

Rooted resilience: Advancing nature-based solutions for estuarine foreshore erosion management and waterway stability

Daryl Lam¹ and Daniel Trnovsky¹

¹ Water Technology, Brisbane. Queensland 4101. Email: daryl.lam@watertech.com.au

Key points

- Incorporating nature positive concepts to foreshore remediation design. 3-5 points, 1 sentence each.
- Vegetation management and no-mow zones are the most cost-effective and community-compatible measures.
- Giving priority to practical, environmentally sensitive erosion management solutions that balance erosion mitigation, ecological enhancement, community use, and budget constraints.

Abstract

This paper presents examples of ways to incorporate nature positive concepts to foreshore remediation design in the Shoalhaven Region, New South Wales (NSW). Site assessment and options development were undertaken across multiple foreshore sites. The overall assessment integrates site assessment, technical analysis, and design workshops to develop feasible, cost-effective, and environmentally responsible remediation concepts tailored to each location.

Nature positive concepts are emphasised as first-preference interventions consistent with NSW Coastal Design Guidelines. Approaches such as vegetation management, mangrove and saltmarsh establishment, environmentally friendly seawalls, and oyster reefs provide long-term erosion control by working with natural processes. These strategies stabilise foreshore banks through root reinforcement, wave attenuation and sediment capture, while delivering co-benefits including improved water quality, habitat creation, biodiversity enhancement, and reduced maintenance requirements.

Across the project sites, vegetation management and no-mow zones were repeatedly identified as the most cost-effective and community-compatible measures. Where space is available, riparian buffer zone expansion is also recommended. Where erosion pressures are higher, hybrid solutions combining rock beaching, rock fillets, or cobble beaches with riparian revegetation were recommended. Oyster reefs, mangrove planting, and saltmarsh benches offer further opportunities for living shoreline outcomes where ecological conditions allow.

Giving priority to practical, environmentally sensitive solutions that balance erosion mitigation, ecological enhancement, community use, and budget constraints, can provide a clear pathway toward resilient and nature-positive shoreline management in foreshore environment.

Keywords

Estuarine foreshore, Foreshore erosion, Nature-based solutions, Erosion management

Introduction

Foreshore erosion is a pervasive challenge affecting estuarine, riverine, and coastal environments globally. While erosion is a natural geomorphic process, it is increasingly exacerbated by anthropogenic influences such as vegetation removal, infrastructure encroachment, altered hydrology, and climate-driven stressors including sea-level rise and intensified storm events.

Traditional approaches to erosion mitigation have relied heavily on hard engineering solutions, such as concrete revetments and riprap. While these structures can provide immediate protection, they frequently disrupt natural processes, degrade ecological habitats, and require ongoing maintenance. In

contrast, nature-based solutions offer a more sustainable alternative by working with, rather than against, natural system dynamics. It is important to note the limitations of both nature-based solutions and hard engineering techniques, and where necessary, use a combination to ensure a remediation solution that achieves multiple objectives and desirable outcomes.

This paper summarises several sites in the Shoalhaven Region, New South Wales (NSW) where erosion remediation design was required and a process of incorporating nature positive concept to foreshore erosion remediation designs was undertaken. Nature positive concepts are emphasised as first preference interventions consistent with NSW Coastal Design Guidelines. Approaches such as vegetation management, mangrove and saltmarsh establishment, environmentally friendly seawalls, and oyster reefs provide long term erosion control by working with natural processes. These strategies stabilise foreshore banks through root reinforcement, wave attenuation, sediment capture, and habitat creation, while delivering co benefits including improved water quality, biodiversity enhancement, and reduced maintenance requirements.

Overview of foreshore erosion drivers

Erosion may be natural but is often exacerbated by anthropogenic actions. Factors influencing foreshore erosion can act in isolation and/or in combination. They can be episodic as a result of individual events, or the processes can be ongoing over time. Table 1 provides a summary of factors influencing foreshore erosion.

Table 1 Foreshore erosion drivers and their causes

Factors influencing Foreshore Erosions	Causes
Tides	Constant physical wave action due to the rise and fall of the of the tides.
Boat wash	Physical wave actions impacting the foreshore.
Onshore wind	Wind set-up caused by wind blowing over the water surface, generating waves. Physical wave actions impacting the foreshore.
Informal public access	Human traffic and activities on the foreshore causing.
Informal structures	Erosion can occur around structures (e.g. local scour around piers of informal jetties can lower foreshore banks and deepen foreshore banks).
Severe storm events	Significant wave actions from storm surges.
Large runoff events from the catchment	- Flow velocity and shear stress on the foreshore banks. - Hydraulic drawdown in soil profile of foreshore banks as floodwater recedes.
Removal of riparian vegetation	- Lack of roots to hold the soil together. - In channel vegetation can be physical barrier to wave actions.
Mowing of grass to the edge of the foreshore	Limiting the opportunity for riparian vegetation establishment.
Sea level rise	- Increase in water levels and physical erosive forces on the foreshore. - Increase in the frequency of storm surges.
Sediment availability from upstream and coast	Inability to replenish sediment loss within the foreshore area.
Changes in river hydrodynamics	Due to foreshore and channel realignment and dredging, upstream changes (urbanisation)

Estuarine foreshore remediation

Management of estuarine foreshore erosion can be broadly categorised into soft engineering or hard engineering, acknowledging that a combination of both is not uncommon to address foreshore erosion at a given location. However, there is an increasing preference for foreshore managers to first consider nature-based solutions (soft engineering) to address environmental challenges, and to avoid hard engineering solutions where possible (NSW Coastal Design Guidelines, DPE, 2023). Table 2 provides some examples of remediations options for estuarine foreshore.

