓	✓		✓	✓				

Adaptation Hierarchy	Adaptation Actions	Short-term erosion	Long-term erosion	Cliff erosion	Accretion	Storm tide flooding	Regular inundation	Terrestrial flooding	Saline intrusion	CASS	Sand drift
	Rock bags	✓	✓	✓							
	Groynes	✓	✓		✓						
	Breakwaters	✓	✓		✓	✓					
	Levees					✓	✓	✓			
	Tidal barriers					✓	✓	✓	✓		
	Saline groundwater intrusion barrier								✓		
Protect- hybrid approach	Protect vegetation with hard structure	✓	✓	✓		✓	✓	✓			✓
	Buried seawall complemented by sand management	✓	✓			✓		✓			
	Eco-hard structures	✓	✓	✓		✓	✓	✓			
No regrets	Temporary measures	✓				✓	✓	✓			✓
	Coastal monitoring										
Do nothing	Risk acceptance										

2. Avoid

This section summarises the adaptation actions and provides project examples which fall under the avoid adaptation type. These actions seek to mitigate risk using planning tools which prevent new development in areas exposed to hazard.

2.1. Setbacks

Category	Details
Adaptation Type	Avoid
Adaptation Action	Setbacks
Description	Setbacks involve establishing defined buffer distances between coastal hazards (e.g., erosion-prone shorelines or flood-prone areas) and new infrastructure or development, including private properties. By prescribing where buildings and infrastructure can be safely located, setbacks proactively minimise exposure to coastal risks. They provide space for natural coastal processes, facilitate habitat migration, and enhance ecological resilience (Abel, et al., 2011). On private land, setbacks typically restrict development in vulnerable zones, guiding infrastructure placement behind defined hazard lines to ensure community safety and reduce future damage costs. In the South Australian context, erosion setbacks are required for developments in the coastal zone (see CPB Policy) which are considered on a case-by-case basis. Developing setbacks on a larger scale (e.g. Council) can streamline this process.  <i>Setbacks due erosion in South Australia (source: DEW)</i>
Design Life	Ongoing
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion

	☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☒ Coastal Acid Sulfate Soils ☒ Sand drift
Suitability	• Suitable as proactive planning measures for undeveloped or lightly developed coastal areas. • Ideal for guiding future residential, commercial, and public infrastructure development in hazard-prone zones. • Less suitable in densely urbanised coastal settings without available space, unless combined with strategic retreat measures.
Likely Impact on Coastal Processes	Low - Setbacks support natural coastal processes by maintaining vegetated buffer areas and allowing space for dune formation, sediment transport, and habitat migration.
Implementation	Preparation/Design Period Coastal hazard assessments, flood modelling, erosion mapping, and community consultation are likely required to establish setbacks at scale. Setbacks are generally implemented through statutory amendments to planning instruments (e.g., Planning and Design Code), zoning maps, and development control guidelines. Clear guidelines and mapping must be developed to transparently communicate setback requirements.
	Approvals Planning tools such as zoning and overlays are applied through the Planning and Design Code to manage development in coastal hazard areas. These mechanisms ensure at-risk land is identified and managed appropriately via policies which guide the assessment of development applications. Where development is proposed within the Coastal Areas Overlay, the Coast Protection Board is a statutory referral body and provides advice based on its policy, which outlines requirements for setbacks, site levels and hazard considerations including erosion and flooding.
	Design Considerations • Coastal hazard assessments, including erosion rates, sand drift rates, sea-level rise projections, and flood scenarios in line with CPB Policy.

	• Determination of buffer widths informed by hazard assessments and climate change projections. • Compatibility with, zoning regulations, and community objectives. • Clearly defined rules for the siting of residential, commercial, or public infrastructure behind setback boundaries. • Strategies to clearly communicate setback requirements to property owners, developers, and planners.
	Costs Costs may include: • Coastal hazard and vulnerability assessments. • Community engagement, consultation, and education. • Administrative and Code amendment processes. • Ongoing monitoring, compliance enforcement, and adaptive updates.
	Challenges and Trade Offs • Community acceptance - Landowners and developers may resist setbacks due to perceived restrictions on development potential, economic implications, and concerns about property values, requiring transparent and proactive engagement. • Enforcement and compliance - Ensuring setbacks are enforced consistently may present administrative challenges, requiring clear guidance and effective oversight. • Development pressures - Pressures to develop coastal areas can conflict with setback objectives, necessitating careful balancing of adaptation objectives with economic development considerations. • Economic implications - Potential short-term impacts on property values and development potential, requiring careful evaluation and possible compensation mechanisms and/or identifying alternative development locations. • Implementation timelines and complexity - Introducing setbacks through the Planning and Design Code can involve lengthy statutory processes, detailed assessments, and potentially contentious public consultation.

Project Title		Marion Bay Land Division Setbacks	
Adaptation Action	Setbacks	 Land divisions at Marion Bay (source: SAPPa)	
Location	Marion Bay, Yorke Peninsula, South Australia		
Lead Agency	District Council of Yorke Peninsula and Coast Protection Board		
Objective	Implement setbacks to manage risks of coastal erosion and flooding for proposed land subdivisions.		
Year of Implementation	2006-2008		
Design Features	• Setbacks - Established minimum setbacks of 50-70 metres from the shoreline. • Minimum site level - Required minimum site levels to account for flood levels. • Protection works - Recommended integration of coastal protection works into road infrastructure.		
Process	• CPB advised council on setbacks for a proposed 64 allotment development, recommending refusal due to coastal hazard risks. • Revised proposal with increased setbacks and coastal reserve was submitted, with conditions recommended by CPB. • Development initially refused by Council, citing inadequate erosion buffers. • Decision upheld by Environment, Resources and Development Court (2007) and Supreme Court of South Australia (2008). • Final amended proposal (78 allotments) approved in 2008, incorporating setbacks and coastal protection.		
Cost Estimate	Administrative, legal and regulatory implementation costs		
Useful Resources and References	SA Property and Planning Atlas https://sappa.plan.sa.gov.au/		

2.2. Planning Change

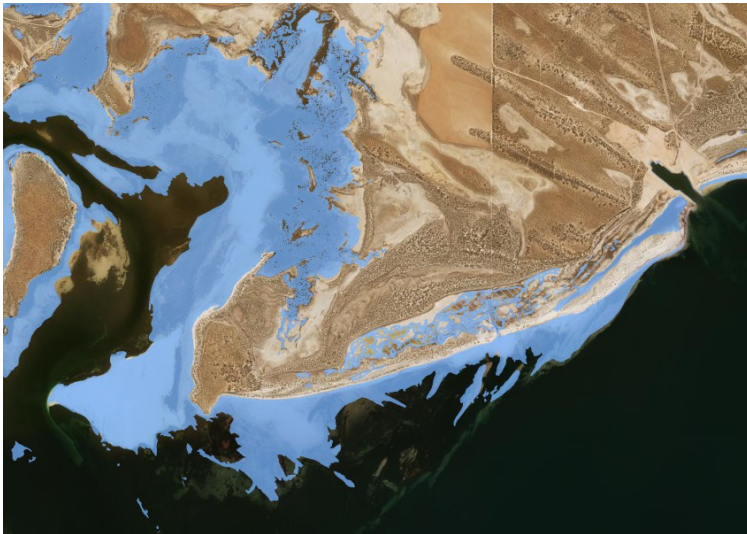
Category	Details	
Adaptation Type	Avoid	
Adaptation Action	Planning Change	
Description	Planning changes involve adjustments to zoning provisions and land-use regulations within existing statutory planning frameworks, with the primary purpose of reducing risks associated with coastal hazards. Changes can include rezoning land from higher-risk residential or commercial uses to lower-risk, hazard-compatible uses such as open spaces, conservation zones, or recreational areas. Planning change effectively reduces future hazard exposure by restricting or prohibiting intensive or inappropriate development or redevelopment within areas subject to current or projected coastal erosion, flooding, or other climate-related hazards (Hino, Field, & Mach, 2017).	
Design Life	Ongoing	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular flooding ☒ Terrestrial flooding ☐ Saline intrusion ☒ Coastal Acid Sulfate Soils ☒ Sand drift	 P&D Code Zones - Goolwa - Alexandrina P&D Code Zones - Employment Zones - Employment - Strategic Employment - Infrastructure Zones - Infrastructure (Ferry and Marina Facilities) - Natural Resources and Environment Zones - Coastal Waters and Offshore Islands - Conservation - Open Space - Recreation - Neighbourhood and Corridor Zones - Established Neighbourhood - Waterfront Neighbourhood - Home Industry - Neighbourhood - Rural Neighbourhood - Rural Living - Rural - Deferred Urban - Tourism Zones - Caravan and Tourist Park - Tourism Development - Township and Settlement Zones - Township Main Street - Township Activity Centre - Rural Living <i>Example of P&D Code Zones in the Alexandrina council where areas by the coast are zoned as Coastal Waters and Offshore Islands, or Conservation.</i>

Suitability	• Suitable for areas with existing or projected exposure to coastal hazards, particularly where intensification of development poses unacceptable risks. • Ideally applied proactively, especially in regions not yet extensively developed, or where development patterns can still be influenced. • Less suitable in densely developed urbanised areas where existing infrastructure limits opportunities for strategic land-use adjustments without significant community impact.
Likely Impact on Coastal Processes	Low - Does not directly influence coastal processes but indirectly minimises potential future impacts by controlling land use, density, and development intensity within identified hazard-prone areas.
Implementation	Preparation/Design Period Planning changes typically require detailed coastal hazard assessments, land-use evaluations, risk analyses, community consultation, and formal statutory amendment procedures. Comprehensive stakeholder engagement, technical studies, and statutory planning amendment processes (Code amendments PlanSA) are likely necessary. Amendments typically progress through preliminary investigations, public consultation, formal exhibition, statutory review, and ultimate adoption within local planning frameworks.
	Approvals Planning changes in South Australia require an amendment to the Planning and Design Code, authorised by the Minister for Planning under the <i>Planning, Development and Infrastructure Act 2016</i>. Councils can initiate amendments, which must align with relevant State Planning Policies, such as SPP 13 - Coastal Environment (under the <i>Planning, Development and Infrastructure Act 2016</i>).
	Design Considerations • Clear identification and mapping of areas susceptible to coastal hazards using current and future hazard projections and allowances, such as erosion mapping and flooding modelling. • Defining appropriate zoning to reflect hazard risk, such as open space, recreation or conservation zones. • Ensuring changes to the Planning and Design Code align with strategic coastal management objectives, strategic planning documents such as the State Planning Policies and Regional Plans, existing policy frameworks, and broader community expectations. • Assessment of economic implications for affected landowners, including potential impacts on property values or redevelopment potential.

	• Identification of transitional arrangements, alternative options or compensation frameworks, if applicable, to support landowners affected by zoning changes.
	Costs Costs may include: • Hazard assessments and technical evaluations. • Statutory and planning amendment processes. • Community consultation and stakeholder engagement.
	Challenges and Trade Offs • Community acceptance - Rezoning or down-zoning can provoke opposition from local residents or property owners who perceive a reduction in property values or loss of development opportunities, requiring extensive stakeholder consultation and transparent communication. • Economic and equity considerations - Planning changes may affect local property values, economic activity, and community development aspirations, raising issues of equity, fairness, and potential compensation obligations. • Regulatory complexity and timeframes - Code amendments can involve complex statutory processes, prolonged timeframes, and resource-intensive consultation processes. • Balancing strategic objectives - Zoning adjustments must balance climate adaptation objectives with broader land-use goals, community aspirations, economic development needs, and environmental conservation objectives. • Implementation uncertainty - The effectiveness of planning changes in achieving hazard mitigation depends on rigorous compliance, enforcement, and monitoring, necessitating ongoing resources and administrative commitment to ensure outcomes align with intended planning objectives. • Future uncertainty - Planning changes must incorporate flexibility to address evolving coastal hazard risks, climate projections, and changing development pressures, creating inherent uncertainty in long-term effectiveness.

Project Title		Black Point Coastal Area Overlay Expansion
Adaptation Action	Planning Change	 Updated Coastal Areas Overlay at Black Point (source: SAPPA)
Location	Black Point, Yorke Peninsula, South Australia	
Lead Agency	Yorke Peninsula Council	
Objective	Expand the Coastal Areas Overlay to address future hazard risks and guide sustainable coastal development.	
Year of Implementation	2020	
Design Features	• Expanded Coastal Areas Overlay - Expanded to include relocation zones for coastal shacks. • Referral trigger - Development applications now referred to CPB for hazard assessment.	
Process	• Existing coastal hazard risks identified prior to overlay expansion. • Original zoning under the Development Plan had front shacks as 'Coastal Open Space' and rear allotments as 'Settlement', causing development approvals without CPB referral or coastal hazard provisions. • Numerous dwellings were previously approved close to the seaward allotment boundaries, complicating management of coastal hazards, environmental impacts, and public access. • Expanded Coastal Areas Overlay to include allotments behind shack settlements to ensure future developments consider coastal hazards, setbacks, and other coastal management concerns. • Required new developments to comply with setback and coastal hazard policies.	
Cost Estimate	Administrative and regulatory implementation costs	
Useful Resources and References	SA Property and Planning Atlas https://sappa.plan.sa.gov.au/	

2.3. Planning Overlay

Category	Details
Adaptation Type	Avoid
Adaptation Action	Planning Overlay
Description	A planning overlay is a regulatory planning tool applied to land within the Planning and Design Code, identifying areas subject to coastal hazards and providing guidelines to manage development and land use in those hazard-prone areas. In a coastal context, planning overlays specify objectives, considerations, and particular requirements for development proposals, often requiring proponents to demonstrate how their project addresses and minimises coastal hazard risks. The Coastal Areas Overlay seeks to include areas subject to current or future coastal hazards including sea level rise, flooding, erosion and sand drift. Specific rules such as minimum floor heights for houses can apply in different locations and hazard contexts, providing clear guidelines for assessment and approval processes.  <i>Example output from SA Coastal Flood Map viewer which maps areas potentially subject to flooding and inform policy (source: DEW)</i>
Design Life	Ongoing
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☒ Storm tide flooding

	☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☒ Coastal Acid Sulfate Soils ☒ Sand drift
Suitability	• Suitable as a proactive planning measure in areas identified as vulnerable to coastal hazards, including erosion, flooding, or sea-level rise when applied in combination with appropriate zoning. • Particularly effective for managing risks associated with future developments, infill, or significant redevelopment in hazard-prone locations. • Less suitable as the sole measure in already densely developed areas without complementary hazard management strategies, such as protective structures or retreat options.
Likely Impact on Coastal Processes	Low - Overlays themselves do not directly affect physical coastal processes but provide guidance for development that may reduce future adverse impacts on these processes. However, decisions informed by overlays may indirectly affect coastal processes by influencing the types and locations of subsequent adaptation actions.
Implementation	Preparation/Design Period Introduction or amendment of planning overlays involves detailed technical studies to define hazard extents and overlay areas. The process includes stakeholder consultation, community engagement, and statutory procedures to amend the Planning and Design Code, including the development of appropriate Assessment Provisions such as Desired Outcomes and Performance Outcomes. Close collaboration with DEW/CPB is required. The resulting overlay clearly maps affected land and provides explicit objectives, development requirements, and considerations relevant to coastal hazard management.
	Approvals Establishing or amending a planning overlay in South Australia requires an amendment to the Planning and Design Code, authorised by the Minister for <i>Planning under the Planning, Development and Infrastructure Act 2016</i>. Overlays must be supported by hazard mapping and technical assessments and align with relevant State Planning Policies, such as SPP 13 - Coastal Environment (under the <i>Planning, Development and Infrastructure Act 2016</i>).
	Design Considerations

	- Clearly defined overlay extents supported by hazard assessments, and risk analyses. - Compatibility with existing and adjacent planning zones and overlays (e.g., heritage, environmental protection, cultural significance) to avoid regulatory conflicts. - Detailed guidelines for managing various development scenarios, such as greenfield developments, infill, or redevelopment in existing urbanised areas. - Ensuring overlay provisions align with State Planning Policies and Regional Plans and strategic objectives, including consistency with broader environmental and cultural considerations. - Clear articulation of objectives, expectations, and performance requirements in overlay schedules. - Consideration of community perceptions, property values, and potential implications for insurance premiums due to inclusion within overlays. - Periodic reviews to accommodate updated scientific data, climate projections, and evolving community needs. Costs Costs may include: - Hazard mapping and technical studies. - Administrative procedures for Code amendments. - Community consultation and stakeholder engagement. - Ongoing compliance monitoring. Challenges and Trade Offs Potential community resistance - overlays may be perceived to negatively impact property values or restrict development rights, requiring effective community engagement and transparent communication. Regulatory complexity - Code amendments can involve lengthy statutory processes, inter-agency coordination, and complex consultation requirements, potentially extending timelines. Ensuring integration with other planning instruments - overlays need to be carefully coordinated with existing zones, heritage or environmental overlays, and strategic land-use policies to avoid contradictions or regulatory conflicts. Managing uncertainty - overlays must balance conservative hazard projections with economic development aspirations, which may create tensions between precautionary approaches and development pressures. Legal and administrative costs - the preparation, amendment, and ongoing implementation of planning overlays involve resource commitments, potentially affecting local government budgets and resources.
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Project Title		South Australian Coastal Flood Mapping Viewer	
Adaptation Action	Planning Overlay	 Example output from SA Coastal Flood Map (including various SLR scenarios) viewer which maps areas potentially subject to flooding and inform policy (source: DEW)	
Location	Coastal regions of South Australia, including metropolitan Adelaide and regional coastal councils		
Lead Agency	Department for Environment and Water (DEW), Government of South Australia		
Objective	To provide broad-scale mapping of coastal flood hazards, including sea level rise and storm surge flooding, to support land use planning, emergency management, and infrastructure adaptation. The viewer is designed to inform updates to planning overlays and support evidence-based decision-making by councils and state agencies.		
Year of Implementation	Initial release in 2020, with updates ongoing		
Design Features	• Interactive online mapping tool - Allows users to visualise potential coastal flood extents under different sea level rise scenarios. • Scenario-based risk layers - Users can toggle between time horizons (2020, 2050, 2100) and hazard types (coastal flooding at mean high water springs or coastal flooding from a 1% AEP coastal storm event) to identify vulnerable areas. • Elevation data and modelling - Uses LiDAR and local tide and storm surge data to identify areas at risk of coastal flooding at a local to regional scale predominantly using bathtub modelling. • Planning integration - Supports local governments and the state planning system to assess development risks and inform the application or amendment of planning overlays (e.g. the Coastal Areas Overlay in the Planning and Design Code).		

	• Accessible format - Publicly available to councils, developers, planners, and the general community via an interactive web platform.
Process	• Data integration and viewer development - Elevation data (LiDAR), tidal records, and historical flood data were compiled and validated to create reliable visual outputs. • Stakeholder consultation - The tool was developed in consultation and collaboration with local government associations and members. • Planning system alignment - Outputs from the viewer are used to inform future changes to planning policies, overlays, and zoning in areas at risk of coastal flooding, particularly through the Coastal Areas Overlay and future climate adaptation policy amendments. • Ongoing updates and refinement - The tool is updated as new modelling, sea level allowances, and flood data become available.
Cost Estimate	NA
Useful Resources and References	Further information is available at: https://data.environment.sa.gov.au/Coast-and-Marine/Data-Systems/Coastal-Flood-Mapping-Viewer/Pages/default.aspx

3. Accommodate

This section summarises the adaptation actions and provides project examples which fall under the accommodate adaptation type. These actions seek to mitigate risk by adopting solutions which increase the hazard tolerance of the land or assets exposed to hazard.

3.1. Upgrade to More Resilient Infrastructure

Category	Details	
Adaptation Type	Accommodate	
Adaptation Action	Upgrade to More Resilient Infrastructure	
Description	Upgrading to more resilient infrastructure involves improving the capacity of existing assets to withstand coastal hazards such as erosion, flooding, sand drift and saline exposure. This approach typically includes retrofitting, strengthening, or rebuilding existing assets using resilient materials, design standards, or construction techniques. Incorporating resilience in infrastructure reduces vulnerability, increases asset lifespan, and minimises damage and disruption during coastal hazard events.	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☒ Saline intrusion ☒ Coastal Acid Sulfate Soils ☒ Sand drift	 <i>Boardwalk upgrades at Hallet Cove (source: APR composites)</i>
Suitability	- Suitable for coastal areas with critical or high value infrastructure susceptible to coastal hazard impacts, including urban areas, transport networks, utilities, and public facilities. - Ideal in contexts where relocation is impractical or cost-prohibitive.	

	Less suitable in highly dynamic areas with rapid shoreline retreat, unless combined with complementary protection or retreat measures. In such environments, modular or expendable components such as boardwalks or staircases designed as separate elements can be used so that high risk sections can be easily replaced if damaged.
Likely Impact on Coastal Processes	Low - Infrastructure upgrades primarily enhance asset resilience without significantly altering sediment dynamics or natural coastal processes. Appropriate designs and site-specific evaluations help minimise unintended environmental impacts.
Implementation	Preparation/Design Period Detailed planning and engineering design by qualified professionals is required. This may involve vulnerability assessments, engineering analyses, climate risk projections, geotechnical investigations, environmental assessments, material selection, and stakeholder consultation. The process moves from initial feasibility studies to detailed designs for resilient infrastructure construction or retrofitting. Approvals A range of approvals may be required for upgrading to more resilient infrastructure, including: - Land Owner's consent. - Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017 - Schedule 9</i>). - Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. Design Considerations - Detailed assessment of asset vulnerability under current and projected coastal hazard scenarios, including sea-level rise, flooding frequency, and storm intensity. - Selection of resilient construction materials, including corrosion-resistant, water-resistant, and erosion-resistant materials. - Consideration of adaptive design elements for incremental upgrading to accommodate future hazard projections. - Integration with broader infrastructure and planning frameworks to maintain connectivity, access, and critical service continuity.

