Restoring mangroves for bank stabilisation on the Caboolture River

Margie Dickson[1], Misko Ivezich[2]

1 Healthy Land and Water, Brisbane, QLD 4000 Email: margie.d@hlw.org.au

2 Alluvium Consulting, Email: Misko.Ivezich@alluvium.com.au

Key Points

- Erosion control works in the Caboolture River estuary aimed to re-establish mangroves for bank protection, using earthworks to create a level bench in the tidal zone and placing hardwood logs to protect mangrove saplings from boat wash.
- The tidal zone of the Caboolture River is classified as Fish Habitat A, meaning nature-based solutions to bank erosion mitigation were preferred.
- The first three sites have now experienced one wet season, including a major flood, with good stability on all three sites and evidence of mangrove recruitment from the Spring 2023 grey mangrove fruiting event.
- Acid sulphate soil was managed through onsite spoil treatment and design modification to avoid disturbance of material with high acid-generating potential.

Abstract

Bank stabilisation works in the tidal zone of the Caboolture River aim to re-establish a mangrove fringe and upper and overbank native riparian vegetation. This is being achieved 1.2km of riverbank (6 separate sites) using a combination of earthworks and hardwood logs.

The eroding banks were reprofiled to create a 3-4 m bench which is wide enough, flat enough and at a suitable elevation to establish mangroves. The bench is typically in the upper part of the tidal range, at 200mm below mean high water springs. Logs were pinned into the bench to protect the mangrove propagules from boat wash until they grow large enough to form a resilient community.

Three sites were complete by January 2024, when they experienced their first flood event. There was no major damage to the profile of the sites or the log structures, and young mangroves and bank plantings had a high survival rate.

Mangroves often co-exist with acid-sulphate soils, posing a significant environmental risk for this project. Spoil was successfully treated on site by mixing with lime on clay-lined treatment pads. The project was also able to adjust the elevation of the bench to avoid disturbance of soil with high acid-generating potential.

Mangrove restoration can provide protection and resilience to waterways and infrastructure in many locations, and we hope the restoration method and on-ground learnings will be of use to others working in similar ecosystems and as an approach to increase climate resilience associated with rising sea levels.

Keywords

Mangrove restoration, bank stabilization, nutrient offset, fish habitat, nature-based solutions

Introduction

Bank stabilisation works in the tidal zone of the Caboolture River are being funded by local water utility Unitywater under a nutrient offset policy framework. Erosion control and riparian restoration is achieved on 1.2km of riverbank (across multiple sites) using a combination of earthworks and hardwood logs. Bank stabilisation works were designed by Alluvium Consulting, and Healthy Land and Water was responsible for project scoping and on-ground delivery. Table 1 presents key details for the three sites which have been completed at the time of writing.

Table 1: Details of site completed as of April 2024.

Site name	Length	Earthworks completed	Planting completed	Rootball logs	Logs without rootball	Piles
Site B1	184	September 2023	October 2023	19	37	55
Site 5	148	October 2023	December 2023	17	30	43
Site 6	201	December 2023	April 2024	20	38	58

Nutrient abatement through erosion control works was calculated based on observed average annual sediment loss at each site, soil testing for total nitrogen and total phosphorus, and a "delivery ratio" of 1.5 accounting for uncertainty and temporal variability in this type of nutrient abatement compared to point source controls at wastewater treatment plants.

The observations and learnings from the first year of on-ground works, including a wet season with one major flood, have been incorporated into other sites within the program and other nutrient offset scoping work in the region, and may provide useful insights for others working in similar tidal ecosystems.

Drivers of erosion

Scoping studies identified sections of bank suffering ongoing erosion. These are all located on outside bends, indicating that fluvial scour likely played a role in the initial destabilisation of unvegetated banks. However, studies during project scoping phase concluded that recreational boat wash is the most significant driver of ongoing erosion at these sites. Some colonisation of mangrove propagules and presence of young mangrove plants was observed at the sites, but these have not been able to form a resilient, self-stabilising community. Pre-existing mangroves noted in 2020 ecological surveys had significantly diminished after flooding in 2022.