Table 2 Examples of remediation options for estuarine foreshore erosions

Remediation Options	Type	Overview
Vegetation Management	Nature-based /soft engineering	- Revegetation and maintenance program - Buffer zone (no mow zone)
Mangrove Establishment	Nature-based /soft engineering	- Effective in attenuating waves and building up sediment - Considerations to spatially varying conditions (e.g. tidal range, temperature)
Saltmarsh Establishment	Nature-based /soft engineering	- Saltmarshes often coexist with mangroves, but in higher elevations. - Interconnected habitats facilitate sediment capture and stabilisation and also support biodiversity.
Environmentally friendly seawalls	Nature-based /soft engineering	- Seek to enhance the ecological value of seawalls and seawall-lined foreshores - Mimics natural intertidal shorelines
Oyster Reefs	Nature-based /soft engineering	- Acts as a natural breakwater, attenuating wave energy - Considerations to spatially varying conditions (e.g. tidal range, water depth range, slope)
Bank battering	Soft engineering	- Reduce bank slope to improve bank stability - Create more favourable conditions for vegetation establishment.
Rock fillet	Hard engineering	- Designed to stabilise foreshore by acting as barriers, dissipating the energy of waves or currents. - Also encourages sediment deposition.
Rock beaching	Hard engineering	Typically used when other options are viable, or where critical assets are to be protected.

Key design process

Site assessment and options development was undertaken across multiple riverine and estuarine foreshore sites. The overall assessment integrates site assessment, desktop review (including review of options provided by Decision Support Tool (DST) for Bank Erosion Management in NSW Estuaries), and design workshops to develop feasible, cost effective, and environmentally responsible remediation concepts tailored to each location. Key stakeholders from Council and Department of Climate Change, Energy, the Environment and Water (DCCEEW) were actively involved in the project throughout, from site assessment to design workshops, to ensure the respective proposed designs were accepted by the various stakeholders.

To inform the design, the technical analysis of each site was framed within the context of:

- Understand the **issues** that needs to be addressed.
- Recognise the **risks** if issues are not.
- Appreciate **constraints** that can impact design options.
- Identify any **opportunities** to improve outcomes.

This framework works with a key underlying understanding that nature-based solutions and soft engineering techniques will be the preferred options where viable. As an outcome of the design optioneering process and design workshop, a ‘shopping list’ of options were provided for each site to address the various issues identified and provided flexibility for Council to implement the remediation on the ground based on approvals, budget and other considerations.

Examples of proposed of remediation design solutions incorporating nature-based solutions

A total of five sites allowed for the use of nature-based solutions as the primary or part of the design solutions. Table 3 provides a list of recommended nature-based solutions and soft-engineering techniques for respective sites. Figure 1 and Figure 2 provide examples of conceptual design drawings of the nature-based solutions recommended. It is of note that, at some sites, hard engineering was required due to the high risk to assets and not included in this table.

Across the project sites, vegetation management and no-mow zones were repeatedly identified as the most cost-effective and community-compatible measures (Figure 3). Where space is available, riparian buffer zone expansion is also recommended.

Table 3 Summary of site-specific recommendations

Site	Recommended Nature-Based Solutions	Description
1	Salt marsh bench	Locally modify topography to facilitate periodical inundation with tides to allow establishment of salt marsh.
	Revegetation – low grasses and sedges	Plant and maintain a strip of native grasses and sedges along the top of the foreshore bank. Signage may be incorporated to describe the role of vegetation in foreshore protection.
	Revegetation - trees	Plant and maintain native trees along the top of the foreshore bank.
	Remove existing concrete cap along foreshore	Concrete is not sympathetic to foreshore processes, inhibits vegetation growth and cannot adjust to accommodate minor topographic changes
	Delineate no mow zone	Allow for natural recruitment of native vegetation
	Vegetated Swale	Replace concrete stormwater outfalls with vegetated swales.
2	Salt marsh bench	Locally modify topography to facilitate periodical inundation with tides to allow establishment of salt marsh.
	Delineate no mow zone	Allow for natural recruitment of native vegetation
	Revegetation – low grasses and sedges	Plant and maintain a strip of native grasses and sedges along the top of the foreshore bank. Signage may be incorporated to describe the role of vegetation in foreshore protection.
	Revegetation - trees	Plant and maintain native trees along the top of the foreshore bank.
3	Beach nourishment	Provide amenity for park users.
	Vegetation Management	Plant low riparian vegetation and trees
	Delineate no mow zone	Allow for natural recruitment of native vegetation
	Weed management	Management of invasive, non-native plants within the delineated no-mow zone.
4	Revegetation Management	Pockets of mangroves, low riparian vegetation and trees
	Delineate no mow zone	Allow for natural recruitment of native vegetation
	Weed management	Management of invasive, non-native plants within the delineated no-mow zone.
5	Oyster Reef	In this instance, the primary design intent of the oyster reef is to create conditions that are favourable for mangrove establishment.
	Mangrove establishment	Mangrove establishment on the landward side of the oyster reef