	• Assessment of environmental impacts, particularly on local ecosystems, drainage patterns, and coastal processes, and implementation of mitigation strategies where necessary. • Design for ease of future maintenance and long-term asset sustainability. • Ensuring compatibility with existing urban infrastructure, land-use planning, and regulatory compliance frameworks. • Consideration of asset life expectancy and the cost benefit of increased investment, including the design life of infrastructure to withstand relevant hazard scenarios such as a 1% AEP event with 1 metre sea level rise or a 10 %AEP event with 0.3 metre sea level rise.
	Costs Costs may include: • Engineering and climate risk assessments. • Materials, construction and retrofitting costs. • Regulatory approvals and environmental assessments. • Ongoing operational and maintenance costs.
	Challenges and Trade Offs • High upfront costs and funding - Resilient infrastructure typically involves higher upfront investment compared to conventional infrastructure, necessitating financial commitment balanced against future cost savings from reduced damage and maintenance requirements. • Construction disruption - Upgrading or retrofitting infrastructure can significantly disrupt existing services, transport networks, and community access, requiring careful planning, community consultation, and minimisation of construction impacts. • Compatibility with existing assets - Ensuring resilient upgrades integrate seamlessly with existing infrastructure and asset management systems, without causing unintended impacts to adjacent infrastructure or exacerbating risks elsewhere. • Environmental considerations - Construction works or the introduction of new materials or structures may impact local ecological systems, groundwater dynamics, or habitat values, requiring comprehensive environmental assessments and careful design. • Regulatory complexity - Navigating approvals and compliance requirements can be complex and time-consuming, potentially affecting project timelines and overall costs. • Uncertainty in long-term climate impacts - Designing infrastructure to withstand uncertain future climate conditions involves balancing the increased initial costs with uncertain long-term benefits, requiring adaptive approaches and robust scenario planning.

Project Title	Cape Jervis and Penneshaw Ports Resilience Upgrades
Adaptation Action	Upgrade to More Resilient Infrastructure
Location	Cape Jervis and Penneshaw, South Australia
Lead Agency	South Australian Department for Infrastructure and Transport
Objective	To enhance the resilience and longevity of the Cape Jervis and Penneshaw ports, ensuring the continued safe and efficient operation of ferry services between Kangaroo Island and the mainland, while mitigating risks associated with coastal hazards.  <i>Cape Jervis upgrade works (source: Government of South Australia - Department for Infrastructure and Transport)</i>
Year of Implementation	Started in 2024, ongoing.
Design Features	• Structural reinforcement - Strengthening of berthing and mooring structures to withstand increased wave action and storm surges. • Material upgrades - Utilisation of corrosion-resistant materials in construction to combat saline exposure and extend the lifespan of port infrastructure. • Enhanced safety measures - Improvement of pedestrian, vehicle, and freight access to ensure safe and efficient operations under varying coastal conditions.
Process	• Background - The ports at Cape Jervis and Penneshaw are critical infrastructure facilitating transportation between Kangaroo Island and mainland South Australia. Over time, exposure to coastal hazards such as erosion, storm surges, and saline exposure has necessitated upgrades to maintain their structural integrity and operational efficiency. • Assessment and planning - Comprehensive evaluations of existing port conditions to identify vulnerabilities to coastal hazards.

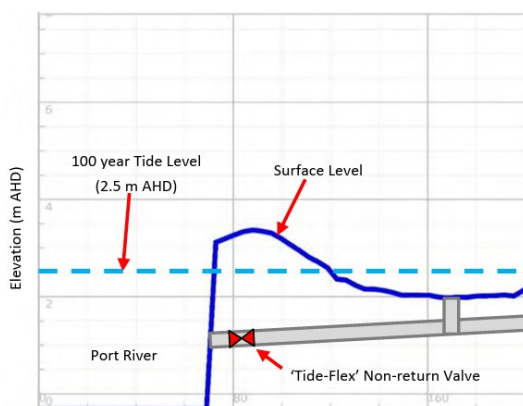
	• Design and engineering - Development of upgrade plans incorporating resilient materials and design standards tailored to the specific environmental challenges of each port. • Construction - Execution of upgrades with minimal disruption to ongoing ferry services, ensuring continuous connectivity between Kangaroo Island and the mainland.
Cost Estimate	\$73 million (including all project costs, not just resilient infrastructure upgrade)
Useful Resources and References	Further information is available at: https://www.dit.sa.gov.au/infrastructure/marine_and_bridges_projects/kangaroo-island-ports-upgrade

3.2. Upgrade Drainage Network (Including Non-Return Valves)

Category	Details										
Adaptation type	Accommodate										
Adaptation Action	Upgrade Drainage Network (Including Non-Return Valves)										
Description	Drainage networks manage and mitigate flood risks arising from high tides, storm surges, sea-level rise, and heavy rainfall events in coastal areas. Effective drainage systems typically include upgraded stormwater drains, culverts, improved pumping systems, and may incorporate additional components such as one-way tide valves (non-return valves). One-way valves allow drainage of freshwater runoff while preventing seawater from entering drainage networks during high tides or storm surges, reducing flooding and saline intrusion. Properly designed drainage networks ensure ongoing protection of infrastructure, freshwater ecosystems, and local communities.  <i>Example of non-return valve which can be used at coastal outfalls (duckbill valve) (source: Utility Magazine)</i>										
Design Life	25+ years, dependent on design intention										
Coastal Hazard Mitigation	<table border="0"> <tr> <td>☐ Short-term erosion</td><td>☒ Regular inundation</td></tr> <tr> <td>☐ Long-term erosion</td><td>☒ Terrestrial flooding</td></tr> <tr> <td>☐ Cliff erosion</td><td>☐ Saline intrusion</td></tr> <tr> <td>☐ Accretion</td><td>☐ Coastal Acid Sulfate Soils</td></tr> <tr> <td>☒ Storm tide flooding</td><td>☐ Sand drift</td></tr> </table>	☐ Short-term erosion	☒ Regular inundation	☐ Long-term erosion	☒ Terrestrial flooding	☐ Cliff erosion	☐ Saline intrusion	☐ Accretion	☐ Coastal Acid Sulfate Soils	☒ Storm tide flooding	☐ Sand drift
☐ Short-term erosion	☒ Regular inundation										
☐ Long-term erosion	☒ Terrestrial flooding										
☐ Cliff erosion	☐ Saline intrusion										
☐ Accretion	☐ Coastal Acid Sulfate Soils										
☒ Storm tide flooding	☐ Sand drift										
Suitability	• Suitable in low-lying coastal areas where infrastructure faces increasing flooding risks due to storm surges, flooding, or sea-level rise. • Particularly appropriate where critical infrastructure access and community connectivity must be maintained or enhanced.										

	• Less suitable in highly dynamic coastal settings experiencing active erosion without complementary protective measures. • Less suitable in low lying coastal areas or where local landform and elevation restrict effective stormwater drainage during high tides or storm events, increasing the risk of backflow or inland flooding.
Likely Impact on Coastal Processes	Low - Minimal direct impact on sediment dynamics or coastal morphology. However, drainage systems may influence local hydrological and ecological conditions, necessitating careful design and management. Scour potential should also be considered for coastal outfalls. While some upgrades, such as switching from open pipes to one-way valves, may have limited physical impact, drainage networks may have a higher impact on coastal processes such as erosion, accretion, scour and longshore drift.
Implementation	Preparation/Design Period Detailed engineering and hydrological assessments by suitably qualified professionals are required. Typically involves hydraulic modelling, drainage system evaluations, infrastructure planning, environmental impact assessments, and community consultation. Preliminary design progresses to detailed planning, specifying infrastructure components, such as upgraded culverts, drainage channels, pumps, and the potential use of one-way tide valves where appropriate. These may be used in combination with other stormwater management measures such as wetlands, detention basins or rain gardens, where appropriate, to enhance flood mitigation, water quality and ecological outcomes. Approvals A range of approvals may be required upgrading drainage networks, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. Design Considerations • Detailed hydrological and hydraulic modelling to determine optimal drainage configurations and capacities. • Integration of one-way tide valves or non-return valves in areas susceptible to tidal inundation or saline intrusion.

	• Engineering design, including consideration of appropriate storm event (coastal and rainfall) ensuring adequate capacity and reliability of pumps, drainage channels, and culverts. • Consideration of complementary stormwater management measures such as wetlands, rain gardens or detention basins to improve water quality, ecological outcomes and overall system performance. • Geotechnical assessments for infrastructure stability and resilience. • Evaluation of potential ecological impacts, such as altered tidal exchange, freshwater hydrology, and habitat impacts and connectivity. • Sediment and debris management plans to maintain infrastructure effectiveness and operational reliability.
	Costs Costs may include: • Engineering design and assessments. • Construction and installation of drainage infrastructure and tide valves. • Ongoing maintenance and inspections. • Approvals and stakeholder engagement. • Complementary flood mitigation measures.
	Challenges and Trade Offs • Operational reliability and maintenance - Drainage systems, especially mechanical components like pumps and valves, require regular maintenance and inspection to ensure reliability, increasing long-term operational costs. • Ecological and hydrological impacts - Drainage infrastructure may affect natural water flow, vegetation and ecosystems, and water quality, necessitating careful management and mitigation strategies. • Community acceptance - Construction or upgrading drainage infrastructure may temporarily disrupt local access or negatively affect coastal aesthetics, requiring community consultation and effective engagement strategies. • Flood management balance - Improving coastal drainage may exacerbate flooding inland during significant rainfall events, requiring integrated management and complementary solutions such as pumps or flood storage areas. • Environmental and regulatory constraints - Implementation may involve complex permitting processes and ecological assessments, potentially delaying project timelines or increasing costs.

Project Title		Port River East Stormwater Management Plan
Adaptation Action	Upgrade Drainage Network (Including Non-Return Valves)	 Example of non-return valve used in the Port Adelaide drainage system (modified from Southfront Port River East Stormwater Management Plan, 2019)
Location	Port River and surrounding suburbs, Port Adelaide, South Australia	
Lead Agency	City of Port Adelaide Enfield	
Objective	To improve stormwater drainage infrastructure in the Port River region, reducing the risk of coastal flooding and tidal inundation through the installation of flood mitigation measures, including one-way valves to prevent seawater backflow into stormwater drains.	
Year of Implementation	Plan developed in 2020, with ongoing implementation of flood mitigation strategies.	
Design Features	• One-way tide valves - Installed in key drainage outfalls to prevent tidal backflow and reduce the risk of stormwater network flooding during high tides and storm surge events. • Stormwater network upgrades - Assessment and improvement of existing stormwater infrastructure to enhance drainage capacity. • Flood mitigation planning - Identification of areas prone to flooding and development of site-specific solutions to manage coastal flood risks. • Water-sensitive urban design (WSUD) elements - Integrating measures to improve water quality and natural filtration of stormwater before discharge into the Port River.	
Process	• Site assessments and flood risk modelling - Detailed studies were conducted to assess the impact of coastal flooding and storm surge on the Port River region. GIS-based flood modelling helped identify key drainage points at risk of tidal backflow and surface flooding. • Infrastructure audit - An assessment of existing drainage infrastructure was completed to determine capacity limitations and identify sections requiring upgrades. Historical flooding events and maintenance records were reviewed to inform decision-making. • Engineering design and approvals - Designs for stormwater upgrades, including one-way tide valves, were developed to align with South Australia's coastal adaptation and flood management policies. The project required coordination with state agencies, environmental regulators, and urban planners to ensure compliance with existing development frameworks.	

	• Implementation of flood mitigation measures - Installation of one-way tide valves and stormwater network upgrades were carried out in a staged approach, prioritising high-risk areas. Construction was coordinated to minimise disruption to local communities and businesses in the Port Adelaide area.
Cost Estimate	Total budget for flood strategies \$47,400,000
Useful Resources and References	The Stormwater Management Plan developed by Southfront in 2019 provides further details.

3.3. Upgrade Roads

Category	Details										
Adaptation Type	Accommodate										
Adaptation Action	Upgrade Roads										
Description	Upgrading roads involves modifying or redesigning existing road infrastructure to increase resilience against coastal hazards, such as flooding, erosion, and sea-level rise. Upgrades may include elevating road surfaces, improving drainage systems, enhancing the structural integrity of embankments, and incorporating adaptive design elements that accommodate anticipated climate impacts. Often, these upgrades are complimented by protection works. This measure ensures continued safe access, protects critical transport infrastructure, and enhances resilience in coastal communities.  <i>Moana Esplanade during 2016 storms (source: ABC)</i>										
Design Life	25+ years, dependent on design intention										
Coastal Hazard Mitigation	<table border="0"> <tr> <td>☒ Short-term erosion</td><td>☒ Regular inundation</td></tr> <tr> <td>☐ Long-term erosion</td><td>☒ Terrestrial flooding</td></tr> <tr> <td>☐ Cliff erosion</td><td>☐ Saline intrusion</td></tr> <tr> <td>☐ Accretion</td><td>☐ Coastal Acid Sulfate Soils</td></tr> <tr> <td>☒ Storm tide flooding</td><td>☐ Sand drift</td></tr> </table>	☒ Short-term erosion	☒ Regular inundation	☐ Long-term erosion	☒ Terrestrial flooding	☐ Cliff erosion	☐ Saline intrusion	☐ Accretion	☐ Coastal Acid Sulfate Soils	☒ Storm tide flooding	☐ Sand drift
☒ Short-term erosion	☒ Regular inundation										
☐ Long-term erosion	☒ Terrestrial flooding										
☐ Cliff erosion	☐ Saline intrusion										
☐ Accretion	☐ Coastal Acid Sulfate Soils										
☒ Storm tide flooding	☐ Sand drift										
Suitability	• Suitable in low-lying coastal areas where roads face increasing flooding risks due to storm surges, flooding, or sea-level rise. • Particularly appropriate where critical infrastructure access and community connectivity must be maintained or enhanced. • Less suitable in highly dynamic coastal settings experiencing active erosion without complementary protective measures.										

Likely Impact on Coastal Processes	Low - Road upgrades primarily address surface flooding and inundation impacts, with limited direct influence on sediment transport or coastal dynamics. However, careful design is required to ensure minimal impacts on drainage patterns, groundwater flows, or adjacent ecological systems.
Implementation	Preparation/Design Period Design and feasibility studies by suitably qualified practitioners are required. Typically includes flood modelling, infrastructure vulnerability assessments, geotechnical investigations, detailed engineering designs, environmental impact assessments, and community consultation.
	Approvals A range of approvals may be required for upgrading roads, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners where works intersect with areas of cultural significance, in accordance with the <i>Aboriginal Heritage Act 1988</i>. • Approval from the Department for Infrastructure and Transport (DIT) if upgrades affect state-managed roads, highways, or related infrastructure.
	Design Considerations • Engineering standards to ensure adequate resilience against predicted flood and storm tide scenarios. • Geotechnical assessments to address road foundation stability and embankment resilience. • Consideration of optimal road elevation to mitigate flooding risks while minimising environmental impacts. • Consideration of incorporating complementary protection works. • Enhanced drainage infrastructure to accommodate increased rainfall intensity or sea-level rise scenarios. • Integration of adaptive design elements to accommodate future climate change projections, including provisions for incremental upgrades or adjustments. • Environmental assessments to ensure minimal impact to sensitive coastal habitats and groundwater flow.
	Costs Costs may include: • Engineering design and geotechnical assessments. • Road construction and materials.

	• Drainage infrastructure improvements. • Regulatory approvals and environmental assessments. • Ongoing maintenance and monitoring. Challenges and Trade Offs • Costs and funding availability - Substantial upfront investment required, coupled with ongoing maintenance and potential incremental upgrades in response to climate change, requiring committed and sustainable long-term funding sources. • Ecological impacts - Raised roads or new embankments can impact local drainage, wetland hydrology, coastal vegetation or habitat connectivity, necessitating careful environmental assessments and mitigation strategies. • Community acceptance - Elevated or widened roads can alter landscape aesthetics, restrict views, or limit recreational access, potentially causing community opposition and requiring significant consultation and engagement. • Displacement of flooding - Upgraded roads can alter flood pathways, potentially increasing flooding risks elsewhere, requiring coordinated regional flood management planning. • Construction impacts and disruption - Road upgrading works may disrupt local traffic, access, or commercial activities temporarily, requiring careful planning and management to minimise community and economic impacts.
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Project Title		Miami Beach Road Elevation and Stormwater Management Initiative	
Adaptation Action	Upgrade Roads	 <i>Raised road in Miami Beach (source: Miami Herald)</i>	
Location	Miami Beach, Florida, USA		
Lead Agency	City of Miami Beach		
Objective	To enhance the resilience and safety of Miami Beach's infrastructure against coastal hazards by elevating roads and upgrading stormwater management systems, ensuring continued safe access and protecting vital urban infrastructure.		
Year of Implementation	Initiated in 2014, with ongoing projects and phased implementations.		
Design Features	• Road Elevation - Streets in vulnerable neighbourhoods, such as Sunset Harbour and West Avenue, have been raised to mitigate the impacts of sea-level rise and frequent tidal flooding. • Stormwater Pump Stations - Installation of high-capacity pump stations to effectively manage stormwater and reduce flood risks associated with heavy rainfall and storm surges. • Seawall Enhancements - Upgrading and raising seawalls to provide additional protection against storm surges and coastal erosion. • Green Infrastructure - Integrating features such as bioswales and permeable pavements to enhance natural stormwater infiltration and improve water quality.		
Process	• Project Planning - Comprehensive assessments were conducted to identify vulnerable infrastructure and design appropriate resilience measures, incorporating sea-level rise projections and community input. • Construction - Projects are executed in phases, focusing on minimising disruptions to residents and businesses, with continuous monitoring and adaptation based on performance and environmental feedback.		
Cost Estimate	>\$100,000,000		
Useful Resources and References	Further information is available at: https://www.miamibeachfl.gov/wp-content/uploads/2020/01/Jacobs-Engineering-Final-Presentation-Tasks-2-3.pdf		

4. Retreat

This section summarises the adaptation actions and provides project examples which fall under the retreat adaptation type. These actions seek to mitigate risk by withdrawing, relocating or retreating landward to reduce exposure to hazard.

4.1. Land Acquisition

Category	Details
Adaptation type	Retreat
Adaptation Action	Land Acquisition
Key function	Land acquisition involves the strategic transfer of private land to public ownership in areas vulnerable to coastal hazards, such as erosion, flooding, or sea-level rise. This action enables long-term planning, reduces development pressure in high-risk zones, and facilitates hazard avoidance through land-use transition. Acquisition can occur through negotiated purchase, compulsory acquisition, land swaps, or lease-back agreements. These approaches help restore or protect natural coastal processes, create buffer zones or habitat corridors, and offer space for future adaptation measures. Land acquisition supports managed retreat pathways and can deliver environmental, cultural, recreational, and economic co-benefits (Alexander, Ryan, & Measham, 2012).  <i>Example of land acquisition proposal in Crystal Beach Park (United States) where government have proposed to acquire land and convert to a park for public amenity</i>
Design life	Ongoing

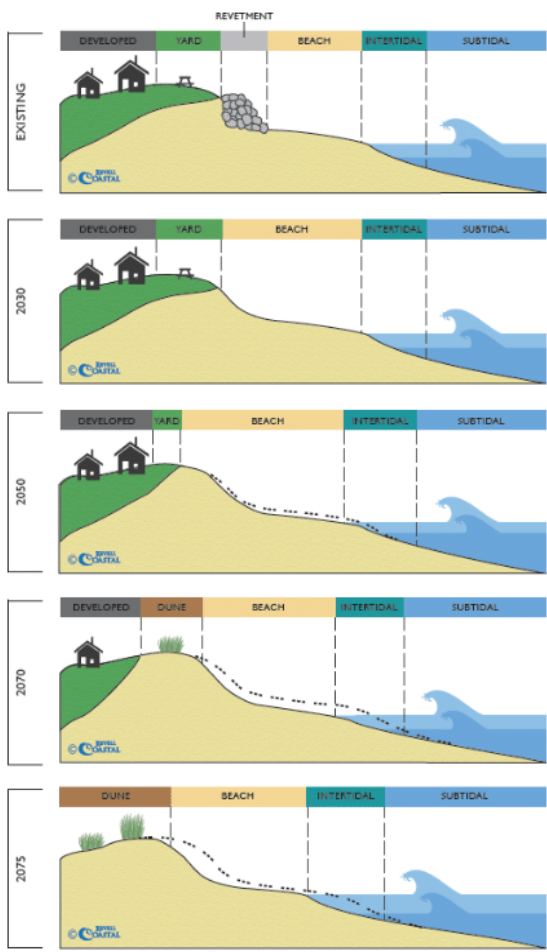
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☒ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☒ Saline intrusion ☒ Coastal Acid Sulfate Soils ☒ Sand drift
Suitability	• Best suited to undeveloped or low-density areas at high risk from coastal hazards where land can be proactively purchased, acquired, or re-purposed. • Also applicable where development rights exist but long-term viability is low. • Less suitable where property costs are prohibitive or land supply is constrained. • Land swaps and lease-back schemes offer alternatives in these cases.
Likely Impact on Coastal Processes	Low - land acquisition supports natural coastal processes by preventing development in vulnerable areas, allowing for natural dynamics for continue, maintaining ecological resilience.
Implementation	Preparation/Design Period Projects require detailed hazard assessments, economic assessment, strategic land-use planning, and multi-stakeholder engagement. Common phases include: • Identification of high-risk parcels via CHAP or similar assessments. • Negotiation or compulsory acquisition processes. • Cultural heritage due diligence and Traditional Owner engagement. • Community consultation and communication planning. • Legislative compliance and Code amendments. Approvals A range of approvals may be required for land acquisition actions in South Australia, including: • Voluntary or compulsory acquisition processes, typically under the <i>Land Acquisition Act 1969 (SA)</i>. • Development approval, if land use changes are required under the <i>Planning, Development and Infrastructure Act 2016</i>. • Consultation with Traditional Owners and authorisation under the <i>Aboriginal Heritage Act 1988</i> and the <i>Native Title Act 1993 (Cth)</i> where Native Title rights exist. • Legal and valuation processes for determining fair compensation and executing land transfer.