Figure 1. Site B1 prior to works, November 2022. Note mature mangrove community on the opposite bank as seed source and reference ecological community.

Design approach

The tidal zone of the Caboolture River is classified as Fish Habitat A. This means that rock protection of the toe was not permissible and a flexible, nature-based solution was required.

A long-term restoration strategy for the sites is to re-establish a robust mangrove community within the bench zone, similar to that observed upstream, downstream and opposite the eroding sites. The roots and pneumatophore beds of the established mangroves will physically stabilise the bank and safely dissipate energy from boat wash. The dominant mangrove species in the Caboolture River are the Grey mangrove (*Avicennia marina*) and the River mangrove (*Aegiceras corniculatum*), with Milky mangrove (*Excoecaria agallocha*) also present.

The design approach developed consisted of a range of engineering and vegetation components:

Bank reprofiling including bench – Reprofiling of the unstable bank to a stable gradient suitable for vegetation establishment (1V:3H). A 4 m bench was included to maximise the ecological niche of tidal species by increasing the bank area within the tidal zone.

Log groynes – An approximately 500 mm diameter log with a root ball were placed at a 45˚ angle with the root ball extending upstream within the channel. The root ball protrudes into the channel to:

- Maximise the physical and hydraulic habitat within the river
- Reduce near bank velocity through flow disturbance
- Reduce wave action impacts against the bank

The log groynes were also designed to be able to adjust vertically if required to allow for some bank movement below the water line.

Footer logs - The footer logs serving to protect the lower bank from scour and support the log groynes by distributing the load.

The footer logs were relatively straight homogenous logs with a diameter of approximately 500 mm with no root ball. The logs were Australian hardwood and approximately 6 m in length. The footer logs were placed along the toe of bench and held down by the log groynes. The log groynes were designed to be able to adjust vertically if required to allow for some bank movement below the water line.

Boulders ballast - Two large boulders of 800mm-100mm diameter were placed on the log groynes to secure their position on the footer logs. The January 2024 flood confirmed that these boulders are heavy enough to resist buoyancy and river flow forces, as designed.

Pinned logs - The pinned logs help reduce the wave action against the bank, promote deposition, and assist in vegetation establishment.

The pinned logs are relatively straight homogenous logs with a diameter of approximately 500 mm with no root ball. The logs were Australian hardwood and approximately 6 m in length. The logs were placed along the bench and anchored by timber piles (with a diameter of 300 mm and length of approximately 2.5 m). The piles were embedded to a depth of 2 m. This was increased at Site 6 in order to reach a suitably firm foundation.

Riparian vegetation establishment – The embankments between the bench and the upper batter have been densely revegetated. Over the long-term vegetation will provide natural bank stability and erosion protection. The erosion protection will occur through root reinforcement and flow and wave disturbance.