Figure 1 Example conceptual design incorporating various nature-based solutions

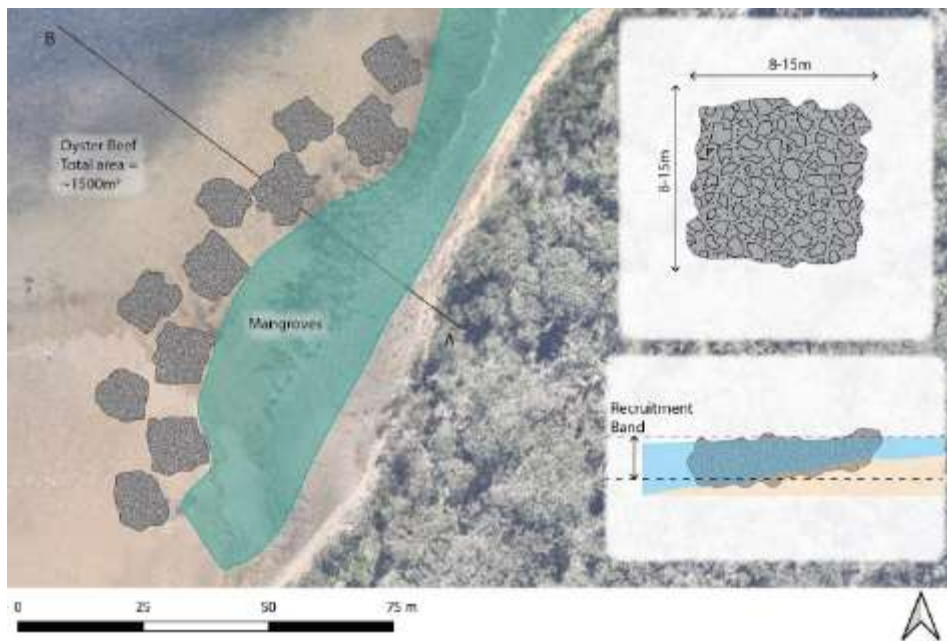


Figure 2 Example of estuarine foreshore remediation conceptual design incorporating mangroves and oyster reefs



Figure 3 Example elsewhere, showing natural recruitment of she-oaks on the edge of riparian vegetations where mowing did not get to

Conclusions

This paper provides examples of prioritising nature-based solutions to mitigate estuarine foreshore erosion concerns through practical, environmentally sensitive solutions that balance erosion mitigation, ecological enhancement, community use, and budget constraints. The examples can provide a clear pathway toward resilient and nature-positive shoreline management in foreshore environment.

It is of note that consideration was not given to economics of the nature-based solutions options in this project. However, it is important to acknowledge that often CAPEX cost can determine the decision when choosing options, but if the long-term OPEX cost is also included or quantifying return on the asset is included then nature-based solutions often provide larger ecological, environmental and social returns as the asset ages, which is typically the opposite for engineered solutions as they tend to depreciate over time and require ongoing maintenance.

Acknowledgements

Acknowledgement to Shoalhaven City Council for leading this project with fundings from Coast and Estuaries grants, and a Bushfire Affected Coastal Waterways grant from the Department of Climate Change, Energy, the Environment and Water (DCCEEW). The grants have allowed for the preliminary studies in the ongoing development of various Coastal Management Programs (CMPs) and a Bushfire Recovery Plan, with aims to determine bank condition, erosion causes and foreshore issues, riparian health and assessment of management options and priorities. This project is funded by the Australian Government's Urban Rivers and Catchments Program Short.

References

Department of Planning and Environment. (2023). *NSW Coastal Design Guidelines: For a thriving and resilient coast*. <https://www.planning.nsw.gov.au/sites/default/files/2023-10/nsw-coastal-design-guidelines-2023.pdf>

Wiesenfeld, C., Vietz, G., Fryirs, K., Fitzpatrick, C., Dickson, M., Lanigan, V., Lloyd, L., Athapaththu, C. and Cadornigara-Corpuz, M. A. (Eds.) (2026) *Proceedings of the 12th Australian Stream Management Conference*, 6-9 September 2026, Kingscliff, NSW. River Basin Management Society, Melbourne, Australia.