	It's acknowledged that the legal and approval aspects of land acquisition are complex with a lack of precedence in the Australian policy landscape. Design Considerations • Determine which areas are most vulnerable and prioritise them for acquisition based on hazard assessments and climate change projections. • Ensure alignment with broader strategic land-use plans, zoning regulations and community objectives. • Ensure availability of necessary infrastructure and resources in new locations. • Ensure clarity in future land-use intent. • Develop clear communication strategies to inform the public, property owners and developers about the benefits and objectives of land acquisitions. Costs Costs may include: • Land purchase and transaction costs. • Hazard and vulnerability assessments. • Administrative processes and planning amendments. • Community consultation. Challenges and Trade Offs • Community acceptance - Landowners may resist selling their properties due to emotional attachment, perceived loss of property value and concerns about relocation. • Funding and budget constraints - Securing adequate funding for land acquisition and then for ongoing management. • Legal and administrative process -Processes involved in property acquisition can be complex and time-consuming, requiring clear guidelines and effective oversight. • Economic implications - Cost associated with purchasing land and potential compensation for property owners can be significant. Evaluating long-term benefits versus initial expenses is crucial. • Implementation timelines and complexity - Process of acquiring land can involve lengthy negotiations, detailed assessments, and potentially contentious public consultation, requiring careful planning and management.
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Project Title	Managed retreat at Black Point
Adaptation Action	Land Acquisition
Location	Black Point, South Australia
Lead Agency	Yorke Peninsula Council & CPB
Objective	Enable the planned relocation of foreshore shacks to adjacent land to reduce coastal hazard risks.
Year of Implementation	Ongoing
Design Features	Among other things, the protocols require shack owners to: • Maintain the improvements on the land in good working repair and condition. • At the termination of the lease or sooner, surrender the land to the Minister. • Comply with the relocation protocols as approved by the Minister. • Not transfer or sublet the land without the approval of the Minister. • Not carry out earthworks without the approval of the Minister. • Not erect or alter or permit to be constructed any buildings, erections, or other improvements, including fencing, external structural alterations, and additions, without prior approval in writing of the Minister.  <i>Black Point shack (source: SA Life)</i>
Process	• Assessment of high-risk coastal zones and identification of suitable relocation sites: The local government conducted assessments to determine areas at risk from coastal hazards, identifying zones where continued habitation was unsustainable and prioritising these for relocation or surrender. • Engagement with affected property owners to ensure smooth transition and compensation where necessary: Crown Lease shack owners were informed of

	the retreat protocols through consultations. These protocols required compliance with specific conditions, such as maintaining structures, surrendering the land upon lease termination, and obtaining approvals for any alterations. Public consultations were conducted to ensure community understanding and acceptance of the retreat strategy. • Coordination with councils to update zoning policies and planning approvals: Zoning changes were introduced under the Development Plan and Planning and Design Code to manage land use in hazard-prone areas. These included restricting development in high-risk zones and ensuring relocation sites were available.
Cost Estimate	TBC
Useful Resources and References	Further information is available from Yorke Peninsula Council https://yorke.sa.gov.au/community-services/public-consultation/past-consultations/review-of-zoning-of-land-at-black-point-and-pine-point/

4.2. Removal of Assets

Category	Details	
Adaptation Type	Retreat	
Adaptation Action	Removal of Assets	
Description	Planned retreat can involve the strategic removal or abandonment of infrastructure and buildings in areas vulnerable to coastal hazards. This approach allows for the restoration and preservation of natural coastal ecosystems, facilitating habitat migration and proving ecological resilience. Planned retreat requires comprehensive planning, community engagement, and coordination with various stakeholders to ensure a smooth transition and long-term sustainability.	
Design Life	Ongoing	 Diagram outlining the progressive removal of assets in the hazard zone Source: http://dx.doi.org/10.3390/w13091324
Coastal Hazard Mitigation	☑ Short-term erosion ☑ Long-term erosion ☑ Cliff erosion ☑ Accretion ☑ Storm tide flooding ☑ Regular inundation ☑ Terrestrial flooding ☑ Saline intrusion ☑ Coastal Acid Sulfate Soils ☑ Sand drift	

Suitability	• Suitable for high-risk coastal areas where ongoing erosion, flooding, or sea-level rise pose significant threats to infrastructure and communities. • Ideal for long-term risk reduction and enhancing community safety, and effective in areas where maintaining or defending existing infrastructure is not feasible, environmentally acceptable or cost-effective. • Less suitable in densely populated urban areas where relocation is challenging due to high costs, limited available land, and significant social and economic impacts.
Likely Impact on Coastal Processes	Low - Allows natural coastal processes to continue without artificial interference, promoting long-term ecosystem stability.
Implementation	Preparation/Design Period Before the demolition, removal or relocation of assets can be performed, a considerable planning effort is required. This will likely involve a series of stakeholder engagements, coordination between multiple agencies and the redesign/approvals associated with any asset relocation. Approvals A range of approvals may be required for planned retreat, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. Design Considerations • Coastal hazard assessments, including erosion rates, sea-level rise projections, and flooding scenarios. • Requires integration into long-term asset management plans, considering infrastructure design life and maintenance schedules. • Must be supported by appropriate land-use planning policies, ensuring relocated assets are sited in low-risk areas. • Strong stakeholder engagement is essential to manage community expectations and reduce opposition.

	Costs Costs may include: • Coastal hazard and vulnerability assessments. • Property purchase and relocation and asset demolition. • Administrative and Code amendment processes. Challenges and Trade Offs • Community acceptance - Landowners and residents may resist relocation due to emotional attachment, perceived loss of property value, and concerns about relocation logistics. • Economic implications - Costs associated with acquiring or providing appropriate alternative land and relocating infrastructure and communities can be significant • Legal and administrative processes - Involved in removal of assets can be complex and time-consuming. • Implementation timelines and complexity - Process of relocating communities and infrastructure can involve lengthy negotiations, detailed assessments, and potentially contentious public consultation, requiring careful planning and management.
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Project Title		Marion Bay Shack Removal
Adaptation Action	Removal of Assets	 <i>Marion Bay coastal shack</i>  <i>Marion Bay coastal shacks</i>
Location	Marion Bay, Yorke Peninsula, South Australia	
Lead Agency	Yorke Peninsula Council and Department for Environment and Water	
Objective	Progressively remove coastal shacks at risk from erosion and flooding to mitigate hazard exposure.	
Year of Implementation	Since 1991	
Design Features	Removal of coastal shacks with unacceptable risk to coastal hazard - Progressive reduction of shack numbers from 22 in 1994 to 6 remaining in 2025. Managed natural restoration - management of the coastal environment post-removal	
Process	- Initial assessment in 1991 identified shacks as unsustainable due to hazard risks. - Additional 1994 hazard study confirmed high erosion and flooding risks. - Shack removal executed incrementally, based on tenure expiration and hazard severity. - Ongoing engagement with shack owners and community on removal strategy and coastal adaptation.	
Cost Estimate	Administrative and regulatory implementation costs	
Useful Resources and References		

5. Protect

This section summarises the adaptation actions and provides project examples which fall under the protect adaptation type. The actions have been classified as nature-based solutions, soft engineering solutions, hard engineering solutions or hybrid approaches. These actions seek to mitigate risk by protecting land or assets against hazard.

5.1. Nature-based Solutions

5.1.1 Mangrove Forests & Saltmarsh

Category	Details
Adaptation Type	Protect - Nature-based solutions
Adaptation Action	Mangrove Forests & Saltmarshes
Description	Mangrove forests and saltmarshes are coastal habitats that act as natural buffers, dissipating wave energy, capturing and stabilising sediments, and reducing erosion and flooding risks (CSIRO, 2020). Restoration and enhancement projects typically involve planting or facilitating natural regeneration of mangroves and saltmarsh vegetation, removal of invasive species, and improving hydrological conditions (e.g., tidal flows). These habitats also provide substantial ecological benefits, including improved water quality, increased biodiversity, habitat for fisheries, and carbon sequestration (Saintilan, Rogers, Kelleway, Ens, & Sloane, 2019).  <i>Mangrove planting at the Yitpi Yartapuultiku living shoreline project (source: Friends of Port River)</i>
Design Life	Operationally ongoing, dependent on species, environmental conditions, sedimentation rates, and climatic conditions.

Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☒ Coastal Acid Sulfate Soils ☐ Sand drift	 <i>St Kilda mangroves (source: Salisbury Council)</i>
Suitability	- Suitable for sheltered or semi-sheltered estuarine and low-energy coastal settings with suitable tidal regimes, sediment characteristics, and ecological conditions conducive to mangrove and saltmarsh establishment. - Particularly beneficial in regions experiencing sediment instability, erosion, or tidal inundation impacts. - Less suitable in highly exposed, high-energy coastal environments or locations where site-specific conditions (e.g., salinity, wave energy, or substrate type) preclude successful habitat establishment.	
Likely Impact on Coastal Processes	Moderate to high - Mangrove forests and saltmarshes capture and stabilise sediments, enhance sedimentation, dissipate wave energy, and reduce shoreline erosion. Positive ecological impacts include increased biodiversity, enhanced fisheries productivity, and improved water quality.	
Implementation	Preparation/Design Period Ecological assessments by qualified coastal ecologists are required. This may involve habitat suitability studies, ecological and sedimentation assessments, hydrodynamic modelling, stakeholder consultation, and detailed restoration planning, progressing from preliminary site selection through to detailed operational plans.	Approvals A range of approvals may be required for mangrove and/or saltmarsh restoration including: - Land Owner's consent. - Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> &

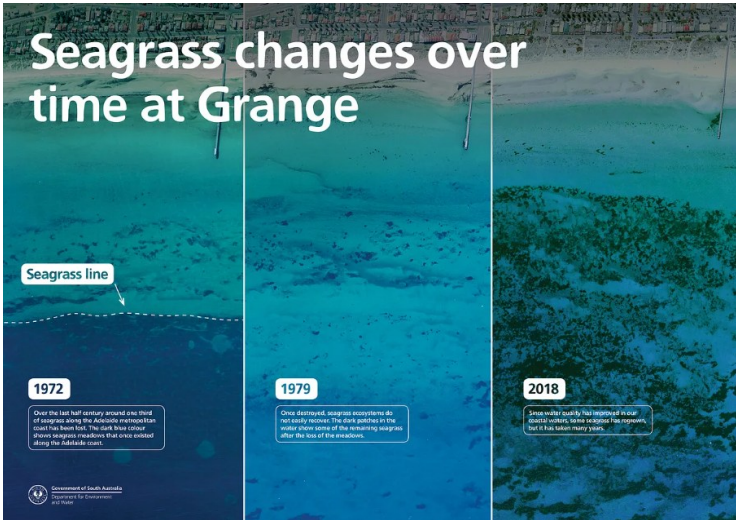
	<i>Planning, Development and Infrastructure (General) Regulations 2017 - Schedule 9).</i> • Consultation with Traditional Owners and, where required, authorisation under the Aboriginal Heritage Act 1988, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA)), the Environment Protection Authority and the Department for Infrastructure and Transport. Design Considerations • Ecological and hydrological assessments to identify optimal species and suitable planting or regeneration locations. • Appropriate selection of mangrove and saltmarsh species compatible with local salinity, flooding frequency, sediment characteristics, and climate conditions including predicted climate change conditions. • Consideration of design life (e.g. whether the restoration is intended to protect for 50, 100 or 150 years), and whether it can be expanded, upgraded, or integrated with future protection measures. • Consideration of any earthworks required, and assessment of potential impacts on adjacent land and drainage. • Consideration of if works may impact on adjacent land. • Methods for promoting natural regeneration, planting, or direct seeding techniques. • Integration of protective measures (e.g., temporary fencing or barriers) to ensure vegetation establishment and minimise disturbances. • Management strategies for invasive species control and habitat enhancement. • Consideration of incorporating recreational or educational elements such as boardwalks or signage where appropriate. • Evaluation of opportunities to generate carbon credits under the Australian Government's Australian Carbon Credit Units (ACCU) Scheme, where eligible. Costs Costs may include: • Ecological and hydrological assessments and site preparation. • Planting materials and labour. • Infrastructure for habitat protection (e.g., fencing). • Monitoring, maintenance, and adaptive management. Challenges and Trade Offs • Ecological complexity - Success depends heavily on suitable ecological conditions, including salinity, flooding frequency, sediment dynamics, and
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	climate variability, requiring thorough ecological assessments and ongoing monitoring. • Timeframes and establishment success - Mangroves and saltmarshes typically require several years to mature and provide full erosion protection, leaving areas vulnerable to erosion or flooding impacts during early establishment. Interim protection may be necessary. • Community acceptance - Community concerns related to visual impacts, reduced coastal access, or perceived restrictions on recreational uses may require targeted engagement and education strategies. • Regulatory and institutional complexities - Approvals and permitting processes can be complex, involving multiple jurisdictions, potentially prolonging project timelines. • Potential changes to recreational and navigational use - Establishment of vegetation in previously open areas may alter recreational or navigational access, requiring careful planning and stakeholder consultation. • Climate change uncertainty and adaptability - Mangroves and saltmarshes may require active management to respond to future sea-level rise, increased storm intensity, or shifting ecological conditions, necessitating ongoing management and monitoring.
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Project Title	"Reel Big Fish" Mangrove Restoration Project
Adaptation Action	Mangrove Forests & Saltmarshes
Location	Western Port, Victoria, Australia.
Lead Agency	Melbourne Water, in collaboration with OzFish Unlimited, Bass Coast Landcare Network, and supported by the Australian Government's Fisheries Habitat Restoration Program.
Objective	To restore and enhance mangrove habitats in Western Port to improve coastal protection, support fish habitats, and bolster local biodiversity.  <i>Westport shoreline (source: Ozfish)</i>
Year of Implementation	2020
Design Features	• Community engagement - Mobilising local volunteers, recreational fishers, and community groups in planting and monitoring activities to foster stewardship and ensure project success. • Strategic planting - Implementing refined planting techniques, such as attaching mangrove seeds to bamboo stakes, to enhance seedling survival rates and establish robust mangrove forests. • Habitat enhancement - Restoring mangrove forests to provide critical nursery habitats for various fish species, thereby supporting fisheries and enhancing biodiversity.
Process	• Site selection - Identified priority locations within Western Port's intertidal zones, including Hastings Foreshore, Lang Lang Foreshore, Grantville Foreshore, French Island Marine National Park, and Churchill Island Marine National Park, for mangrove restoration efforts.

	• Seed collection and propagation - Collected over 50 kilograms of mangrove seeds, which were then prepared for planting using methods refined by the Bass Coast Landcare Network. • Planting initiatives - Engaged community volunteers in planting over 10,000 mangrove seeds across selected sites, utilising bamboo stakes to secure seeds and protect young seedlings. • Monitoring and evaluation - Established protocols to assess the growth, health, and ecological impact of restored mangrove areas, ensuring long-term success.
Cost Estimate	Not available
Useful Resources and References	Further information is available at https://www.melbournewater.com.au/about-us/what-we-do/news/habitat-restoration-enhances-ramsar-wetlands-native-fish

5.1.2 Seagrass Meadows

Category	Details
Adaptation Type	Protect - Nature-based solutions
Adaptation Action	Seagrass Meadows
Description	Seagrass meadows involve protecting, restoring, or enhancing submerged aquatic vegetation communities within shallow coastal waters. Healthy seagrass meadows capture and stabilise sediments, dissipate wave and current energy, and help mitigate coastal erosion and storm surge impacts (Ondiviela, et al., 2014). Seagrasses provide vital ecosystem services, including improved water quality, habitat provision, and enhanced fisheries productivity, while simultaneously buffering shorelines from erosion and storm impacts by capturing and stabilising sediments through their dense root systems (Waycott, et al., 2009).  <i>Seagrass coverage at Grange, South Australia (source: DEW)</i>
Design Life	Operationally ongoing, dependent on species, environmental conditions, sedimentation rates, and ongoing management practices.
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift

Suitability	• Suitable in sheltered or semi-sheltered coastal and estuarine areas with suitable sediment conditions, adequate water quality, and limited wave energy to allow establishment and long-term survival. • Particularly beneficial in areas experiencing sediment instability, coastal erosion, or where ecosystem services (such as habitat provision and fisheries support) provide additional benefits. • Less suitable in exposed coastal areas with high wave action, poor water quality, significant sedimentation, or turbidity levels that prevent effective seagrass growth and survival.
Likely Impact on Coastal Processes	Moderate - Seagrass meadows capture and stabilise sediments, reduce wave energy, and promote sediment retention, enhancing shoreline stability with minimal negative impacts when effectively established and maintained.
Implementation	Preparation/Design Period Detailed design and planning by qualified marine ecologists and coastal managers are required. This may involve ecological assessments, habitat suitability analyses, hydrodynamic and sediment transport studies, species selection, restoration technique evaluation, environmental impact assessments, and stakeholder consultations. This progresses from initial feasibility assessments to a detailed implementation plan, including methods, scale, and species selection.
	Approvals A range of approvals may be required for seagrass meadows including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Detailed ecological and coastal process assessments to determine suitable locations and conditions for seagrass establishment.

	• Selection of seagrass species suitable to local environmental conditions (salinity, sediment type, turbidity, wave exposure). • Techniques for seagrass establishment, including seed-based methods, transplantation of mature plants, or sediment stabilisation techniques to facilitate natural colonisation. • Water quality and hydrodynamic conditions assessment to ensure optimal conditions for seagrass survival and growth. • Ecological connectivity with existing seagrass meadows and integration with broader coastal ecosystem management strategies. • Monitoring plans to assess project success, address potential stressors, and ensure long-term viability. • Consideration of broader co-benefits such as provision of fisheries and nursery habitat, carbon sequestration, biodiversity enhancement, improved water quality, and opportunities for recreation, education or tourism.
	Costs Costs may include: • Ecological, coastal process, water quality and hydrodynamic assessments. • Plant preparation, e.g. seed collection, propagation and planting. • Materials, labour and equipment for restoration activities. • Monitoring and maintenance costs.
	Challenges and Trade Offs • Ecological complexity and uncertainty - Seagrass restoration projects often face high levels of ecological complexity, including variable survival rates influenced by water quality, sediment conditions, nutrient loading, and climate impacts. This means that it can be difficult to rely on benefits such as reduced wave energy consistently. • Long establishment timeframes - Successful seagrass establishment typically requires multiple years, potentially leaving shorelines vulnerable to erosion or storm events during early phases. Complementary interim protection measures may be necessary. • Sensitivity to water quality and sedimentation - Degraded water quality (high turbidity, pollution, or nutrient enrichment) can significantly reduce seagrass survival and establishment success, requiring complementary water quality management actions. • Community and recreational impacts - Projects may temporarily restrict access or affect recreational activities during restoration efforts, potentially requiring proactive stakeholder engagement and community education. • Cost-effectiveness and scalability - Seagrass restoration can be labour-intensive and costly, limiting large-scale application unless clear ecological or economic benefits can be demonstrated.

Project Title	Seagrass Restoration Project	
Adaptation Action	Seagrass Meadows	
Location	Port Gawler, Gulf St Vincent, South Australia	
Lead Agency	University of Adelaide, in collaboration with the South Australian Research and Development Institute (SARDI)	
Objective	To restore 20 hectares of seagrass in Gulf St Vincent, enhancing coastal resilience by stabilising sediments, reducing wave energy, and mitigating erosion and storm surge impacts. The project also aims to improve marine biodiversity, support fisheries productivity, and sequester carbon to combat climate change.	 <i>Bio-degradable hessian bags used to encourage seagrass establishment (source: Jason Tanner)</i>
Year of Implementation	Commenced 2022, ongoing	
Design Features	• Innovative restoration techniques - Deployment of approximately 100,000 biodegradable hessian sandbags on the seafloor to facilitate natural attachment and growth of seagrass seedlings. This method provides a stable environment for seedlings to establish before the bags decompose, minimising the need for direct planting and reducing disturbance to existing seagrass beds. • Ecosystem services enhancement - Restoration efforts focus on improving water quality, increasing biodiversity, providing habitat for marine species such as King George whiting and garfish, and enhancing carbon sequestration capabilities.	
Process	• Site selection and preparation - Identification of suitable restoration sites off Port Gawler, considering historical seagrass loss due to decreased water quality over the past 60 to 80 years. • Community engagement - Involvement of local volunteers through programs like "Seeds for Snapper," where community members collect, process, and deploy seagrass seeds into rehabilitation sites, fostering community stewardship and awareness.	

	• Monitoring and research - Continuous assessment of restoration success, including evaluating the effectiveness of restored patches as habitats for fauna and their role in accumulating blue carbon.
Cost Estimate	\$2 million
Useful Resources and References	Information on the project is available at https://www.adelaide.edu.au/newsroom/news/list/2022/06/30/blue-carbon-funding-secures-seagrass-restoration-in-gulf-st-vincent

5.1.3 Dune Management

Category	Details	
Adaptation type	Protect - Nature-based solutions	
Adaptation Action	Dune Management	
Description	Dune management involves protecting, maintaining, restoring, creating or enhancing dune systems to stabilise shorelines, reduce impacts of erosion, reduce wave overtopping and provide a natural buffer against coastal hazards. It commonly includes actions such as planting native vegetation, fencing to restrict or control pedestrian and vehicle access, reshaping or creating dunes, controlling invasive species and establishing sand trapping structures (e.g. drift net fencing). Effective dune management maintains the protective function of dunes, provides critical habitat for coastal biodiversity, and supports recreation and visual amenity (Martinez, Psuty, & Lubke, 2004).  <i>Broadly spaced planted tubestock in dunes (source: SA Government)</i>	
Design Life	Operationally ongoing, dependent on vegetation establishment, ongoing maintenance, and climatic conditions.	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion	 <i>Fenced path through the dunes Goolwa Dunes and Tokuremoar Reserve</i>

	☐ Coastal Acid Sulfate Soils ☒ Sand drift	
Suitability	• Suitable for sandy coastlines with existing dune systems or adequate space and sand source to create a dune system, particularly where erosion threatens infrastructure, ecosystems, or recreational areas. • Effective in settings where natural coastal processes and vegetation establishment can be supported and maintained. • Less effective in regions with severe coastal erosion, limited/narrow coastal open space or where human activities significantly disrupt natural dune processes.	
Likely Impact on Coastal Processes	Moderate - Dunes effectively absorb wave energy, stabilise sediment, and support natural sediment transport processes, generally enhancing overall coastal resilience. Minimal negative impacts if managed appropriately.	
Implementation	Preparation/Design Period Detailed planning by qualified coastal ecologists, land managers, or engineers is required. Typically includes assessing dune conditions, vegetation surveys, identifying key threats (invasive species, human impacts), hazard assessments (erosion rates, flood levels, sand drift rates), environmental assessments, and community or stakeholder consultation. This phase transitions from preliminary assessments into detailed site-specific implementation and management plans.	
	Approvals A range of approvals may be required for dune management, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works, including the Department for Environment and Water and the Landscape Boards.	
	Design Considerations • Assessment of dune vegetation, ecology, and sediment dynamics.	