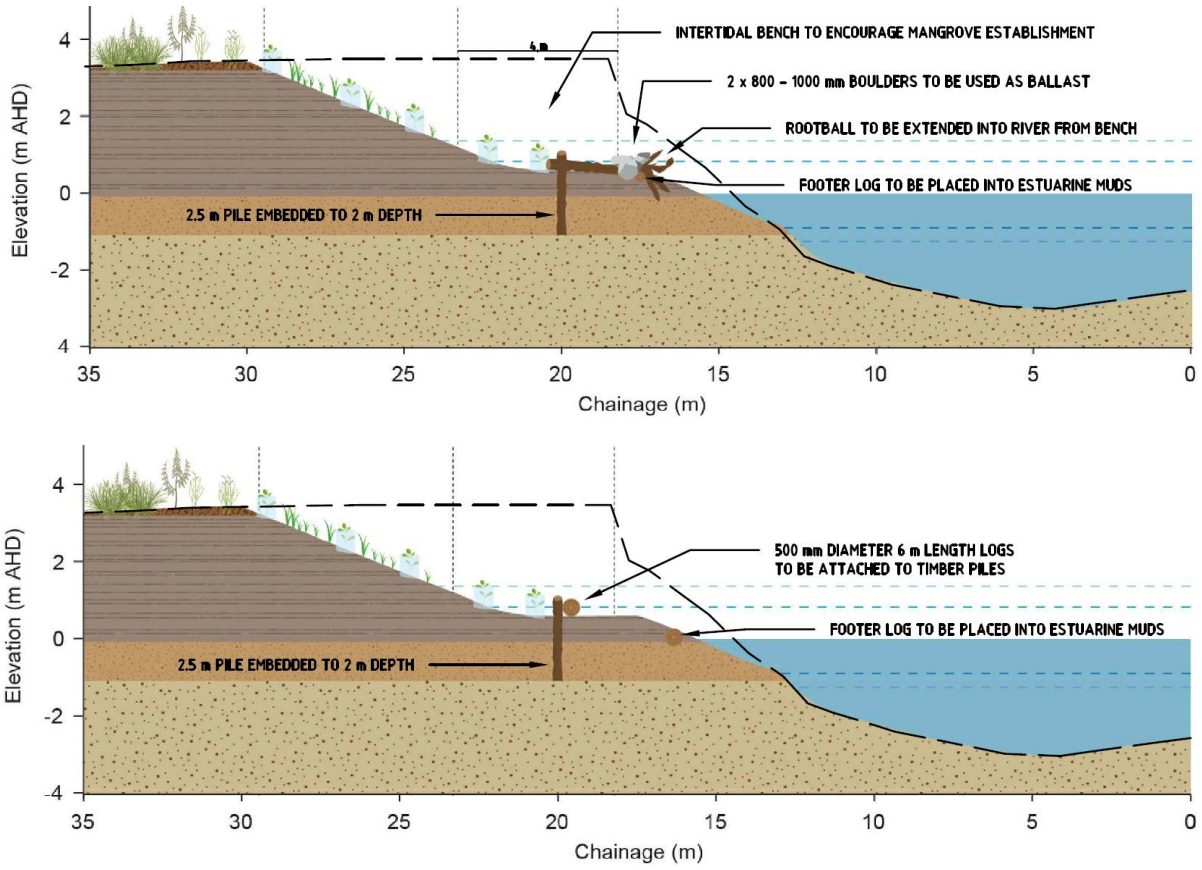

Figure 2: Section showing the proposed log groyne and pinned log arrangement Top: Log groyne. Bottom: Pinned log

Implementation

The eroding banks were reprofiled using a 20t excavator to create a 4m wide "bench" which is flat enough and at a suitable elevation to establish mangroves. The design elevation for the bench is in the upper part of the tidal range, at 0.2m below mean high water springs (MHWS). This means that the bench is underwater in most, but not all, high tides. The bench elevation was based on the advice from the project ecologist regarding the most suitable location for germination and establishment of mangrove propagules. However, the mangrove species present in the Caboolture River grow across a relatively wide tidal range. During the construction phase, some localised adjustments were made to the bench height to accommodate site constraints.

Field measurements at two sites observed mature mangroves and some propagules 0.4m above the design bench elevation (MHWS +0.2m.). Sprouted propagules from the previous season were observed at 0.4m below the design bench elevation (MHWS -0.6m) on site B1 and 0.68m below the design bench elevation (MHWS -0.88m) on Site 24. Site 24 had section of more gently sloping toe at lower elevations, and is also close to the upper limit of tidal influence on the Caboolture River. Based on these observations, up to +/- 0.4m variation in bench height across the sites was deemed acceptable from a design performance and ecological perspective.

This flexibility in bench elevation was used to raise the bench height on the upstream end of Site B1 by 0.3m to avoid disturbing highly reactive acid sulphate soil. It will be used on Site 24 to slightly lower the bench height in some locations to accommodate changes in site profile since the original design, caused by flooding in 2022 and 2024.