	• Selection of appropriate native vegetation species to enhance stabilisation and ecological function, including consideration of climate change projections (e.g. predicted reduction in rainfall). • Design and location of fencing or boardwalks to manage pedestrian access, reduce erosion, and encourage vegetation regeneration. • Control of invasive species to protect and enhance native biodiversity. • Strategic creation, reshaping or restoration of dune profiles for optimal erosion resistance and habitat connectivity. • Integration of sand-trapping and stabilisation measures (e.g., drift-net fencing, jute matting, soil binding polymers). • Design life and level of hazard protection should be considered, including the height and volume of sand required to mitigate against events such as two 1% AEP erosion events or a 1% AEP coastal flood event with a 0.3 metre sea level rise allowance. • Consideration of broader co-benefits such as increased biodiversity, improved visual amenity, recreational and educational opportunities, and the integration of dunes into wider stormwater management systems.
	Costs Costs may include: • Site preparation and earthworks. • Vegetation planting and establishment. • Fencing and access management infrastructure. • Invasive species control. • Monitoring and maintenance.
	Challenges and Trade Offs • Ongoing maintenance - Active dune management involves regular monitoring, vegetation maintenance, invasive species control, and infrastructure upkeep, requiring ongoing financial and resource commitments. • Community access and recreational impacts - Managing access through fencing or restricted pathways may be met with opposition from recreational users, necessitating effective community engagement and education. • Ecological impacts - Inappropriate vegetation selection or disturbance during construction may adversely impact local biodiversity, requiring careful ecological planning and habitat restoration strategies. • Uncertainty in vegetation establishment - Successful dune stabilisation depends on vegetation establishment and survival, influenced by the level of maintenance, climatic conditions, invasive species competition, and recreational pressure, requiring regular monitoring. • Short-term vulnerability - Newly established vegetation and restored dunes can be vulnerable to storm events until vegetation matures, potentially requiring repeated interventions or complementary measures to maintain stability.

	• Adaptability and ongoing management - Changing coastal dynamics, storm patterns, or climate impacts necessitate ongoing monitoring to ensure long-term resilience, potentially requiring adaptive management.
Project Title	Victor Harbor Coastcare
Adaptation Action	Dune Management
Location	Victor Harbor, South Australia
Lead agency	Victor Harbor Coastcare
Objective	To preserve, protect, and restore the natural ecosystem along the coast and dune areas of Victor Harbor, enhancing biodiversity, stabilising dunes, and mitigating coastal erosion.  <i>Dune rehabilitation (source: Victor Harbour Coastcare)</i>
Year of Implementation	Ongoing
Design Features	• Native vegetation planting - Planting and watering native dune plants to stabilise sand dunes and enhance biodiversity. • Biodiversity protection - Protecting sensitive dune areas to maintain and enhance local flora and fauna. • Beach sand monitoring - Monitoring beach sand levels to assess and address erosion issues. • Wildlife conservation - Monitoring vulnerable species, such as the hooded plover, to support conservation efforts.
Process	• Community engagement - Organising working bees twice a month to involve community volunteers in restoration activities. • Collaborative Efforts - Working closely with the City of Victor Harbor's Biodiversity Team and other organisations such as BirdLife Australia to achieve conservation goals. • Educational outreach - Participating in events such as Clean Up Australia Day to raise awareness and educate the public about coastal conservation.
Cost Estimate	Volunteer organisation

Useful Resources and References	Information on the project is available at https://vhcoastcare.org.au/
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5.1.4 Use of On-site Materials

Category	Details										
Adaptation Type	Protect - Nature-based solutions										
Adaptation Action	Use of On-site Materials										
Description	The use of on-site natural materials involves utilising locally available materials, such as beach cast (seagrass or seaweed) wrack, brush, or other natural debris, to provide short-term resistance to erosion and wave impacts. This action typically involves mechanically repositioning these materials from the beach face or high-tide line to areas experiencing active erosion, such as dune toes or beach escarpments. It is primarily used as an emergency or temporary measure, providing immediate erosion protection while more permanent solutions are assessed and developed.  <i>Brush fences planted on the island of Amrum (Source: (Hofstede, 2024))</i>										
Design Life	Typically very short-term, from days to weeks, depending on the materials used and wave energy exposure.										
Coastal Hazard Mitigation	<table border="0"> <tr> <td>☒ Short-term erosion</td><td>☐ Regular inundation</td></tr> <tr> <td>☐ Long-term erosion</td><td>☐ Terrestrial flooding</td></tr> <tr> <td>☐ Cliff erosion</td><td>☐ Saline intrusion</td></tr> <tr> <td>☐ Accretion</td><td>☐ Coastal Acid Sulfate Soils</td></tr> <tr> <td>☐ Storm tide flooding</td><td>☒ Sand drift</td></tr> </table>	☒ Short-term erosion	☐ Regular inundation	☐ Long-term erosion	☐ Terrestrial flooding	☐ Cliff erosion	☐ Saline intrusion	☐ Accretion	☐ Coastal Acid Sulfate Soils	☐ Storm tide flooding	☒ Sand drift
☒ Short-term erosion	☐ Regular inundation										
☐ Long-term erosion	☐ Terrestrial flooding										
☐ Cliff erosion	☐ Saline intrusion										
☐ Accretion	☐ Coastal Acid Sulfate Soils										
☐ Storm tide flooding	☒ Sand drift										
Suitability	Suitable as an immediate or short-term response measure in areas experiencing rapid erosion events, particularly following storm impacts.										

	• Highly opportunistic, dependent on the availability of sufficient suitable near or on-site materials. • Less suitable as a long-term coastal protection strategy, or in areas with limited material availability or restricted vehicle access to beaches.
Likely Impact on Coastal Processes	Low - Typically intended to complement or support natural coastal processes by dissipating wave energy and temporarily stabilising sediments. Minimal disruption expected, provided interventions remain limited in scale and frequency.
Implementation	Preparation/Design Period This measure is opportunistic and can typically be implemented within days to weeks, depending on contractor availability and pre-existing approvals. The preparation involves identifying available materials, obtaining necessary rapid-response approvals, and arranging machinery for material movement.
	Approvals Typically these approaches need to be performed in time critical situations. It is recommended to consider pre approval. Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works, including the Department for Environment and Water and the Landscape Boards.
	Design Considerations • Availability and suitability of on-site natural materials (e.g., beach cast wrack, brush). • Ecological value and habitat considerations, particularly relating to shorebird or marine habitats and ensuring any non-native brush does not contain seeds likely to spread. • Accessibility of site for machinery (e.g., bobcat, loader, excavator) required to relocate materials. • Potential odour or aesthetic impacts if materials like seaweed wrack are used. • Identification of appropriate placement locations to maximise erosion control effectiveness and minimise ecological disturbance.
	Costs Costs may include: • Equipment and labour for material repositioning. • Rapid response approvals. • Short-term maintenance.
	Challenges and Trade Offs

	• Short effectiveness period - Limited to days or weeks, requiring rapid progression to longer-term adaptation solutions. • Material dependency - Reliant on availability and appropriateness of locally available beach materials, which can vary widely in quality and quantity. • Ecological impacts - Potential disruption to shorebird habitats, marine biodiversity, or beach ecology requiring careful management and site-specific environmental assessments. • Social impacts - Possible odour, visual impact, or temporary disruption to beach access, recreational use, or aesthetics, necessitating effective community engagement. • Operational constraints - Limited access or machinery availability may restrict rapid response capability, particularly in remote or sensitive locations. • Uncertainty in outcomes - The opportunistic nature of this action introduces variability and uncertainty regarding its effectiveness and longevity.
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Project Title		Victor Harbor Seagrass Wrack and Sand Reuse	
Adaptation Action	Use of On-site Materials	 Example dune scarp in Victor Harbour (source Coast Protection Board)	
Location	Victor Harbor, South Australia		
Lead Agency	City of Victor Harbor		
Objective	Utilise locally sourced beach cast seagrass wrack mixed with sand as a cost-effective and sustainable coastal protection method to reduce erosion and maintain dune stability.		
Year of Implementation	Ongoing		
Design Features	• Use of seagrass wrack and sand mix - The council trialled a method of mixing naturally accumulated beach cast seagrass wrack with sand and placing it against erosion escarpments. • Dune reinforcement - The mixture helps dissipate wave energy, reduce erosion impacts, and improve dune resilience. • Vegetation support - As the wrack decomposes, it provides nutrients to support dune vegetation regrowth.		
Process	• Wrack and sand collection - Seagrass wrack was collected from the beach and mixed with sand. • Placement against erosion escarpments - The material was strategically placed to reinforce the dunes and provide a buffer against wave impact. • Monitoring and evaluation - The effectiveness of the trial was assessed in terms of erosion reduction and ecological impacts.		
Cost Estimate	Low-cost solution compared to traditional nourishment and revetments. Costs primarily associated with labour and machinery for collection and placement.		
Useful Resources and References	Information on Victor Harbour coastal management strategies is available at https://www.victor.sa.gov.au/notice-board/projects/completed-projects/coastal-adaptation-study-review		

5.1.5 Shellfish Reefs

Category	Details										
Adaptation Type	Protect - Nature-based solutions										
Adaptation Action	Shellfish Reefs										
Description	Shellfish reefs, typically established using oysters or mussels, serve as nature-based solutions to stabilise shorelines and reduce erosion by dissipating wave energy and trapping sediment (Scyphers, Powers, Heck, & Byron, 2011). These reefs can also enhance coastal ecosystems, providing habitat for marine biodiversity, improving water quality through filtration, and potentially supporting fisheries and local economies. Shellfish reef restoration involves creating suitable substrate conditions, introducing shellfish larvae or juveniles, and fostering reef establishment and growth (Beck, et al., 2011).  <i>Rock oyster shellfish reef (source: Francisco Martinez Baena)</i>										
Design Life	Highly dependent on ecological conditions										
Coastal Hazard Mitigation	<table border="0"> <tr> <td>☒ Short-term erosion</td><td>☐ Regular inundation</td></tr> <tr> <td>☒ Long-term erosion</td><td>☐ Terrestrial flooding</td></tr> <tr> <td>☐ Cliff erosion</td><td>☐ Saline intrusion</td></tr> <tr> <td>☐ Accretion</td><td>☐ Coastal Acid Sulfate Soils</td></tr> <tr> <td>☐ Storm tide flooding</td><td>☐ Sand drift</td></tr> </table>	☒ Short-term erosion	☐ Regular inundation	☒ Long-term erosion	☐ Terrestrial flooding	☐ Cliff erosion	☐ Saline intrusion	☐ Accretion	☐ Coastal Acid Sulfate Soils	☐ Storm tide flooding	☐ Sand drift
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☐ Cliff erosion	☐ Saline intrusion										
☐ Accretion	☐ Coastal Acid Sulfate Soils										
☐ Storm tide flooding	☐ Sand drift										
Suitability	- Suitable in sheltered estuarine or nearshore coastal environments with appropriate salinity and water quality conditions to support shellfish growth. - Particularly effective in regions seeking habitat restoration alongside erosion control.										

	Less suitable for highly energetic, exposed wave environments, or where water quality, temperature, or sedimentation conditions do not support reef survival or growth.
Likely Impact on Coastal Processes	Moderate - Reefs stabilise shorelines by dissipating wave energy, promoting sediment deposition, and reducing erosion rates. Ecological and hydrodynamic impacts are generally positive, enhancing habitat and biodiversity.
Implementation	Preparation/Design Period Detailed ecological and engineering assessments by qualified professionals are essential. Typically includes assessments of hydrodynamics, sediment transport, water quality, ecological suitability studies, selection of reef species, reef placement design, stakeholder consultations, and permitting processes. This progresses from preliminary ecological and hydrodynamic modelling to a refined, detailed final design suitable for implementation. Approvals A range of approvals may be required for shellfish reefs including: - Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016 & Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). - Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage and the <i>Native Title Act 1993</i> (Cth) where Native Title rights exist. - Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport. Design Considerations - Detailed ecological and hydrodynamic assessments to determine reef placement, size, shape, and material type. - Selection of appropriate shellfish species based on local environmental conditions, habitat suitability, and desired ecosystem services. - Reef design considering wave attenuation effectiveness, sediment trapping potential, and ecological connectivity. - Potential interactions with existing navigation, recreational activities, or commercial fisheries. - Monitoring plans to assess reef performance, ecological health, and coastal stabilisation outcomes.

	Costs Costs may include: • Site assessments and ecological studies. • Reef materials and deployment. • Regulatory approvals and monitoring costs. Challenges and Trade Offs • Ecological uncertainties - Reef establishment success depends on water quality, salinity, predation, disease risk, and environmental and climate-related impacts, requiring careful site selection and management. • Time required for reef establishment - Shellfish reefs typically take several years to fully establish, potentially limiting immediate coastal protection benefits. • Maintenance - Ongoing monitoring and management, including restocking, disease control, and sediment management, can increase long-term costs and resource demands. • Community acceptance and stakeholder engagement - Successful reef projects require broad community support and can be hindered by concerns regarding navigation hazards, access restrictions, or fisheries interactions. • Navigational and recreational trade-offs - Careful consideration must be given to reef locations to minimise conflicts with boating, fishing, or recreational activities. • Adaptability to climate change - Future changes in temperature, sea-level rise, salinity, or storm patterns may influence reef longevity and effectiveness, requiring adaptable design and management strategies.
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Project Title		Glenelg Shellfish Reef Restoration	
Adaptation Action	Shellfish Reefs	 <i>Shellfish reef off the coast of Adelaide (source: The Nature Conservancy Australia)</i>	
Location	Glenelg, Adelaide, South Australia		
Lead Agency	The Nature Conservancy (TNC) in partnership with the South Australian Government		
Objective	To restore native shellfish reefs off Adelaide's coast, enhancing marine biodiversity, improving water quality		
Year of Implementation	2020		
Design Features	• Reef construction - The project began with a 2-hectare reef constructed using limestone and recycled shells, expanded to 5 hectares in 2021. • Oyster seeding - Introduction of hatchery-raised Australian flat oysters (<i>Ostrea angasi</i>) to establish a living reef ecosystem.		
Process	• Site selection - Comprehensive assessments to identify suitable locations that support oyster growth and maximise ecological benefits. • Construction - Deployment of limestone and shell materials to create reef structures conducive to oyster colonisation. • Seeding - Release of juvenile oysters onto the reef to promote the development of a self-sustaining population. • Monitoring - Ongoing evaluation of reef health, oyster survival rates, and ecological impacts to inform management strategies.		
Cost Estimate	\$1.2 million		
Useful Resources and References	Information on the project is available at https://www.environment.sa.gov.au/topics/coasts/explore-and-learn/restoring-adelaides-lost-reefs		

5.2. Soft Engineering Solutions

5.2.1

Beach Nourishment, Configuration Dredging and Beach Scraping

Category	Details										
Adaptation type	Protect - Soft engineering solution										
Adaptation Action	Beach Nourishment, Configuration Dredging and Beach Scraping										
Description	Beach nourishment involves artificially placing sand onto beaches to restore beach width, protect coastal infrastructure, and maintain recreational and ecological functions. Configuration dredging refers to strategically dredging sediment from navigation channels, harbours, or accreting areas and relocating it to replenish eroding beaches. Beach scraping involves mechanically relocating sand from the lower beach or intertidal area to upper beach profiles or dunes, typically after storm events. Collectively, these actions manage sediment distribution, reduce erosion risk, and enhance coastal resilience.  <i>Tallebudgera Creek - Beach Nourishment Works (QLD)</i>										
Design Life	Ongoing										
Coastal Hazard Mitigation	<table border="0"> <tr> <td>☒ Short-term erosion</td><td>☐ Regular inundation</td></tr> <tr> <td>☒ Long-term erosion</td><td>☐ Terrestrial flooding</td></tr> <tr> <td>☐ Cliff erosion</td><td>☐ Saline intrusion</td></tr> <tr> <td>☐ Accretion</td><td>☐ Coastal Acid Sulfate Soils</td></tr> <tr> <td>☒ Storm tide flooding</td><td>☒ Sand drift</td></tr> </table>	☒ Short-term erosion	☐ Regular inundation	☒ Long-term erosion	☐ Terrestrial flooding	☐ Cliff erosion	☐ Saline intrusion	☐ Accretion	☐ Coastal Acid Sulfate Soils	☒ Storm tide flooding	☒ Sand drift
☒ Short-term erosion	☐ Regular inundation										
☒ Long-term erosion	☐ Terrestrial flooding										
☐ Cliff erosion	☐ Saline intrusion										
☐ Accretion	☐ Coastal Acid Sulfate Soils										
☒ Storm tide flooding	☒ Sand drift										
Suitability	Suitable for beaches experiencing chronic erosion or sediment deficits, particularly near valuable infrastructure, densely populated areas, or recreational assets.										

	• Ideal where ongoing sediment sources (e.g., offshore deposits, dredged material from navigation channels) are available, accessible, and environmentally suitable. • Less effective or practical in high-energy wave environments without protective structures, or where suitable sediment sources are unavailable or prohibitively costly.
Likely Impact on Coastal Processes	Moderate - Typically replicates natural sediment deposition processes, maintaining sediment budgets and coastal stability. However, the artificial nature and periodic interventions require ongoing management, monitoring, and potentially complementary measures to ensure effectiveness.
Implementation	Preparation/Design Period Detailed design by qualified coastal engineers or professionals is required. Typically involves sediment transport modelling, identification of suitable sediment sources and placement areas, environmental impact studies, and community consultation. This progresses from preliminary planning through detailed design, including methods, frequency, and volume of sediment placement or relocation.
	Approvals A range of approvals may be required for sand management including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993</i> (Cth), if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Sediment compatibility assessments, including grain size, composition, and ecological suitability. • Identification of sediment sources, including offshore deposits, dredge spoil, or intertidal extraction sites.

	• Modelling sediment transport and longevity of nourishment effects to optimise volume and frequency of sediment placement. • Consideration of design life and expected recurrence interval, including how long the nourishment is intended to provide protection and what storm event it is designed to withstand (e.g. 1% AEP event), and how frequently renourishment may be required. • Environmental assessments, particularly impacts on benthic habitats, marine biodiversity, water quality, and coastal ecology - for both source and deposition locations as well as transit routes. • Integration with existing coastal structures or complementary protective measures (e.g. groynes, breakwaters). • Stabilisation measures to reduce sand drift and improve retention of placed material. • Monitoring plans to evaluate effectiveness and inform management strategies for future interventions.
	Costs Costs may include: • Sand management design costs. • Sand sourcing and transport costs. • Regulatory approvals and environmental assessments • Machinery and labour for nourishment and dredging. • Stabilisation measures • Monitoring and ongoing maintenance.
	Challenges and Trade Offs • Limited lifespan and ongoing maintenance - Regular replenishment and sediment redistribution are often necessary, involving repeated costs and operational disruptions. • Sediment availability and quality - Finding compatible, sustainable, and ecologically appropriate sediment sources may be challenging, potentially limiting the effectiveness or longevity of nourishment projects particularly in the longer term as sea levels rise. • Ecological impacts - Sediment extraction, dredging, and placement activities can disrupt marine habitats, coastal ecosystems, and biodiversity, requiring thorough ecological assessment and ongoing monitoring. • Community acceptance - Nourishment activities can temporarily disrupt recreational access, alter beach aesthetics, and affect local marine habitats, potentially leading to community resistance if perceived negative impacts outweigh benefits. • Operational complexity and scheduling - Dredging and nourishment operations depend heavily on favourable weather, seasonal considerations, and equipment availability, making precise scheduling challenging and potentially causing disruptions to coastal amenity or activities

Project Title	Adelaide Beach Nourishment and Sand Management Strategy
Adaptation Action	Beach Nourishment, Configuration Dredging and Beach Scraping
Location	Adelaide, South Australia
Lead Agency	DEW
Objective	To maintain and enhance the health, accessibility, and resilience of Adelaide's metropolitan beaches by implementing a comprehensive sand management strategy that addresses coastal erosion and ensures sustainable beach environments.   <i>Sand transfer outlet (source: ABC)</i> <i>Tweed River bypass operations (source: SA Government)</i>
Year of Implementation	Ongoing since 1970's
Design Features	• Sand recycling - Regular movement of sand from areas of accumulation to areas experiencing erosion along the 28-kilometre coastline, effectively mimicking natural littoral drift processes. • Beach replenishment - Supplementing beaches with externally sourced sand, including quarry sand and dredged marine sand, to maintain beach width and protect coastal infrastructure. • Sand transfer infrastructure - Implementation of sand pumping systems, such as pipelines, to efficiently transport sand between different beach sections, reducing reliance on truck haulage.
Process	• Monitoring and assessment - Continuous monitoring of sand movement and beach profiles using hydrographic survey, cameras, drones, and visual inspections to inform management decisions. • Community engagement - Involving local communities and stakeholders in the planning and implementation of sand management activities to ensure transparency and address public concerns.

	• Monitoring - Regularly reviewing and adjusting sand management practices based on environmental monitoring data and community feedback to improve effectiveness.
Cost Estimate	>\$1,000,000 per year
Useful Resources and References	Further information is available at https://www.environment.sa.gov.au/topics/coasts/managing-adelaides-beaches

5.2.2 Sand Bypassing

Category	Details	
Adaptation Type	Protect - Soft engineering solution	
Adaptation Action	Sand Bypassing	
Description	Sand bypassing involves mechanically transferring sediment (sand) from areas of accumulation (updrift) to eroding shorelines (downdrift). This action mimics natural sediment transport processes disrupted by human-made coastal infrastructure such as jetties, harbours, or groynes. Sand bypassing helps maintain beach widths, protects coastal assets, reduces downdrift erosion, and preserves recreational amenity and ecological habitats by restoring sediment supply.	
Design Life	Ongoing	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☒ Accretion ☐ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☒ Sand drift	 <i>Mooloolah River sand bypassing (source: Slurry Systems Marine)</i>
Suitability	• Suitable in coastal areas experiencing significant disruption of natural sediment transport due to structures such as harbours, marinas or groynes. • Most effective in settings where sediment sources are reliable, easily accessible, and economically viable. • Less suitable in locations without a consistent sediment source or where the frequency or scale of sediment transfer would be economically unsustainable or ecologically harmful.	

Likely Impact on Coastal Processes	Moderate - Sand bypassing closely replicates natural sediment transport patterns, maintaining sediment budgets and minimising erosion impacts. However, regular intervention and ongoing management are required to avoid ecological or sediment transport disruptions.
Implementation	Preparation/Design Period Detailed design phase undertaken by qualified coastal engineers or professional is often necessary. This may involve sediment transport modelling, identification of source and receiving locations, engineering and logistical planning, environmental assessments, and stakeholder consultations. This design process progresses from preliminary assessments to detailed operational plans including sediment sourcing, transfer frequency, and operational management strategies.
	Approvals A range of approvals may be required for sand bypassing including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Detailed sediment transport modelling to understand local dynamics and determine optimal bypassing rates. • Identification and selection of sediment source and recipient sites. • Engineering design of sediment extraction, transport methods, and placement techniques. • Investigation and assessment of environmental impacts, particularly potential disruption to foreshore and benthic habitats, water quality, or ecological processes. • Integration with complementary actions such as dune management or nourishment projects.

	• Planning management strategies, including monitoring sediment budgets and adjusting bypass rates to changing coastal conditions.
	Costs Costs may include: • Infrastructure installation and machinery operation. • Engineering and environmental assessments and monitoring costs. • Regulatory approvals • Maintenance, operational and monitoring expenses.
	Challenges and Trade Offs • Ongoing operational requirements - Sand bypassing requires regular and potentially intensive management, including consistent monitoring, mechanical maintenance, and adaptation to changing coastal dynamics. • Ecological impacts - Regular sediment extraction and deposition can disrupt benthic habitats and coastal ecosystems, requiring careful ecological assessments, and potential mitigation measures. • Sediment sourcing and quality - Maintaining an adequate, environmentally appropriate sediment supply may be challenging, particularly if sediment characteristics vary, affecting beach stability or habitat quality. • Community and recreational impacts - Continuous or periodic mechanical operations may impact beach use, public access, or aesthetic qualities, potentially leading to community opposition or concerns requiring ongoing stakeholder engagement. • Cost-effectiveness and financial sustainability - Operational costs can be substantial, necessitating sustained funding and clear cost-benefit justifications compared to alternative adaptation strategies.

Project Title	Tweed River Entrance Sand Bypassing Project	
Adaptation Action	Sand Bypassing	 <i>Tweed river outlet (source: Queensland Government)</i>
Location	Tweed Heads, New South Wales, and Southern Gold Coast, Queensland, Australia	
Lead Agency	New South Wales and Queensland State Governments	
Objective	To maintain a safe, navigable entrance to the Tweed River and to restore and sustain the natural sand drift to the southern Gold Coast beaches, thereby mitigating coastal erosion and supporting beach amenity.	
Year of Implementation	1998 - Present	
Design Features	• Stage 1 - Dredging over 3 million cubic meters of sand from the Tweed River entrance to establish a navigable channel and nourish southern Gold Coast beaches. • Stage 2 - Installation and operation of a permanent sand bypassing system that captures sand from the southern side of the Tweed River entrance at Letitia Spit and pumps it under the river to outlets on the northern side. This system ensures continuous sand supply to beaches such as Snapper Rocks, Duranbah Beach, and Kirra Point.	
Process	• Planning and collaboration - The project is a joint initiative between the New South Wales and Queensland governments, addressing navigation safety and beach erosion issues resulting from the extension of Tweed River breakwaters in the 1960s. • Construction and operation - The permanent sand bypassing system became operational in 2001, featuring a sand collection jetty approximately 450 meters long with submerged jet pumps that create a sand-water slurry. This slurry is transported via a 5-kilometre pipeline to designated discharge points along the southern Gold Coast beaches. • Maintenance and monitoring - Regular dredging is conducted to maintain the navigability of the Tweed River entrance, complemented by continuous monitoring to adapt to coastal dynamics and ensure the effectiveness of sand distribution.	
Cost Estimate	Ongoing cost of ~\$6,000,000 per year	
Useful Resources and References	Further information is available at https://www.tweedsandbypass.nsw.gov.au/index.html	

5.3. Hard Engineering Solutions

5.3.1 Vertical Seawalls

Category	Details	
Adaptation type	Protect - Hard engineering solutions	
Adaptation Action	Vertical Seawalls	
Description	Vertical seawalls are engineered structures constructed parallel to the shoreline with a steep or vertical face, typically built from concrete, steel sheet piles, masonry, wooden piles, or other rigid materials. They act as robust physical barriers that directly absorb and reflect wave energy, protecting infrastructure, properties, and communities from coastal erosion, storm surge impacts, and flooding. Vertical seawalls are commonly employed in urbanised coastal settings or where land constraints restrict the use of more sloped structures such as revetments.	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 <i>Vertical seawall at Henley Beach (source: City of Charles Sturt)</i>
Suitability	• Suitable in urban coastal areas where space is limited and protecting infrastructure or high-value properties is a priority. • Suitable in low energy areas with minimal wave impact • Less suitable in ecologically sensitive areas, high energy or dynamic coastal systems experiencing substantial sediment movement, or locations where wave reflection and downdrift erosion could cause unacceptable impacts.	

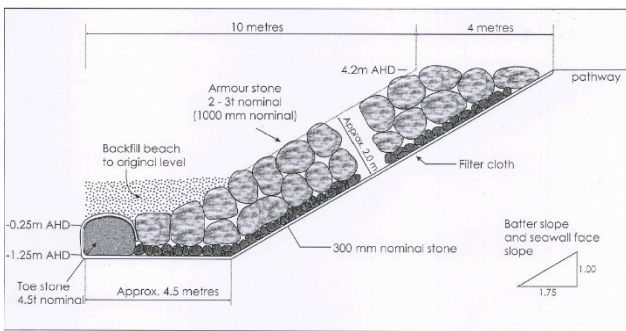
Likely Impact on Coastal Processes	High - Vertical seawalls significantly alter coastal processes by reflecting wave energy, often increasing localised erosion at the toe of the structure and potentially accelerating sediment loss from adjacent shorelines.
Implementation	Preparation/Design Period Detailed design by suitably qualified coastal engineers is required. Typically involves comprehensive assessments of wave climate and coastal dynamics, geotechnical studies, detailed structural engineering, environmental impact assessments, and stakeholder consultation. This process progresses from preliminary assessments to a detailed final design suitable for construction.
	Approvals A range of approvals may be required for the construction of a vertical seawall, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Comprehensive assessment of wave climate, including wave height, period, and storm surge scenarios. • Assessment of environmental impacts • Geotechnical evaluations to ensure foundation stability and prevent undermining. • Adequate crest height and structural design to minimise overtopping and flooding risks. • Material selection for durability, strength, and resistance to wave impact, abrasion, and corrosion. • Consideration of subsoil drainage and stormwater management behind the seawall to prevent waterlogging, pressure build-up and structural instability. • Integration with existing infrastructure, stormwater systems, and public access provisions.

	• Consideration of complementary beach nourishment or toe protection to mitigate potential erosion. • Provision for adaptability to future sea-level rise and changing wave conditions. • Consideration of incorporating nature-based design features such as a buried seawall or eco-hard structures (see Protect - Hybrid approach adaptation types below). Costs Costs may include: • Engineering assessments and design. • Construction materials and labour. • Regulatory approvals and environmental assessments. • Ongoing inspection, monitoring and maintenance. Challenges and Trade Offs • Downdrift erosion - Vertical seawalls reflect wave energy, often accelerating localised erosion of beaches and shorelines immediately adjacent or downdrift, necessitating complementary sediment management strategies such as beach nourishment. • Structural integrity and failure risk - Vertical seawalls can experience structural failure through undermining, scour, or wave impact damage, requiring robust design, frequent inspections, and proactive maintenance regimes. • Ecological impacts - Seawalls may displace natural coastal habitats, impede habitat migration, and disrupt ecological connectivity, requiring ecological assessments and possible mitigation or offsetting actions. • Community acceptance and aesthetics - Vertical seawalls can significantly alter coastal landscapes, potentially limiting beach accessibility, reducing recreational amenity, and causing visual intrusion, leading to possible community opposition. • Wave overtopping and safety - Wave overtopping during storms poses flooding and safety risks, necessitating careful design of crest height and ongoing management of risks to public safety and adjacent assets. • Long-term financial commitments - High upfront construction costs compared to softer approaches such as beach nourishment, along with significant ongoing maintenance, monitoring, and potential upgrades due to climate change impacts, require sustained financial commitment and planning.
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Project Title	Collaroy-Narrabeen Beach Vertical Seawall Construction
Adaptation Action	Vertical Seawalls
Location	Collaroy-Narrabeen Beach, Northern Beaches, Sydney, New South Wales, Australia
Lead Agency	Northern Beaches Council
Objective	To protect private properties and public infrastructure along Collaroy and Narrabeen beaches from severe coastal erosion and storm surges by constructing a vertical seawall, while maintaining beach accessibility and integrating with long-term coastal management strategies.  <i>Collaroy-Narrabeen Beach vertical seawall (source: nature.org)</i>
Year of Implementation	Construction commenced in 2016 and remains ongoing, with further extensions planned.
Design Features	• Vertical seawall - A 7-metre-high reinforced concrete wall constructed along the beachfront to provide erosion protection for properties vulnerable to storm events. • Foundations and stability - Deep foundations to prevent undermining from wave action and sand loss. • Public access integration - Incorporation of beach access points, pathways, and landscaping features to balance coastal protection with community use. • Aesthetic considerations - Sand-coloured facings and vegetation screens to integrate with the natural coastal environment.
Process	• Assessment and planning - Following the significant 2016 storm event that caused severe erosion and property damage, coastal engineers conducted extensive studies to determine the optimal design and location of the seawall. • Community consultation - Stakeholder engagement with affected residents, environmental groups, and local businesses to address

	concerns about aesthetics, long-term sustainability, and coastal processes. While consultation was undertaken, the project still faced significant and vocal community opposition, highlighting the importance of transparent communication and early involvement. • Approval process - Design compliance with the <i>Coastal Management Act 2016</i>, the NSW Coastal Zone Management Plan, and relevant planning regulations. • Construction - Phased implementation to minimise disruption, with sections of the seawall completed progressively as part of broader coastal resilience strategies. • Ongoing maintenance - Regular monitoring of structural integrity, sand movement, and potential impacts on adjacent unprotected beaches.
Cost Estimate	The project has been funded through a combination of contributions from private property owners, Northern Beaches Council, and the NSW Government. Estimated total cost of ~\$25,000,000
Useful Resources and References	Further information is available at northernbeaches.nsw.gov.au

5.3.2 Rock Revetments

Category	Details	
Adaptation Type	Protect - Hard engineering solutions	
Adaptation Action	Rock Revetments	
Description	A rock revetment is a sloped structure comprised of large rocks. They are designed to provide protection for assets or values from erosion and wave impacts by providing a robust barrier that absorbs and dissipates wave energy, reducing the impact on shorelines and built structures. Generally, rock revetments are comprised of a core layer, underlayer and armour layer of rock.	
Design Life	25+ years, dependent on design intention	 Brighton Beach rock revetment during a storm  Example rock revetment seawall cross section.
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	
Suitability	- Suitable for coastlines with vulnerable assets where the impact of storms or ongoing recession is not tolerable and cannot be mitigated by softer alternatives. - Effective in areas where the revetment can tie into natural hard features such as headlands or cliffs.	

	• Effective in locations requiring robust, long-term protection for infrastructure, roads, or public facilities exposed to high wave energy or erosion. • Less suitable in natural or ecologically sensitive environments where hard structures may disrupt coastal processes, limit public access, or cause downdrift impacts.
Likely Impact on Coastal Processes	High - Can significantly alter sediment transport and wave reflection patterns, potentially leading to substantial edge effects, downdrift erosion and changes to adjacent shoreline stability.
Implementation	Preparation/Design Period A coastal engineer is required to develop the design of the rock revetment. Typically, this involves an assessment of metocean conditions, followed by a preliminary design to be refined into detailed design.
	Approvals A range of approvals may be required for the construction of a rock revetment, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Understanding of geotechnical characteristics of the area. • Assessment of impacts to coastal processes including potential edge effects and downdrift impacts. • Assessment of environmental impacts, including the areas seaward, landward and downdrift of the revetment. • Availability of suitable rock supply and associated design implications. • Ensure adequate toe protection to prevent undermining and structural failure.

	• Ensure adequate crest height and width based upon acceptable overtopping of the seawall. • Impact of proposed seawall footprint on beach widths and existing environment. • Consider the need for beach nourishment if required to maintain natural sediment transport and beach width. • Utilise appropriately sized rock materials to prevent displacement during storm events. • Consideration of incorporating nature-based design features such as a buried seawall (see Protect - Hybrid approach adaptation types below). • Design for adaptability to future sea level rise and changing wave dynamics.
	Costs Costs may include: • Engineering and Environmental assessments and design. • Rock source and supply. • Approvals. • Construction methodology and constraints including access. • Sand nourishment to maintain beach widths in areas subject to erosion induced by the seawall. • Maintenance of the seawall post storms (dependent on adopted damage criteria).
	Challenges and Trade Offs • Erosion and changes to coastal dynamics - Reflected wave energy can accelerate sand loss, leading to upper beach erosion and potential edge effects and downdrift impacts on adjacent shorelines. • Access and aesthetics - Revetments create a physical barrier, altering the natural look of the coastline, restricting beach access, and preventing habitat migration. • Safety concerns - Large rock voids, sharp edges, and elevation differences during storm erosion pose risks to beach users. • Ecological impacts - Placement may impact nearshore and intertidal habitats, potentially disrupting local ecosystems and requiring careful ecological management and mitigation strategies. • Ongoing maintenance - Regular upkeep and potential upgrades are necessary to sustain structural integrity and effectiveness over time. • Asset protection vs beach loss - While revetments safeguard infrastructure, they may contribute to beach narrowing or loss, requiring a balance between protection, social and environmental values. • Accepted damage vs capital cost - In the design process of a rock revetment the level of acceptable damage needs to be considered, if occasional damage (and associated repair costs) can be tolerated, capital costs can be reduced with a scaled down design.

Project Title	Wyomi Beach Seawall (Stage 2)	
Adaptation Action	Vertical Seawalls	
Location	Wyomi Beach, South Australia	
Lead Agency	Kingston District Council	
Objective	Address chronic erosion threatening homes and roads.   <i>Wyomi Beach prior to construction of Stage 2 seawall (source: Patrick Hesp 2021)</i> <i>Wyomi Beach seawall under construction</i>	
Year of Implementation	2022 - Present	
Design features	350-metre rubble mound seawall extension to existing seawall.	
Process	• Site assessments and community engagement. • Rock sourced locally to minimise transport costs. • Integrated dune revegetation for added resilience.	
Cost Estimate	\$2.6 million	
Useful Resources and References	Fact sheets, including adaptation pathways considered, technical considerations and community engagement is available from the Kingston District Council website. https://www.kingstondc.sa.gov.au/our-services/major-projects/wyomi-beach-seawall-stage2-project	

5.3.3 Geobags

Category	Details	
Adaptation type	Protect - Hard engineering solutions	
Adaptation Action	Geobags	
Description	Geobags are durable, UV-resistant geotextile fabric bags filled with sand used for shoreline stabilisation and erosion control. Sometimes utilised as temporary measures, geobags provide a flexible and cost-effective alternative to traditional rock revetments, particularly for rapid deployment in coastal areas experiencing active erosion, storm impacts, or emergency situations. Geobags dissipate wave energy effectively, reducing erosion and protecting coastal assets, infrastructure, and sensitive ecosystems until more permanent solutions are implemented or site conditions stabilise.	
Design Life	5+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 (source: geofabrics)
Suitability	• Suitable for sites requiring rapid response to erosion threats, emergency protection, temporary stabilisation measures, or where traditional rock-based structures are impractical due to limited site access, environmental sensitivity, or budget constraints. • Less suitable as a permanent long-term protection measure in areas of high wave energy or significant ongoing erosion due to lower durability compared to traditional structures.	
Likely Impact on Coastal Processes	Moderate to high - geobags effectively dissipate wave energy, reducing local erosion, but their flexibility can allow movement or displacement under high-	

	energy conditions. They may cause localised sediment transport changes and downdrift impacts requiring ongoing monitoring.
Implementation	Preparation/Design Period Detailed design by qualified coastal engineers is necessary. Typically includes assessments of local wave, sediment, and erosion conditions, preliminary design considerations, material selection, environmental assessments, and community consultation. Final detailed design will refine placement, size, material selection, and integration into broader coastal management strategies.
	Approvals A range of approvals may be required for the installation of geobags, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Selection of durable, UV-resistant geotextile fabric appropriate for site conditions. • Consideration of design life • Crest height and toe depth. • Optimal sizing, arrangement, and filling of geobags to maximise stability and wave energy dissipation. • Geotechnical considerations to ensure anchoring and structural stability. • Assessment of local sediment dynamics and potential downdrift impacts. • Assessment of environmental impacts • Accessibility of site for installation equipment and machinery and ongoing maintenance. • Consideration of incorporating nature-based design features such as a buried seawall (see Protect - Hybrid approach adaptation types below). • Suitable sediment source

	Costs Costs may include: • Geotextile materials and sediment sourcing. • Design, engineering, and environmental assessments. • Regulatory approvals • Costs associated with site preparation, transportation, placement, and anchoring. • Regular inspection, maintenance, and potential replacement following storm events. Potential complementary sediment management or beach nourishment actions to address downdrift impacts. Challenges and Trade Offs • Durability and maintenance - geobags are susceptible to damage from UV exposure, abrasion, vandalism, or displacement during storms, requiring regular inspections, repairs, and replacements, adding to ongoing operational and maintenance costs. • Ongoing maintenance - As with other forms of revetment, performance and durability depend on using appropriately sized and placed materials or bags. Regular inspections and maintenance are required to ensure long-term stability, especially following storm events or periods of high wave energy. • Ecological impacts - Placement may impact nearshore and intertidal habitats, potentially disrupting local ecosystems and requiring careful ecological management and mitigation strategies. • Environmental impacts - Geotextile fabrics may contribute to microplastic pollution. The fabric may degrade over time, particularly under UV exposure and wave action and abrasion, releasing microplastic particles into the environment. Tides and wind can then transport these microplastics to the ocean. • Community acceptance and visual impacts - geobags may negatively affect coastal aesthetics and recreational access, potentially causing community opposition, necessitating careful engagement and communication. • Sediment management - Potential localised impacts on sediment transport, downdrift erosion, or accretion may require complementary interventions such as beach nourishment or sediment bypassing. • Cost-effectiveness considerations - While initially cost-effective and rapidly deployable, ongoing maintenance and regular replacement may lead to higher overall long-term costs compared to more permanent structures.
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Project Title	Ettalong Point Geotextile Sand Container Seawall		
Adaptation Action	Geobags	 <i>Ettalong Point geotextile sand container seawall (source: Geofabrics)</i>  <i>Ettalong Point geotextile sand container seawall (source: Geofabrics)</i>	
Location	Ettalong Point, New South Wales, Australia		
Lead Agency	Central Coast Council		
Objective	To protect The Esplanade roadway and adjacent infrastructure from coastal erosion exacerbated by storm events.		
Year of Implementation	2015		
Design Features	Installation of a 100-metre-long seawall using 2.5 cubic meter Elcorock geotextile sand containers.		
Process	• Storm impact assessment - Following a major storm event in 2015 that caused significant erosion at Ettalong Point, threatening The Esplanade roadway. • Design and implementation - The Water Research Laboratory of UNSW Sydney designed the seawall, which was constructed by council crews using Elcorock units. • Monitoring - A comprehensive monitoring program was implemented to assess the seawall's performance and effectiveness.		
Cost Estimate	Unknown		
Useful resources and references	Project sheet available from https://www.geofabrics.co/news/safer-coastal-roads-elcorock-sand-containers		

5.3.4 Rock Bags

Category	Details	
Adaptation Type	Protect - Hard engineering solutions	
Adaptation Action	Rock Bags	
Description	Rock bags are engineered, mesh bags filled with rocks or aggregate material, used to stabilise shorelines and provide immediate erosion protection. These structures serve as flexible alternatives to conventional rock revetments, dissipating wave energy, preventing erosion, and protecting coastal infrastructure. Rock bags are typically employed in temporary or semi-permanent settings, as they allow for easier placement, removal, and adaptation compared to rigid structures.	
Design Life	10+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☐ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 (source: RockBags)
Suitability	• Suitable for locations requiring rapid deployment of erosion protection measures or where conventional hard structures (e.g., seawalls, revetments) are impractical due to site constraints, limited access, or budget restrictions. • Particularly useful as temporary measures or in emergency situations. • Less suitable for long-term coastal protection where high wave energy or significant ongoing erosion exists, as rock bags have lower durability than traditional hard structures.	