Figure 2. Site B1 after work, November 2023. Dense mangrove saplings in the foreground were translocated within the site during earthworks, while sparse saplings are natural recruits from the Spring 2023 grey mangrove fruiting event.

Figure 3. Site B1 post-flood, February 2024.

Post-flood performance

In January 2023, the Caboolture River experienced a major flood which was the second largest event since 1965 and likely had an annual exceedance probability of 5 %. Three sites had been completed by this point. All three were located downstream of the Bruce Highway. Large areas of the floodplain were engaged in this event, with all three sites inundated above top-of-bank. This flood provided the first significant test for performance of the bank stabilisation design at these sites.

Riparian plantings and naturally recruited mangrove saplings all survived well, which was encouraging given the recent planting (<3 months since riparian planting at Site 5). The logs also remained generally stable, with the following post-flood observations:

- Logs were obviously buoyant against their restraints. One log on Site 5 had floated up and remained resting on top of its piles.
- Boulders on two rootball logs at the downstream end of Site B1 have slipped out of place and fallen off the bench, although the log itself remained in the correct orientation after the floodwaters subsided.

The pinned log was pushed back into place with a crowbar and cables were tightened. This highlights that inspection and possibly occasional replacement of the cables securing piled logs will be an important component of site maintenance over the medium term.

No repair was deemed necessary for the partial loss of restraint on a single rootball log. On subsequent sites, the boulders will be moved slightly to the landward side of the footer log.

Acid sulphate soil management

Mangroves often co-exist with actual/potential acid-sulphate soils (ASS/PASS), and disturbance causing oxidation of these soils is a significant environmental risk. Avoiding disturbance to ASS/PASS soils is always the most preferable option, both under the Queensland Government ASS/PASS Soil Management Guidelines and from a project cost and risk management perspective.

Soil testing investigations identified a range of soils on the project sites including:

- Soils with non-sulphuric acidity (non-regulated and typically much lower acid-leaching potential).
- ASS/PASS with moderate acid-generating potential, requiring liming rates of 5kg/m2 – 20kg/m3 spoil.
- PASS with high acid-generating potential, requiring liming rates of >100kg/m3 spoil, underlying other soil types on some sites.

The project was able to avoid disturbance to any soil with high acid generation potential. This was achieved by raising the bench elevation by 0.3m at the upstream end of Site B1, and by conducting additional soil testing at Site 24 to confirm the PASS was located below design bench elevation throughout the site.

In areas of the site disturbing ASS/PASS, the exposed surface of the reprofiled bank presents a low risk of oxidation, due to ongoing tidal wetting/drying cycles identical to the in-situ state. However, spoil from bank reprofiling will fully oxidise over time. Liming was required to treat ASS/PASS spoil. At the three completed sites, this was undertaken on site on a clay-lined treatment pad (Figure 4). Offsite treatment at a licenced third-party facility was the preferred option for sites where onsite placement was not acceptable to the landholder or no elevated land was available for the treatment pad. Both on-site and off-site treatment options were a significant project cost.

Figure 4. Acid sulphate spoil treatment pad at site 6. Lime application and mixing at 5kg/m3 spoil.

Conclusions

This project aims to re-establish a resilient mangrove community for long-term protection of eroded sections of the Caboolture River. The design uses a combination of earthworks and hardwood log placement to create a suitable, protected zone for mangrove recruitment and establishment. The design accommodates fish habitat requirements, avoids disturbance of highly reactive acid sulphate soil and provides protection from

both river flow and boat wash impacts. Both vegetation and structural components of the design performed well during the first wet season, including a major flood.

The nature-based approaches adopted for this project have potential to be more widely utilized across estuarine and coastal zones as an alternative to hard engineering. These approaches have co-benefit of improved fish habitat and riparian vegetation quality and connectivity and can help increase climate resilience associated with rising sea levels.

Acknowledgments

The authors acknowledge Unitywater as the funder of these Lower Caboolture River bank stabilisation works.