Likely Impact on Coastal Processes	Moderate to high - Rock bags dissipate wave energy and reduce local erosion effectively, but their relatively flexible structure can allow minor movement, possibly affecting adjacent sediment dynamics. Regular monitoring and maintenance are required to manage localised impacts.
Implementation	Preparation/Design Period Design by qualified coastal engineers is required. Typically, this involves an assessment of local wave and sediment conditions, preliminary engineering design, selection of appropriate geotextile and fill material, environmental assessments, and community or stakeholder consultation. This phase then progresses into detailed final design and planning.
	Approvals A range of approvals may be required for the installation of rock bags, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design considerations • Assessment of coastal processes and environmental impacts • Selection of bag material appropriate to withstand local wave energy, UV exposure, and abrasion. • Optimal sizing and arrangement of rock bags to effectively dissipate wave energy and minimise displacement. • Availability and sourcing of suitable rock or aggregate fill material • Geotechnical assessment for stability and anchoring, where required. • Consideration of potential downdrift erosion or sediment accumulation and integration with complementary management actions. • Accessibility to site for installation equipment and machinery

	Costs Costs may include: • Engineering and environmental assessments and design • Materials and rock bag preparation costs. • Installation labour and machinery. • Regulatory approvals and monitoring. • Maintenance and inspection costs. • Removal and disposal costs Challenges and Trade Offs • Durability and lifespan - Rock bags have a relatively limited lifespan compared to traditional hard structures, requiring regular inspections, maintenance, and periodic replacements, particularly following storms or periods of high wave activity. • Structural stability - Susceptibility to displacement or damage from high wave energy or storm events may necessitate frequent adjustments or repairs, increasing operational costs and resource demands. • Environmental impacts - Materials used for the rock bags may contribute to microplastic pollution. The material may degrade over time, particularly under UV exposure and wave action and abrasion, releasing microplastic particles into the environment. Tides and wind can then transport these microplastics to the ocean. • Ecological impacts - Placement of rock bags may alter nearshore habitats, potentially affecting local ecosystems, requiring careful ecological assessment and possible mitigation strategies. • Visual and recreational impacts - Changes to the aesthetic qualities of shorelines and potential impacts on beach access or recreational use, possibly resulting in community opposition or concerns. • Downdrift sediment impacts - Potential changes to local sediment transport dynamics, possibly requiring complementary interventions such as beach nourishment or sediment management. • Temporary vs. permanent solutions - Although flexible and easier to install, rock bags may represent a less cost-effective long-term solution compared to traditional hard protection methods, necessitating careful long-term planning and budgeting.
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Project Title	Wamberal Beach Coastal Erosion Protection	
Adaptation Action	Rock Bags	
Location	Wamberal Beach, New South Wales, Australia	
Lead agency	Central Coast Council	
Objective	To mitigate severe coastal erosion threatening residential properties and infrastructure along Wamberal Beach by implementing sustainable and effective shoreline stabilization measures.	
Year of Implementation	2020	
	 <i>Wamberal Beach rock bags during installation (source: RockBags)</i>  <i>Wamberal Beach rock bags following installation and backfill (source: RockBags)</i>	
Design Features	• Rock bag installation - Deployment of Kyowa Rock Bags, flexible mesh nets filled with rocks, to create a protective barrier against wave action and prevent further shoreline erosion. • Flexibility and durability - The Rock Bags' design allows them to conform to the seabed's contours, providing stability and resilience against harsh marine conditions.	
Process	• Emergency response - In response to significant erosion events in 2020, the Central Coast Council initiated emergency works to protect beachfront properties. • Rock bag deployment - Kyowa Rock Bags were strategically placed along the most vulnerable sections of Wamberal Beach to serve as a temporary protective measure against ongoing erosion.	

	• Monitoring and assessment - Continuous monitoring was conducted to evaluate the effectiveness of the Rock Bags in stabilising the shoreline and to inform future long-term coastal management strategies.
Cost Estimate	Approximately \$1 million
Useful Resources and References	Information on the wider project is available at https://www.yourvoiceourcoast.com/wamberal-beach-terminal-protection-and-sand-nourishment

5.3.5 Groynes

Category	Details	
Adaptation Type	Protect - Hard engineering solutions	
Adaptation Action	Groynes	
Description	Groynes are structures built perpendicular to the shoreline, designed to manage coastal erosion by capturing and stabilising sediment transported alongshore. Constructed from robust materials such as rock, concrete, geobags, or timber, groynes extend from the shore into the water, trapping sand on their updrift side to build or maintain beach width. This stabilisation reduces erosion and protects coastal assets, recreational areas, and ecological habitats located behind and adjacent to the groyne structures.	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☒ Accretion ☐ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 <i>Groyne at City Beach in Perth (source: Surf Life Saving Western Australia)</i>
Suitability	• Suitable for sandy coastlines with consistent sediment transport. • Best implemented where maintaining beach width is critical. • Less effective or appropriate in areas with minimal sediment transport or where downdrift impacts cannot be adequately managed.	
Likely Impact on Coastal Processes	High - Groynes significantly influence sediment transport, potentially causing erosion downdrift if sediment supply is limited or incorrect design. Careful management and potentially complementary strategies (e.g., beach nourishment) are essential to mitigate these effects.	
Implementation	Preparation/Design Period	

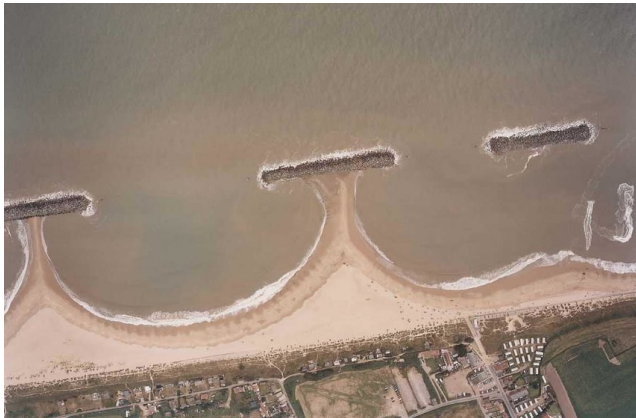
	Following an options assessment that results in the decision to build groynes, a suitably qualified engineer or practitioner should develop the groyne design. Typically, this involves an assessment of metocean conditions, followed by a preliminary design that is refined into a detailed design. Approvals A range of approvals may be required for the construction of groynes, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport. Design Considerations • Understanding of geotechnical characteristics of the area • Assessment of impacts to coastal processes. • Assessment of environmental impacts • Availability of suitable construction materials supply and associated design implications. • Determining optimal groyne length, height, and spacing to effectively manage sediment transport. • Ensuring structures are adaptable to future sea level rise and changing wave dynamics. • Integration with complementary actions such as beach nourishment. • Utilise appropriately sized rock materials to prevent displacement during storm events. Costs Costs may include: • Construction materials source and supply. • Coastal processes and environmental assessments.
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	• Design. • Approvals. • Construction methodology and constraints including access. • Sand nourishment or bypassing to maintain beach widths in areas subject to erosion induced by the groynes. • Maintenance of the groynes post storms (dependent on adopted damage criteria).
	Challenges and Trade Offs • Downdrift erosion - Trapped sediment can lead to erosion downdrift, potentially causing negative impacts on adjacent shorelines, necessitating complementary actions such as beach nourishment. • Altered coastal aesthetics and access - Groynes change coastal landscape aesthetics and can restrict public beach access, altering recreational opportunities and impacting community acceptance. • Ecological impacts - Groynes may disrupt local ecosystems by altering habitat distribution, affecting coastal and marine biodiversity, and requiring ecological assessments and mitigation strategies. • Maintenance requirements - Regular monitoring and maintenance are essential to maintain functionality and structural integrity over time, resulting in ongoing costs. • Balance between asset protection and coastal values - While groynes protect infrastructure, there may be trade-offs with beach narrowing, downdrift impacts, and possible loss of natural beach areas, necessitating careful planning and stakeholder negotiation. • Cost and damage acceptance - The capital cost of groynes can vary based on design robustness, materials and location. Accepting minor downdrift impacts may reduce initial costs but requires ongoing management and stakeholder engagement to address community concerns

Project Title	Beachport Groyne Field
Adaptation Action	Groynes
Location	Beachport, South Australia
Lead Agency	Wattle Range Council
Objective	To mitigate coastal erosion and stabilise the shoreline by constructing rock groynes along the town beaches of Beachport.  <i>Aerial imagery of part of the Beachport groyne field (source: Google Earth)</i>
Year of Implementation	1940's with ongoing modifications and extensions in subsequent decades
Design features	• Rock groynes - Installation of multiple rock groynes perpendicular to the shoreline to trap sand moving along the coast, thereby widening the beach on the updrift side. • Beach realignment -The groynes have realigned the beaches to face southeast, effectively managing the wave energy and reducing erosion.
Process	• Initial construction - Beginning in the 1940s, rock groynes were constructed to address ongoing erosion issues. • Modifications and extensions - Over the years, the groynes have been modified, added to, and extended based on continuous monitoring and assessment of their effectiveness.

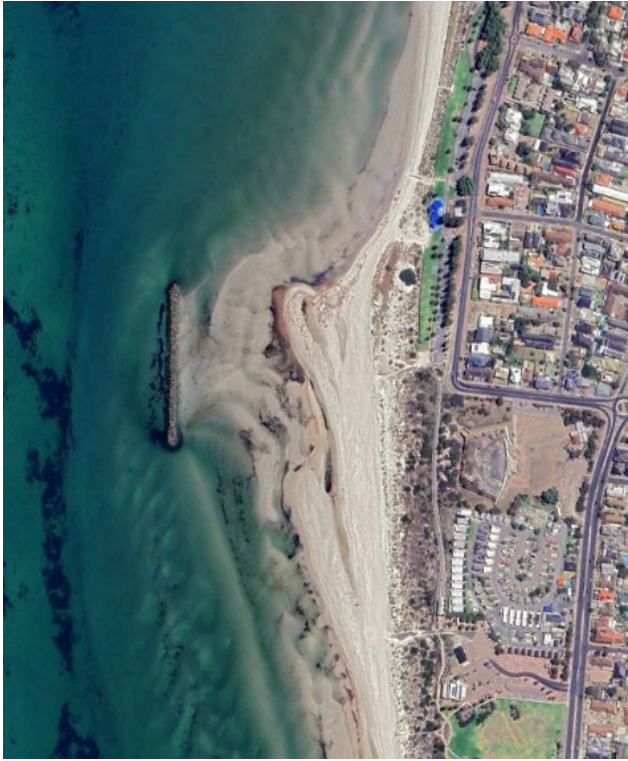
	• Sand management plan - A plan was developed to manage sand accumulation and distribution, ensuring the groynes function effectively without causing adverse effects on adjacent beach areas.
Cost Estimate	Cost unknown
Useful Resources and References	A number of coastal studies are available from the Wattle Range Council website https://www.wattlerange.sa.gov.au/living-here/our-environment/coastalmanagement

5.3.6 Breakwaters

Category	Details	
Adaptation Type	Protect - Hard engineering solutions	
Adaptation Action	Breakwaters	
Description	Breakwaters are offshore structures constructed parallel or angled relative to the shoreline, designed primarily to reduce wave energy reaching the coast and thus mitigate coastal erosion. Offshore breakwaters for coastal hazard management typically stabilise beaches, create sheltered waters for ecosystems or recreational use, and protect shoreline infrastructure. Breakwaters used in ports and navigation contexts, however, primarily facilitate safe navigation, provide shelter for vessels, and protect infrastructure within harbours and marinas. Both types are usually constructed from rock, concrete units, or other durable materials, but the placement, scale, and specific design criteria differ significantly based on their intended function. They may also be constructed from materials such as geobags or tubes and, in some cases, used for purposes other than coastal hazard protection, such as enhancing surf conditions or supporting ecological features like seagrass beds.	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☐ Cliff erosion ☒ Accretion ☒ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 <i>Detached breakwaters forming salients and tombolos (source: (Brew, Guthrie, McArthur, & Williams, 2005))</i>
Suitability	• Suitable for exposed coastlines facing significant wave-induced erosion threats. • Appropriate for areas requiring sediment retention and beach stabilisation, especially near valuable coastal infrastructure or recreational amenities.	

	Breakwaters within ports and harbours are more suitable for navigation protection and sheltering vessels but have limited direct relevance to broader coastal erosion management.
Likely Impact on Coastal Processes	High - Offshore breakwaters significantly alter wave patterns, affecting sediment transport and shoreline dynamics. Comprehensive monitoring and complementary measures such as beach nourishment are often necessary.
Implementation	Preparation/Design Period Detailed design by suitably qualified engineers is required. Typically, this involves extensive hydrodynamic and sediment transport modelling, environmental assessments, and stakeholder consultations.
	Approvals A range of approvals may be required for the construction of a breakwater, including: - Land Owner's consent. - Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). - Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. - Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations - Comprehensive metocean and geotechnical assessments. - Optimisation of breakwater alignment, length, height, and configuration. - Material selection considering local availability, durability, ecological impacts, and aesthetics. - Impact analysis on sediment transport, including potential erosion or accretion at adjacent shorelines. - Assessment of environmental and ecological impacts and habitat preservation or enhancement opportunities. - Adaptive design to address future sea level rise and changing wave climates.

	Costs Costs may include: • Material sourcing and supply. • Design and engineering assessments. • Environmental assessments • Approvals and consultation processes. • Construction methodology and site accessibility. • Complementary beach nourishment to manage sediment impacts. • Ongoing monitoring and maintenance. Challenges and Trade Offs • Downdrift impacts - Breakwaters alter wave and sediment transport, potentially causing significant downdrift erosion and accretion. This can require additional interventions such as beach nourishment or secondary structures to manage these effects. • Ecological impacts - Significant changes to local marine and coastal habitats and ecosystems, including the alteration of nearshore habitats, potentially affecting marine life and requiring thorough environmental assessments and mitigation strategies. • Safety and navigation - Structures can create hazards for navigation or recreational users, requiring careful consideration of location, marking, and ongoing risk management. • Ongoing maintenance - High ongoing costs for structural integrity, repairs, monitoring, and sediment management, requiring consistent budget and resource allocation. • Community acceptance and aesthetics - Visual impacts on coastal landscapes and potential limitations to beach accessibility or recreational uses, influencing local acceptance and support. • Balancing protection and environmental considerations - Effectively balancing the protection of assets and property against potential negative environmental impacts, including loss of natural habitat and recreational opportunities. • Adaptability to future conditions - Designing structures adaptable to future sea-level rise, climate change impacts, and evolving coastal processes, increasing complexity and potential initial costs.
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Project Title	Semaphore Breakwater
Adaptation Action	Breakwaters
Location	Semaphore South, Adelaide, South Australia
Lead Agency	DEW, South Australia
Objective	To mitigate coastal erosion and stabilise the shoreline by constructing a breakwater designed to trap sand.  <i>Aerial imagery of part of the Semaphore Breakwater (source: Google Earth)</i>
Year of Implementation	2004
Design Features	• Breakwater structure - An offshore rock breakwater situated approximately 200 meters from the shoreline at the southern end of Semaphore Beach. • Sand accumulation - Designed to trap approximately 50,000 cubic meters of sand annually, serving as a source for replenishing eroded beaches further south.

Process	• Construction - The breakwater was constructed to address ongoing erosion issues by capturing sand moving along the coast. • Sand management - The accumulated sand is periodically harvested and transported to replenish beaches experiencing erosion, such as West Beach.
Cost Estimate	N/A
Useful Resources and References	Information on Adelaide's beach management is available at https://www.environment.sa.gov.au/topics/coasts/managing-adelaides-beaches

5.3.7 Levees

Category	Details	
Adaptation Type	Protect - Hard engineering solutions	
Adaptation Action	Levees	
Description	Earth levees are engineered embankments constructed primarily from compacted earth materials, parallel to shorelines or waterways. Their primary purpose is to prevent flooding by containing or diverting rising water during storm events and high tides. Earth levees protect communities, agricultural lands, critical infrastructure, and natural habitats by reducing flood risk and minimising damage from coastal flooding and storm surges. They can also be constructed from other materials, such as rock or geotextile-reinforced fill, and may be combined with other protection measures like rock revetment to improve erosion resistance.  <i>Levee section at Thompson Beach (source: https://www.thompsonbeach.info/)</i>	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☐ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding	☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift
Suitability	Effective in low-lying and low energy coastal regions subject to regular inundation or significant storm tide impacts. Suitability may depend on the levee type, with earthen levees more appropriate for stable ground conditions and low energy environments.	

	• Suitable for protecting critical infrastructure, urban areas, or agricultural land where the relocation or retreat of these assets is impractical or economically unviable. • Not suitable where ecological impacts are unacceptable. • Not suitable for highly dynamic coastlines or in areas subject to ongoing erosion or unstable sediment dynamics unless combined with complementary measures.
Likely Impact on Coastal Processes	Moderate - Levees can significantly alter local hydrology by restricting natural water flow and potentially impacting groundwater levels, drainage patterns, and adjacent habitats.
Implementation	Preparation/Design Period Detailed design and planning by qualified engineers are required. Potentially involves hydrological and hydraulic modelling, geotechnical assessments, environmental impact studies, and stakeholder consultation.
	Approvals A range of approvals may be required for the construction of earth levees, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Geotechnical investigations for soil stability and risk of levee failure. • Hydrological and hydraulic investigations including groundwater • Environmental assessments and consideration of incorporating nature-based design features e.g. vegetation • Appropriate crest height accounting for future sea-level rise and storm surge scenarios. • Effective drainage solutions to manage seepage and runoff behind the levee.

	• Integration of levees with existing or planned infrastructure (e.g., roads, drainage systems, floodgates). • Environmental assessments to determine potential impacts and mitigation measures and incorporate ecological enhancements where possible. • Consideration of levee alignment and footprint to minimise impacts on existing land uses and ecosystems. Investigation and consideration of materials and incorporating additional protection/design measures to improve effectiveness and minimise impact (e.g. Incorporate rock revetment to reduce erosion, include design features to avoid/minimise dispersal of clay into the marine environment).
	Costs Costs may include: • Engineering assessments and design. • Construction materials and installation. • Regulatory approvals and environmental assessments. • Monitoring, maintenance and operational costs.
	Challenges and Trade Offs • Altered hydrology and ecological impacts - Levees disrupt natural drainage patterns, potentially affecting groundwater recharge, wetland dynamics, and habitat connectivity, requiring ecological assessments and mitigation measures. • Risk of failure and safety - Poorly constructed or inadequately maintained levees can fail, posing significant risks to protected communities and infrastructure, necessitating rigorous engineering standards, ongoing inspections, and maintenance. • Community acceptance and aesthetics - The visual and landscape impacts of levees can trigger opposition from local communities due to reduced recreational access, altered views, and loss of natural aesthetics, requiring community engagement and careful design considerations. • Asset protection versus environmental and social costs - Balancing asset protection and economic benefits against potential negative impacts, such as displacement of ecosystems, loss of recreation opportunities, and restricted coastal access, requires careful decision-making. • Flood management and internal drainage - Levees may exacerbate inland flooding by restricting rainfall runoff drainage, necessitating additional investments in pumping stations and drainage infrastructure.

Project Title	Barker Inlet Central Stormwater Management Plan - Levee Construction	
Adaptation Action	Levees	
Location	Barker Inlet, Adelaide, South Australia	
Lead Agency	City of Port Adelaide Enfield	
Objective	To mitigate flood risks in the Barker Inlet region by constructing levees along both sides of the channel from Grand Junction Road to approximately Myuna Street, thereby protecting surrounding communities and infrastructure from stormwater flooding.	 <i>Aerial imagery of part of the levees in Barker Inlet (source: Google Earth)</i>
Year of Implementation	TBC	
Design Features	• Levee construction - Building levees on both sides of the channel extending from Grand Junction Road to approximately Myuna Street, covering a distance of 470 meters.	
Process	• Planning and design - Development of the Barker Inlet Central Stormwater Management Plan, which includes the levee construction as a key component to address stormwater management and flood mitigation in the area. • Approvals and funding - Securing necessary approvals and funding to proceed with the levee construction as outlined in the stormwater management plan. • Construction - Execution of the levee construction project as per the detailed designs and specifications.	
Cost Estimate	~\$1,000,000	
Useful Resources and References	Details on the proposed levee construction and overall stormwater management strategies can be found at: https://www.cityofpae.sa.gov.au/_data/assets/pdf_file/0025/1584205/PAE-stormwater-management-plan-barker-inlet-central.pdf	

5.3.8 Tidal Barriers

Category	Details
Adaptation Type	Protect - Hard engineering solutions
Adaptation Action	Tidal Barriers
Description	Tidal barriers are engineered structures designed to control or restrict tidal flows and storm surge flooding into estuaries, rivers, or coastal embayments. Typically comprising gates, sluices, or other movable barriers built into embankments or causeways, tidal barriers close during storm events or high tides to prevent flooding, protecting low-lying inland areas, communities, and critical infrastructure from flooding.  <i>Then 'Maeslant Barrier' in the Netherlands (source: Rijkswaterstaat)</i>
Design Life	25+ years, dependent on design intention
Coastal Hazard Mitigation	☐ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☒ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift
Suitability	• Effective in coastal areas with clearly defined entry points for tidal waters, such as estuaries, lagoons, rivers, or tidal inlets.

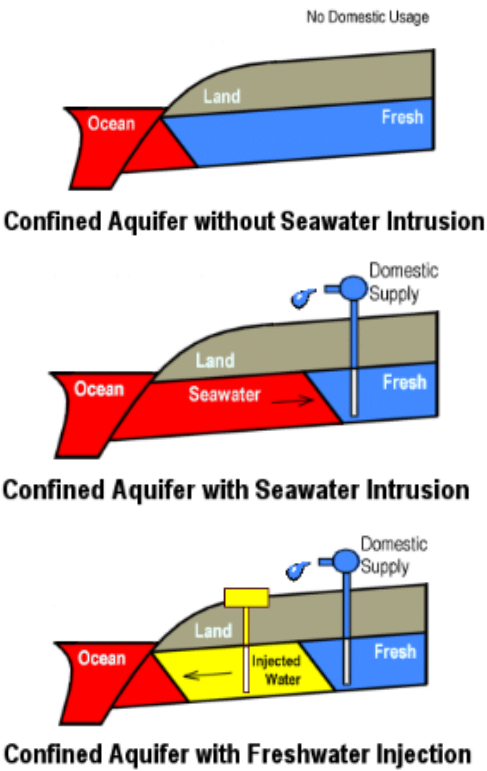
	• Suitable in urbanised or agriculturally productive regions where the economic and social costs of inundation justify significant investment. • Less suitable where ecological impacts, disruption to sediment transport, fish migration, or navigation cannot be effectively mitigated.
Likely Impact on Coastal Processes	High - Tidal barriers significantly alter tidal flow patterns, sediment dynamics, and ecological connectivity, potentially leading to sediment accumulation, habitat loss, water quality changes, and impacts on fisheries and biodiversity.
Implementation	Preparation/Design Period Detailed design and planning by qualified engineers are required. Potentially involves hydrological and hydraulic modelling, geotechnical assessments, environmental impact studies, and stakeholder consultation.
	Approvals A range of approvals may be required for the construction of tidal barriers, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design considerations • Detailed tidal and hydrodynamic modelling to accurately predict operational performance and environmental impacts. • Design of gates, sluices, or barriers ensuring operational reliability, durability, and ease of maintenance. • Detailed investigations of ecological impacts, particularly on fish migration, estuarine habitat connectivity, and water quality. • Integration with existing coastal infrastructure and urban drainage systems. • Mechanisms for sediment management to avoid undesirable accumulation or erosion patterns.

	• Provision for navigation channels, where necessary, including operational schedules or locks. • Adaptive features to accommodate future sea-level rise and increased storm intensity.
	Costs Costs may include: • Engineering design and modelling. • Environmental assessments. • Construction and installation costs. • Regulatory approvals. • Monitoring, maintenance and operational monitoring.
	Challenges and trade offs • Ecological impacts - Tidal barriers significantly alter estuarine and riverine ecosystems, impacting fish migration, sediment transport, biodiversity, water quality, hydrology and habitat health, requiring extensive ecological mitigation or compensation strategies. • Sediment accumulation and erosion - Altered tidal regimes may lead to unwanted sediment deposition or erosion, requiring regular dredging or sediment management interventions. • Operational complexity and reliability - Reliable operation during extreme weather events is critical; mechanical failure or incorrect operation could lead to catastrophic flooding, requiring robust maintenance and management systems. • Community acceptance and visual impacts - Tidal barriers can substantially alter coastal aesthetics, disrupt local recreational activities, and impact local community identity, requiring substantial community consultation and landscape-sensitive designs. • Navigation impacts - Barriers may impede navigation for recreational or commercial vessels, requiring careful planning, navigational infrastructure (e.g., locks), or operational schedules to minimise disruption. • Long-term costs and commitment - Substantial initial investment and long-term operational costs require ongoing funding commitments, potentially diverting resources from other adaptation measures.

Project Title	Barker Inlet Tidal Gates Upgrade
Adaptation Action	Tidal Barriers
Location	Barker Inlet, Adelaide, South Australia
Lead Agency	City of Port Adelaide Enfield
Objective	To reduce localised flooding in adjacent industrial areas by installing new tidal gates in the Barker Wetlands, which create a barrier between saltwater and freshwater. The project also supports the maintenance of a managed freshwater wetland system for stormwater treatment, with secondary benefits for biodiversity enhancement.  <i>Barker Inlet Tide Gate (source:weekendnotes.com)</i>
Year of Implementation	Preliminary works completed during the 2022-23 financial year, with further developments ongoing.
Design Features	• Tidal gates installation - Implementation of structures to regulate tidal flow, maintaining the ecological balance between saltwater and freshwater environments in the wetlands. • Flood mitigation - The gates function to control water levels, thereby reducing the risk of flooding in nearby industrial zones.
Process	• Planning and Design - Development of designs to improve tidal exchange and water quality, considering environmental impacts and community needs. • Approvals and Funding - Securing necessary approvals and allocating budget as part of the council's Annual Business Plan 2022-23.

	• Construction - Execution of preliminary works during the 2022-23 period, with ongoing construction phases.
Cost Estimate	>\$1,000,000
Useful Resources and References	Further information is available at https://www.cityofpae.sa.gov.au/_data/assets/pdf_file/0025/1584205/PAE-stormwater-management-plan-barker-inlet-central.pdf

5.3.9 Saline Groundwater Intrusion Barrier

Category	Details	
Adaptation Type	Protect - Hard engineering solutions	
Adaptation Action	Saline Groundwater Intrusion Barrier	
Description	Saline groundwater intrusion barriers are engineered solutions designed to prevent or significantly reduce the inland movement of saltwater into freshwater aquifers. These barriers typically involve the injection of freshwater, the construction of impermeable underground structures, or a combination of hydraulic and physical barriers. The primary aim is to protect freshwater resources for agriculture, human consumption, and ecological sustainability in coastal regions at risk from rising sea levels and groundwater salinisation.	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☐ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion ☐ Accretion ☐ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☒ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 Confined Aquifer without Seawater Intrusion Confined Aquifer with Seawater Intrusion Confined Aquifer with Freshwater Injection Hydraulic Basis for Seawater Intrusion (source: Los Angeles County)
Suitability	- Effective in coastal regions reliant on groundwater for agriculture, drinking water supply, or sensitive ecosystems. - Particularly suitable in regions with well-defined aquifers and clear salinity intrusion threats.	

	Less effective or economically viable in areas with highly complex geology, diffuse aquifer boundaries, or where groundwater extraction significantly exceeds recharge rates.
Likely Impact on Coastal Processes	Low to moderate - Primarily affecting subsurface water dynamics and salinity distribution, with minimal direct impact on surface coastal processes. However, indirect ecological or hydrological impacts should be assessed carefully.
Implementation	Preparation/Design Period Detailed design by suitably qualified practitioners is required. This typically includes comprehensive hydrogeological investigations, groundwater modelling, geotechnical assessments, environmental impact studies, and stakeholder consultations. The preliminary design phase will define barrier type, materials, construction methodology, and operational management. This phase is then refined through further consultation and engineering reviews into a detailed final design suitable for construction.
	Approvals A range of approvals may be required for the installation of saline groundwater intrusion barriers, including: - Land Owner's consent. - Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). - Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. - Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design considerations - Comprehensive groundwater modelling to understand aquifer dynamics and the extent of saline intrusion. - Ecological assessments. - Determination of appropriate barrier type (e.g., injection wells, impermeable subsurface barriers, or hybrid approaches).

	• Geotechnical assessments to identify suitable construction techniques and materials. • Detailed understanding of freshwater recharge rates, groundwater extraction, and sustainable management practices. • Integration with regional groundwater and water resource management strategies. • Provision for ongoing monitoring and management to respond to changing groundwater conditions or sea-level rise.
	Costs Costs may include: • Hydrogeological investigations and groundwater modelling. • Design, engineering, and geotechnical assessments. • Construction or injection infrastructure. • Operational costs, including freshwater injection management or barrier maintenance. • Regulatory approvals and environmental assessments • Monitoring infrastructure for groundwater salinity and barrier effectiveness.
	Challenges and Trade Offs • Technical complexity and uncertainty - Designing effective groundwater barriers requires comprehensive hydrogeological knowledge and sophisticated modelling, often dealing with high levels of uncertainty and variability in subsurface conditions, potentially increasing project complexity and costs. • Ongoing resource requirements - Barriers relying on freshwater injection require a consistent freshwater source and energy for pumping, presenting sustainability and long-term cost challenges. • Ecological and environmental impacts - Unintended ecological impacts, such as altered groundwater levels affecting vegetation or surface water bodies, must be carefully considered, requiring ongoing ecological monitoring and management. • Community engagement and perceptions - Community support can be challenging if local land users perceive risks to water supply, quality, or changes in land management practices. Clear communication, consultation, and demonstration of benefits are essential. • Regulatory and institutional coordination - Implementing groundwater barriers requires coordination across multiple jurisdictions, water management agencies, and legislative frameworks, potentially complicating approval processes and project timelines. • Adaptability to future climate scenarios - Barriers must remain effective under uncertain future conditions, including sea-level rise and increased groundwater extraction pressures, necessitating adaptive design and flexible management strategies.

Project Title	Los Angeles County Seawater Intrusion Barrier Wells	
Adaptation Action	Saline Groundwater Intrusion Barrier	
Location	Los Angeles County, California, USA	
Lead Agency	Los Angeles County Department of Public Works	
Objective	To prevent seawater intrusion into coastal groundwater aquifers by constructing a series of injection wells that create a hydraulic barrier, thereby protecting freshwater resources vital for municipal and agricultural use.	 <i>Los Angeles County Barrier Operation (source: Los Angeles County)</i>
Year of Implementation	Initiated in the 1950s, with ongoing operations and expansions.	
Design Features	• Injection wells - Installation of wells that inject freshwater into aquifers to create a hydraulic barrier against seawater intrusion. • Monitoring systems - Implementation of monitoring wells and systems to track the effectiveness of the barrier and aquifer health.	
Process	• Assessment and planning - Identification of seawater intrusion threats due to over-extraction of groundwater, leading to the development of the barrier well concept. • Design and construction - Drilling and installation of injection wells along the coastline to form a continuous freshwater barrier. • Operation and maintenance - Regular injection of freshwater and monitoring to ensure the barrier's effectiveness and adjust operations as needed.	
Cost Estimate	~\$16,000,000 in 1952	
Useful resources and references	Further information is available at: https://pw.lacounty.gov/core-service-areas/water-resources/seawater-barrier/	

5.4. Hybrid Approaches

5.4.1 Protect Vegetation with Hard Structure

Category	Details	
Adaptation Type	Protect - Hybrid approach (Combined Soft and Hard Protection)	
Adaptation Action	Protect Vegetation with Hard Structure	
Description	A hybrid approach that combines a low-crested rock structure (e.g., breakwater, revetment, or sill) with the restoration or protection of coastal vegetation such as mangroves, saltmarshes, or dune systems. The hard structure dissipates wave energy and reduces erosion pressure, creating a calmer environment behind it to enable vegetation to establish, expand, or thrive. This living shoreline approach enhances natural buffers against erosion and flooding, while promoting habitat diversity and coastal resilience (Temmerman, et al., 2013). Vegetation provides ongoing sediment trapping and shoreline stabilisation, while the structure acts as a secondary defence during high-energy events.	
Design Life	20-50+ years, depending on structure type, exposure, maintenance and adaptability	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☒ Sand drift	 <i>Rock fillet protecting mangrove establishment in Ballina NSW (source: (Morris, et al., 2021))</i>
Suitability	Suitable in estuarine environments, low- to moderate-energy shorelines, and degraded vegetated systems with potential for recovery.	

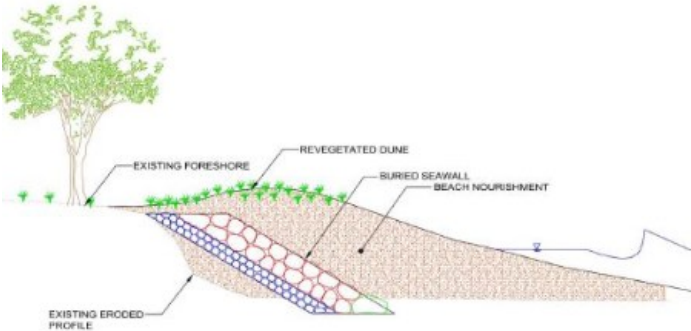
	• Ideal for areas where ecological restoration, biodiversity, and habitat conservation are co-priorities with hazard protection. • Less suited to high-energy open coasts or steep shorelines without adequate substrate or hydrological conditions to support vegetation growth.
Likely Impact on Coastal Processes	Low to moderate - Structures reduce wave energy and promote sediment accretion behind the barrier, supporting vegetation growth and natural stabilisation processes. Minimal interruption to longshore transport compared to traditional hard engineering. Promotes natural resilience and sediment trapping in the long term.
Implementation	Preparation/Design Period • Requires site-specific ecological, hydrological, and geomorphic assessments to determine suitable vegetation species and structure design. • Modelling of wave attenuation, sediment dynamics, and vegetation growth potential. • Involves multidisciplinary collaboration between engineers, ecologists, and community stakeholders.
	Approvals • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design Considerations • Coastal process and environmental assessments. • Structural design to attenuate wave energy without blocking tidal exchange. • Use of low-crested or submerged structures to allow habitat connectivity and maintain natural water flow.

	• Selection of vegetation appropriate to salinity, tidal range, and substrate. • Integration with natural dune or wetland systems. • Long-term vegetation monitoring and adaptive replanting where needed. • Consideration of ecological corridors and habitat use by local fauna. • Adaptive design for sea-level rise, climate change and potential shifts in vegetation zones.
	Costs Costs may include: • Engineering design and materials. • Construction and ecological assessments. • Regulatory approvals. • Ongoing monitoring, maintenance and adaptive management.
	Challenges and Trade Offs • Time lag in vegetation establishment - Full protective function may take years to develop depending on species and conditions. • Site limitations - Success depends on suitable tidal range, sediment, and salinity; some sites may require costly modifications. • Maintenance - Living systems require active monitoring and maintenance, especially in early stages. • Climate sensitivity - Vegetation may be vulnerable to extreme events, sea-level rise, rainfall changes or temperature changes. • Structural balance - Hard components must be carefully designed to avoid over-hardening or ecological fragmentation. • Community understanding - Long-term, “softer” benefits may be less immediately visible compared to traditional structures, requiring clear communication and engagement.

Project Title	Port Phillip Bay Mangrove Restoration Using Concrete Cultivars
Adaptation Action	Protect Vegetation with Hard Structure
Location	Port Phillip Bay, Victoria, Australia
Lead Agency	University of Melbourne
Objective	To mitigate coastal erosion and enhance shoreline stability by implementing a hybrid approach that combines the planting of mangroves within specially designed concrete cultivars. This method aims to attenuate wave energy, promote sediment accretion, and provide suitable conditions for mangrove forest establishment.  <i>Mangroves planted within concrete cultivars (source: Reefball)</i>
Year of Implementation	Initiated in 2017, with ongoing monitoring and adaptation.
Design Features	• Concrete cultivars - Installation of concrete structures designed to attenuate waves and trap sediments, creating a conducive environment for mangrove seedling growth. • Mangrove planting - Establishment of mangrove seedlings within the concrete cultivars to stabilise sediments and enhance coastal resilience. • Wave attenuation - The combined structure reduces wave energy, protecting the shoreline from erosion.
Process	• Site assessment - Identification of eroding shorelines within Port Phillip Bay suitable for mangrove restoration. • Design and Approvals - Development of concrete cultivar designs and securing necessary environmental approvals.

	• Construction and planting - Deployment of concrete cultivars and planting of mangrove seedlings. • Monitoring - Ongoing assessment of mangrove growth, sediment accumulation, and shoreline stability.
Cost Estimate	Cost unknown
Useful Resources and References	Further information available at: https://pursuit.unimelb.edu.au/articles/protecting-our-coasts-naturally

5.4.2 Buried Seawall Complemented by Sand Management

Category	Details										
Adaptation Type	Protect - Hybrid approach										
Adaptation Action	Buried Seawall Complemented by Sand Management										
Description	A buried seawall or levee complemented by sand management integrates a hard protection structure (typically a vertical or sloped seawall or revetment) beneath an artificially created or maintained sand buffer (through nourishment or sand dune construction). Under normal conditions, the seawall remains buried and invisible, preserving natural coastal aesthetics, habitat, and recreational values. During extreme storm events or significant erosion periods, the sand buffer provides initial protection. If erosion continues beyond the capacity of the sand buffer, the buried seawall becomes exposed, acting as a final line of defence to protect critical infrastructure. Post-event sand replenishment or dune construction restores the natural appearance and ongoing protection function, maintaining the balance between hazard mitigation and natural coastal amenity.  <i>Buried seawall design example (source: Bundaberg Regional Council)</i>										
Design Life	25+ years, dependent on design intention										
Coastal hazard mitigation	<table border="0"> <tr> <td>☒ Short-term erosion</td><td>☐ Regular inundation</td></tr> <tr> <td>☒ Long-term erosion</td><td>☒ Terrestrial flooding</td></tr> <tr> <td>☐ Cliff erosion</td><td>☐ Saline intrusion</td></tr> <tr> <td>☐ Accretion</td><td>☐ Coastal Acid Sulfate Soils</td></tr> <tr> <td>☒ Storm tide flooding</td><td>☐ Sand drift</td></tr> </table>	☒ Short-term erosion	☐ Regular inundation	☒ Long-term erosion	☒ Terrestrial flooding	☐ Cliff erosion	☐ Saline intrusion	☐ Accretion	☐ Coastal Acid Sulfate Soils	☒ Storm tide flooding	☐ Sand drift
☒ Short-term erosion	☐ Regular inundation										
☒ Long-term erosion	☒ Terrestrial flooding										
☐ Cliff erosion	☐ Saline intrusion										
☐ Accretion	☐ Coastal Acid Sulfate Soils										
☒ Storm tide flooding	☐ Sand drift										
Suitability	Suitable in coastal areas with adequate space and high-value infrastructure, residential properties, recreational beaches, or ecologically sensitive locations.										

	• Ideal in areas where ongoing beach amenity and aesthetics are important, while still requiring robust infrastructure protection during severe coastal events. • Less suitable in areas without reliable sediment supply or locations with frequent, intense erosion where maintaining the sand cover is impractical or uneconomical.
Likely Impact on Coastal Processes	Moderate - Under normal conditions, sand nourishment and scraping maintain sediment budgets, shoreline width, and natural coastal processes. However, during storms or prolonged erosion, exposed seawalls can alter sediment dynamics, potentially causing downdrift erosion and affecting coastal habitat temporarily.
Implementation	Preparation/Design Period Implementation requires detailed coastal hazard and sediment transport modelling, engineering design of buried structures, sediment sourcing and placement planning, environmental assessments, and stakeholder consultation. Detailed design progresses from preliminary hazard assessments and feasibility studies to detailed construction plans, clearly defining seawall specifications, location and sediment management plans. Approvals A range of approvals may be required for the construction of a buried seawall, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Environment Protection Agency and the Department for Infrastructure and Transport. Design Considerations • Detailed erosion, wave climate, and sediment transport assessments informing seawall location, type, and sediment management strategy.

	• Optimal seawall design (sloped, vertical, or revetment) ensuring adequate structural protection when exposed. • Sand nourishment or dune construction planning, including sediment source identification, frequency, volume, placement methods, planting and stabilisation methods. • Environmental assessments that include identifying and mitigating potential impacts on habitats, ecosystems, and biodiversity, including effects of sand placement and periodic exposure of seawall structure. • Aesthetic considerations ensuring minimal visual intrusion through appropriate depth and regular replenishment of sand cover.
	Costs Costs may include: • Engineering design and coastal process assessments. • Construction materials and installation costs. • Regulatory approvals and environmental assessments. • Sand sourcing and ongoing management. • Maintenance, monitoring, and adaptive management.
	Challenges and Trade Offs • Ongoing sediment management - Maintaining the buried state of the seawall can require sand nourishment, involving ongoing resource commitments and logistical complexities, including sediment availability and sourcing challenges. • Cost and funding continuity - Initial capital investments combined with long-term operational sediment management require sustained financial and institutional commitments. • Potential downdrift erosion - Periodic nourishment or sand scraping may alter sediment transport patterns, potentially increasing erosion risks downdrift, necessitating integrated sediment management strategies. • Ecological impacts - Sediment sourcing, placement, and periodic beach scraping or nourishment can impact nearshore habitats and marine ecosystems, requiring careful ecological monitoring, impact assessments, and mitigation measures. • Community perceptions and acceptance - While the seawall remains hidden under normal conditions, exposure following storms may raise community concerns about aesthetics, recreational amenity, and environmental impacts, requiring effective community engagement strategies and transparency. • Management complexity - Integrating hard protection with ongoing sediment management requires careful planning, regular monitoring, management strategies, and potential infrastructure adjustments in response to evolving climate conditions, sea levels, coastal processes, and community needs.

Project Title	Midge Point Coastal Protection Project
Adaptation Action	Buried Seawall Complemented by Sand Management
Location	Midge Point, Queensland, Australia
Lead Agency	Mackay Regional Council
Objective	To protect the Midge Point coastal community from severe erosion and storm surge impacts by implementing a hybrid solution that combines a buried geotextile sand container (GSC) seawall with beach nourishment and dune revegetation, thereby enhancing coastal resilience while maintaining natural beach aesthetics.  <i>Buried seawall design at Midge Point (source: JPB Pacific)</i>
Year of Implementation	2018
Design Features	• Buried Seawall - Construction of a 3.6-meter-high seawall using approximately 2,000 geotextile sand containers, each filled with 2.5 cubic meters of sand, serving as a concealed, last-resort defence against extreme erosion events. • Beach Nourishment - Placement of 26,000 cubic meters of imported sand along a 900-meter stretch of shoreline to restore and elevate the frontal dune system. • Dune Revegetation - Planting of native dune vegetation to stabilize the nourished sand, trap wind-blown sediments, and promote ecological recovery.
Process	• Assessment and Design - Following severe erosion from Tropical Cyclone Debbie in 2017, a coastal engineering assessment identified the need for a concealed protective structure.

	• Seawall Construction and Sand Nourishment - A 3.6 m high buried seawall was constructed using 2,000 geotextile sand containers (each 2.5 m³), placed along the most vulnerable section of the foreshore adjacent to Bundesen Avenue. The structure was then buried beneath approximately 26,000 m³ of imported sand placed across 900 m of shoreline to restore the beach and dune system. • Revegetation and Stabilisation - Native dune vegetation was planted to stabilise the nourished dune and support natural sand retention. • Funding and Delivery - The project was jointly funded by the Queensland and Commonwealth Governments and delivered through a multi-month construction program beginning in late 2018.
Cost Estimate	Unknown
Useful resources and references	Further information available at: https://jbpcapacific.com.au/projects/service/service-coastal-hazards/midge-point-coastal-protection-designs-qld/

5.4.3 Eco-Hard Structures

Category	Details	
Adaptation Type	Protect - Hybrid approach	
Adaptation Action	Eco-Hard Structures	
Description	Eco-engineered hard structures integrate ecological enhancements into traditional hard coastal protection infrastructure such as seawalls, revetments, or breakwaters. The primary objective is to enhance habitat quality, biodiversity, and ecological resilience while providing robust coastal protection against erosion, wave action, and storm events. Techniques include incorporating textured or porous surfaces, creating habitat niches or tidal pools, adding substrate diversity, or incorporating ecological materials (e.g., bio-concrete). These adaptations encourage colonisation by marine organisms, improving ecological functionality, biodiversity, and potentially providing additional erosion mitigation through increased surface roughness and wave energy dissipation.	
Design Life	25+ years, dependent on design intention	
Coastal Hazard Mitigation	☒ Short-term erosion ☒ Long-term erosion ☒ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift	 <i>Living Seawall Tiles at Sydney Harbour (source: Estuary Care Foundation)</i>
Suitability	• Suitable for coastal areas where hard protection structures are necessary for asset protection but where ecological enhancement, biodiversity improvement, and community support for environmental values are also priorities. • Particularly appropriate in urban coastal environments, recreational areas, or ecologically sensitive settings.	

	Less suitable in high-energy, severely erosive coastal environments where ecological establishment may be challenging without complementary protective measures.
Likely Impact on Coastal Processes	Moderate - Eco-engineered structures retain many traditional seawall functions, directly influencing wave reflection and sediment dynamics. Ecological features reduce wave reflection and energy, potentially minimising downdrift erosion compared to conventional hard structures. Positive impacts on local biodiversity and habitat quality are expected, though careful design and monitoring are necessary to minimise unintended negative ecological impacts.
Implementation	Preparation/Design Period Implementation requires detailed coastal hazard assessments, ecological habitat studies, structural engineering, and stakeholder consultation. Detailed design involves ecological and engineering collaboration, determining suitable habitat enhancements, structural resilience, material selection, and placement methods. Preliminary concepts evolve into detailed construction and ecological establishment plans.
	Approvals A range of approvals may be required for the construction of a eco structures, including: - Land Owner's consent. - Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). - Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. - Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.
	Design considerations Engineering design ensuring structural robustness, durability, and effective wave energy dissipation.

	• Ecological habitat design considerations, including habitat niches, texture variations, tidal pools, and material selections promoting colonisation by marine species, as well as the availability of nearby habitats to act as colonisation sources or the potential need for artificial seeding where natural recruitment is limited. • Selection of materials and construction methods compatible with ecological objectives (e.g., porous concrete, textured surfaces, ecological substrates). • Habitat compatibility assessments considering local marine biodiversity, habitat conditions, wave climate, tidal range, and water quality. • Balancing ecological enhancement goals with structural and safety considerations (e.g., public access, maintenance requirements). • Ongoing ecological monitoring to evaluate habitat establishment success and guide management actions.
	Costs Costs may include: • Engineering assessments and ecological design. • Construction materials and installation. • Regulatory approvals and monitoring. • Maintenance.
	Challenges and Trade Offs • Cost and complexity - Integrating ecological features into hard protection structures can increase initial design complexity, material costs, and ongoing monitoring and maintenance requirements. • Structural and ecological balance - Ensuring adequate structural integrity and coastal protection effectiveness while achieving meaningful ecological enhancements requires careful, interdisciplinary design and evaluation. • Ecological establishment uncertainties - Successful colonisation and habitat creation depend heavily on local environmental conditions, marine biodiversity, and ecological dynamics, requiring ongoing management, monitoring, and potential adjustments to the initial design. • Community perceptions and acceptance - Eco-engineered structures may initially generate public concerns about aesthetic impacts, access changes, or ecological outcomes, requiring effective community engagement and education. • Regulatory complexity - Ecological considerations can increase regulatory requirements, environmental assessments, and approval processes, potentially extending project timelines and adding costs. • Monitoring and management demands - Ongoing ecological monitoring, maintenance, and management actions can significantly increase resource and funding commitments beyond those typically associated with conventional hard structures.

Project Title	Sydney Harbour Seawall Habitat Enhancement Project
Adaptation Action	Eco-Hard Structures
Location	Sydney Harbour, New South Wales, Australia
Lead Agency	Sydney Institute of Marine Science (SIMS)
Objective	To enhance the ecological value of existing seawalls in Sydney Harbour by retrofitting them with habitat features that promote marine biodiversity, thereby integrating ecological enhancements into traditional hard coastal protection infrastructure.  <i>Living seawall at Sydney Harbour (source: NSW Government)</i>
Year of Implementation	Initiated in 2013, with ongoing monitoring and expansion.
Design Features	• Habitat Panels - Installation of concrete panels with complex textures and crevices attached to existing seawalls to mimic natural habitats and encourage colonisation by marine organisms. • Rock Pools - Creation of artificial rock pools on seawalls to provide habitats for intertidal species, enhancing biodiversity and ecological resilience. • Material Selection - Use of environmentally friendly materials, such as marine-grade concrete, designed to promote biological growth and withstand marine conditions.
Process	• Research and Development - Collaboration between marine ecologists and engineers to design habitat features that support marine life while maintaining structural integrity. • Pilot Testing - Initial deployment of habitat panels and rock pools on selected seawall sections to assess ecological outcomes and structural performance.

	• Monitoring and Evaluation - Ongoing monitoring of biodiversity and ecological processes to evaluate the effectiveness of the enhancements and inform management. • Community Engagement - Involvement of local communities and stakeholders through educational programs and citizen science initiatives to raise awareness about marine conservation.
Cost Estimate	Each living seawall panel costs approximately \$500
Useful resources and references	Further information available at: sims.org.au and https://www.climatechange.environment.nsw.gov.au/stories-and-case-studies/living-seawalls

6. No Regrets

This section summarises the adaptation actions and provides project examples which fall under the retreat no regrets type. These actions involve temporary measures and/or coastal monitoring which can provide additional time to fund or improve understanding on more complex or costly adaptation measures.

6.1. Temporary Measures

Category		Details
Adaptation Type	No regrets	
Adaptation Action	Temporary Measures	
Description	Temporary measures involve rapidly deployable or short-term protective actions to provide immediate coastal hazard mitigation during emergency situations or periods of accelerated erosion and flooding risk. Common examples include the temporary placement of geobags, sandbags, rock bags, or other geotextile structures, the construction of emergency sand berms or bunds, installation of temporary wave barriers, or urgent sand scraping. Such actions offer short-term protection to critical infrastructure, public safety, and environmental assets, allowing time to assess and implement more permanent adaptation solutions.	
Design Life	Short-term; typically weeks to months, rarely exceeding several years, dependent on materials, construction quality, site conditions, and subsequent maintenance or replacement.	
Coastal Hazard Mitigation	☒ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion ☐ Accretion ☒ Storm tide flooding ☒ Regular inundation ☒ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☒ Sand drift	 <i>Sand bagging at Belongil for Tropical Cyclone Alfred (source: Echo)</i>

Suitability	• Highly suitable as emergency or short-term response measures to protect critical infrastructure, residential property, roads, or sensitive coastal habitats experiencing immediate threats. • Ideal for rapidly evolving or unexpected erosion or flooding situations requiring urgent action. • Not suitable as permanent solutions due to limited structural durability, effectiveness lifespan, and maintenance requirements.
Likely Impact on Coastal Processes	Moderate - Temporary measures offer immediate, short-term stabilisation but may alter local sediment dynamics, potentially causing localised downdrift erosion, sediment deposition, or ecological impacts. Careful placement and monitoring are necessary to minimise unintended impacts.
Implementation	Preparation/Design Period Temporary measures often require rapid design and deployment, often facilitated by existing emergency response plans or rapid assessment processes. Design typically includes site inspections, hazard assessments, identification of appropriate materials, rapid regulatory approvals, and community communication, followed by swift deployment and installation by experienced coastal management contractors or authorities. Approvals A range of approvals may be required for temporary measures, including: • Land Owner's consent. • Development approval including potential referrals to the CPB, amongst other agencies (see <i>Planning, Development and Infrastructure Act 2016</i> & <i>Planning, Development and Infrastructure (General) Regulations 2017</i> - Schedule 9). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i> and/or <i>Native Title Act 1993 (Cth)</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage or where Native Title rights exist. • Advice or approval from state Government agencies may be required depending on the location, nature and scale of the works. Agencies may include the Department for Environment and Water, Landscape Boards, the Department of Primary Industries and Regions (PIRSA), the Environment Protection Agency and the Department for Infrastructure and Transport.

	Design Considerations • Identification and selection of rapidly deployable, locally available materials such as geotextile bags, sandbags, or rock bags. • Structural stability under short-term exposure to expected wave, storm surge, and erosion conditions. • Placement methods ensuring effective temporary hazard mitigation with minimal disruption to sediment transport or coastal ecosystems. • Consideration of complementary or subsequent permanent solutions. • Ecological assessments and mitigation strategies, particularly if temporary structures remain in place longer than initially anticipated. • Plans for regular monitoring, inspections, and rapid response to damage or displacement of temporary structures. • Strategies for removal or transition to longer-term management options following the immediate hazard event or risk reduction period. • Accessibility and availability of equipment and machinery and labour. Costs Costs may include: • Engineering and environmental assessments • Rapid-response installation costs. • Materials and labour. • Emergency approvals and permits. • Short-term monitoring and maintenance. • Removal or modification costs Challenges and Trade Offs • Limited lifespan and durability - Temporary measures generally provide short-term protection, requiring rapid transition planning to more permanent adaptation solutions or repeated maintenance and replacements. • Downdrift and adjacent impacts - Placement of temporary structures may cause unintended erosion, sediment build-up, or habitat disturbance in adjacent coastal areas, necessitating careful planning and mitigation. • Ecological impacts - Placement of geotextile bags or other temporary structures can disrupt local ecological processes, including impacts on coast and marine biodiversity, habitats, and water quality, necessitating approvals, environmental assessment, monitoring and mitigation actions. • Cost-effectiveness - Repeated deployment, maintenance, and potential replacement of temporary measures can lead to high cumulative costs, prompting consideration of alternative long-term adaptation options. • Community acceptance and visual impacts - Temporary coastal protection measures may negatively impact beach aesthetics,
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	recreational access, or community perceptions, requiring clear communication about necessity and temporary nature of interventions. • Regulatory and logistical constraints - Rapid approval processes and mobilisation of emergency interventions can be complex and administratively challenging, potentially causing implementation delays or conflicts with established regulatory processes. • Potential for downdrift impacts - Altering sediment transport through temporary structures can affect neighbouring shorelines, requiring complementary sediment management strategies or targeted monitoring and adjustment plans.
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Project Title	Inverloch Surf Life Saving Club Emergency Coastal Protection
Adaptation Action	Temporary Measures
Location	Inverloch, Bass Coast, Victoria, Australia
Lead Agency	Inverloch Surf Life Saving Club, in collaboration with Bass Coast Shire Council
Objective	To protect the Inverloch Surf Life Saving Club (SLSC) and surrounding infrastructure from severe coastal erosion through the implementation of temporary measures, ensuring public safety and the continued operation of the club's essential services.  <i>Inverloch Surf Life Saving Club (source: South Gippsland Sentinel Times)</i>
Year of Implementation	2022
Design Features	• Geotextile sandbags - Installation of large geotextile sandbags along the eroding shoreline to serve as a temporary barrier against wave action and further land loss. • Sand nourishment - Supplementing the shoreline with additional sand to reinforce the beach and enhance the effectiveness of the sandbags.
Process	• Assessment and planning - Rapid evaluation of the erosion threat to the Inverloch SLSC prompted immediate action. Coastal engineers recommended the deployment of geotextile sandbags as a temporary protective measure. • Community engagement - The local community, recognising the critical role of the SLSC, mobilised support, gathering nearly 3,000 signatures in a petition urging the state government to intervene and provide assistance. • Implementation - The Bass Coast Shire Council, in collaboration with the SLSC, coordinated the placement of geotextile sandbags along the vulnerable sections of the shoreline.

	• Monitoring and maintenance - Regular inspections were conducted to assess the integrity of the sandbags and the overall stability of the shoreline, with repairs made as necessary to maintain protection.
Cost Estimate	>\$1,000,000
Useful resources and references	Further information available at: https://www.basscoast.vic.gov.au/

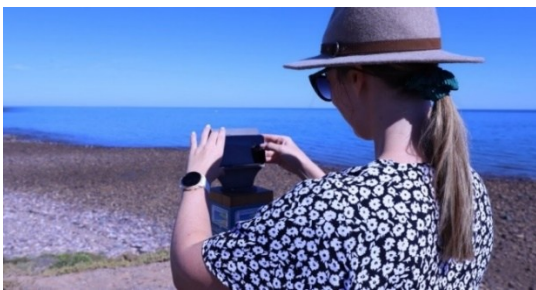
6.2. Coastal Monitoring

Category	Details	
Adaptation Type	No regrets	
Adaptation Action	Coastal Monitoring	
Description	Coastal monitoring involves the collection of coastal data which supports decision making. It can provide baseline data and real-time insights into coastal changes, storm erosion impacts, and the performance of coastal protection measures. Coastal data also assists in predictive modelling and scenario-based decision-making. It helps in understanding long-term trends, informing policy decisions by providing critical information for proactive management and response strategies.  <i>Spotter buoys deployed in South Australia to gain wave data (source: Flinders University)</i>	
Design Life	Permanent or temporary, provided monitoring programs are maintained, data collection is continuous, and findings are integrated into management strategies.	
Coastal Hazard Mitigation	☐ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion ☐ Accretion ☐ Storm tide flooding ☐ Regular inundation	☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift Though monitoring doesn't directly mitigate coastal hazard, data collection can assist in the decision making and optimisation of mitigation measures for all hazards above.

Suitability	• Suitable for locations experiencing dynamic coastal change, areas with active coastal management strategies, and sites where community engagement in monitoring can be beneficial. • Ideal for sites with a history of erosion, high development pressure, or critical infrastructure exposure. • Ideal for areas where sea level rise and/or climate change impacts are expected to impact on coastal processes or ecosystems.  <i>DEW conduct regular beach profile surveys around South Australia (source: Department for Environment and Water)</i>
Likely Impact on Coastal Processes	Low - Monitoring itself does not directly alter coastal processes but provides critical data to inform sustainable management decisions. It allows for the assessment of coastal hazards with minimal intervention.
Implementation	Preparation/Design Period Before coastal data is collected, it is important that a monitoring plan is developed. The monitoring plan should detail the type of data, its purpose, responsible parties, frequency of data capture, costs, required software and licenses, and methods for reporting and review. Approvals Planning and approval requirements vary based on the proposed monitoring. This may include: • Consultation with the Department for Infrastructure and Planning if deploying monitoring instruments which could obstruct vessel routes. • Privacy considerations if capturing imagery including people. • Restrictions and/or approval requirements for drone operation (see https://www.casa.gov.au/drones/drone-rules) • DEW (Marine Parks, Coasts, etc) Design Considerations Design conditions vary based on the form of data collection, examples of data collection techniques are provided below:

	• Remote sensing and aerial surveys including satellite imagery, aerial photography, LIDAR and drone surveys. • Ground based surveys including RTK-GPS methods, swath. • Hydrodynamic and sediment monitoring including wave buoys, current meters, sediment sampling and tide gauges. • Erosion and shoreline change tracking including photographic time series, survey or citizen science observations. • Ecological and habitat monitoring including coastal vegetation surveys and marine habitat surveys. • Community engagement and statistics including public reporting platforms for hazards and beach usage. Across these data collection techniques, the following best practice principles should be considered: • Ensure data consistency by using standardised survey techniques and methodologies. • Seek advice and input from technical experts • Engage local stakeholders, including councils and community groups, to support monitoring efforts and increase awareness. • Integrate monitoring data with adaptation planning and coastal management frameworks. • Funding for duration of required data collection. • Collaboration with universities and research institutions can improve analysis and interpretation of coastal change trends. • Data-sharing platforms should be developed to ensure accessibility for policymakers and coastal managers. • Determine the level of accuracy required for the intended use, consider the benefits and limitations of different collection techniques and methods. Costs Costs may include: • Instrumentation purchase cost (plus required moorings etc). • Consultant or expert advice and involvement • Deployment costs. • Maintenance and ongoing monitoring costs. • Data processing expertise, software and cost.
	Challenges and Trade Offs • Regulatory commitment - Requires long-term funding and institutional commitment to maintain effectiveness. • Community acceptance - Community led monitoring programs need continuous engagement to prevent decline in participation. • Timeframes - Interpretation of monitoring data must be timely to ensure effective response planning.

	• Data management and accessibility - Can be complex if multiple agencies are involved, requiring cross-agency collaboration and governance structures. • Temporal coverage vs spatial coverage vs resolution - In most cases monitoring decisions are constrained by budget. Ensure a balance between the frequency of data capture (to capture dynamics), spatial coverage of data capture (to capture spatial variations) and resolution of data capture (to achieve required detail and accuracy) is considered and optimised.
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Project Title	CoastSnap Community Shoreline Monitoring	
Adaptation Action	Coastal Monitoring	
Location	Hallett Cove & Marino, South Australia	
Lead Agency	City of Marion & CPB	
Objective	Engage the community in collecting shoreline photos to track coastal change over time, supporting local adaptation planning. The initiative enhances public understanding of coastal hazards and encourages participation in evidence-based decision-making.	
Year of Implementation	2020 - Present	
Design Features	5 CoastSnap locations located in Hallett Cove & Marino. Details on CoastSnap are available at https://www.coastsnap.com/	
Process	- Establishment of CoastSnap stations at key coastal locations. - Public education campaigns to encourage participation and long-term data collection. - Data analysis comparing images over time to track beach erosion and sediment movement.	
Cost Estimate	For each station: \$4,000 setup initial setup \$1,500 - \$6,500 /yr for processing (depending on analysis requirements)	 Example of CoastSnap processed output at Manly Beach, NSW (source: https://doi.org/10.1016/j.coastaleng.2019.04.003)
Useful Resources and References	Further information including images taken at the CoastSnap sites is available at https://www.marion.sa.gov.au/services-we-offer/environment/climate-action/coastsnap	

7. Do Nothing

This section summarises provides an example of the do nothing adaptation type where risk is accepted. This means that no action is performed to mitigate risk, and often used as a baseline for comparison to other options.

7.1. Risk Acceptance

Category	Details
Adaptation Type	Do nothing
Adaptation Action	Risk Acceptance
Description	Planning for risk acceptance involves making an informed decision not to undertake significant physical adaptation actions in certain coastal areas, acknowledging and accepting the presence of existing or future coastal hazard risks. This approach is generally applied when risks are assessed as manageable or tolerable, or when other adaptation measures are impractical, uneconomical, or environmentally unsustainable. Planning for risk acceptance typically includes developing policies that transparently communicate risks, ensuring community awareness and preparedness, incorporating hazard disclosure into planning instruments, and preparing effective contingency plans for hazard events.  <i>Cliff erosion resulting in loss of a walking path, North Shields (Source: DEW)</i>
Design Life	Ongoing
Coastal Hazard Mitigation	☐ Short-term erosion ☐ Long-term erosion ☐ Cliff erosion

	☐ Accretion ☐ Storm tide flooding ☐ Regular inundation ☐ Terrestrial flooding ☐ Saline intrusion ☐ Coastal Acid Sulfate Soils ☐ Sand drift
Suitability	• Suitable for locations experiencing dynamic coastal change, areas with active coastal management strategies, and sites where community engagement in monitoring can be beneficial. • Ideal for sites with a history of erosion, high development pressure, or critical infrastructure exposure.
Likely Impact on Coastal Processes	None - Accepting coastal hazard risks does not influence coastal dynamics directly, as it involves no physical intervention.
Implementation	Preparation/Design Period Risk acceptance requires thorough and regular coastal hazard risk assessments, vulnerability analyses, risk communication strategies, stakeholder consultation, and explicit incorporation into local or state planning frameworks or management plans. The process involves clear communication of risks to communities and stakeholders to ensure informed decision-making and awareness of hazard management responsibilities. Approvals A range of approvals may be required for formalised risk acceptance, including: • Local government or state agency decision. • Formal recognition within planning instruments (e.g., Planning and Design Code). • Consultation with Traditional Owners and, where required, authorisation under the <i>Aboriginal Heritage Act 1988</i>, if works are proposed on or near land with known or potential Aboriginal cultural heritage. Design Considerations • Comprehensive hazard identification, risk analysis, and risk communication strategies.

	• Regular reviews and reassessments of hazards and risks to account for new data, climate projections, or changing community expectations. • Clear definition of the responsibilities and liabilities of landowners, local governments, and other stakeholders. • Transparent communication of risk acceptance decisions, ensuring property owners, stakeholders, and community members are informed about potential hazards, impacts, and responsibilities. • Emergency management plans and contingency planning, clearly defining roles, responsibilities, and actions in the event of coastal hazard impacts. • Integration of risk acceptance decisions within broader strategic planning processes, ensuring consistency and transparency.
	Costs Costs may include: • No direct financial costs. • Potential indirect costs related to hazard impacts. • Potential clean up costs
	Challenges and trade offs • Community and land owner perception and acceptance - Transparent communication is required to ensure the land owners and/or community understands and accepts risks and associated responsibilities, particularly in areas where protection measures will not be undertaken. • Legal implications and liability - Clear documentation and communication of accepted risks are critical to managing liability, especially for public authorities or land managers responsible for hazard-prone areas. • Equity considerations - Decisions to accept risks may raise equity issues, particularly in disadvantaged or vulnerable communities unable to afford individual responses or asset relocation. • Changing risk and climate uncertainty - Risk acceptance decisions require regular review and updating in response to changing climate projections, evolving hazards, or community expectations, potentially resulting in shifting responsibilities or management requirements over time. • Balancing economic, social, and environmental priorities - Acceptance of risks involves carefully balancing the costs of potential impacts with the costs of implementing active adaptation measures, which can be complex and contentious. • Emergency response planning - Robust contingency planning and clear communication of responsibilities are critical for effective response and recovery in accepted-risk locations, requiring dedicated resources, education, and preparedness.

Project Title	Robe Obelisk Coastal Risk Acceptance Strategy	
Adaptation Action	Risk Acceptance	
Location	Robe, South Australia	
Lead Agency	District Council of Robe	
Objective	To acknowledge and accept the coastal erosion risks threatening the historic Robe Obelisk by allowing its natural deterioration, while planning for a replica to preserve its cultural significance.	 <i>Cape Dombey headland (source: Flinders University)</i>
Year of Implementation	Decision on strategy in 2024	
Design Features	The Robe Obelisk, erected in 1855, stands as a prominent landmark on South Australia's Limestone Coast. Due to ongoing coastal erosion, studies have projected a 50% chance of the obelisk falling into the sea within the next 27 years.	
Process	• Assessment - Cliff erosion studies indicated significant erosion risks to the obelisk, with potential collapse anticipated by 2051. • Decision - Considering the impracticality and high costs of relocation or protective measures, the council opted for a risk acceptance strategy, allowing the obelisk to succumb to natural forces. • Compromise - To preserve the landmark's heritage, a committee recommended constructing a replica at a safer location, such as near the Old Gaol ruins in Robe. • Community engagement - The council engaged with residents and stakeholders to discuss the obelisk's fate, ensuring transparent communication about the risks and the rationale behind the risk acceptance approach.	
Cost Estimate	N/A	
Useful resources and references	Further information available at: https://www.abc.net.au/news/2024-12-09/robe-obelisk-replica-recommended-in-erosion-battle/104668364	

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