5.0 Foreshore Erosion

5.1 Background

Despite extensive urbanisation along the banks of the estuary, areas of undeveloped foreshore remain. Additional locations of natural regeneration has occurred where reclamation has been abandoned, seawalls have failed and not been replaced and where sediments have accumulated in front of seawalls.

Natural foreshore in the study area falls into the following categories:

- Beaches (Figure 5-1);
- Rock Platforms (Figure 5-2);
- Vegetated Natural Foreshore (Figure 5-3); and
- Non-vegetated Natural Foreshore (Figure 5-4).

Figure 5-1. Typical estuarine beach comprising medium grained sand constrained by rocky outcrops

Figure 5-2. Rock platform with sandy deposits at rear

Figure 5-3. Muddy shoreline vegetated with mangroves

Figure 5-4. Non-vegetated muddy shoreline

Natural foreshore areas may be vulnerable to short duration erosion events and longer term recession or accretion.

Episodic erosion of natural foreshores in the study area may be caused by:

- Severe storms;
- Vessel wash;
- Flooding;
- High tides;
- Loss of riparian vegetation; and
- Informal public access destabilising banks.

Longer term shoreline recession or accretion can be caused by:

- Changes to mean sea level;
- Sediment availability; and
- Changes in river hydrodynamics due to foreshore and channel realignment and dredging.

Foreshore erosion is occurring at a number of locations throughout the estuary, affecting foreshore amenity and causing environmental degradation. Erosion is particularly severe upstream of the Silverwater Bridge due to the narrow channel width and shallow depth at this location combined with the size of vessel operating, resulting in a distinctive wave climate.

5.2 Scope

Cardno Lawson and Treloar (2008) identified a lack of more recent assessments of bank erosion and the need for erosion assessments to be undertaken. Accordingly, the scope of works undertaken for this study includes:

- Identify all foreshore areas that are undergoing erosion (both active and past) and the likely causes of the erosion;
- Map the locations of erosion at the local scale and document the severity of the erosion (including extent/dimensions, type, causes) and capacity to contribute to ongoing environmental and recreational problems such as water quality pollution, smothering of seagrasses, and foreshore amenity and access;
- Develop management actions to rehabilitate eroding areas and prioritise these actions for the whole estuary and for each LGA; and
- Provide three potential options to manage the mangrove undermining and erosion caused by the wake of the River Cat along the section of foreshore from Silverwater Bridge upstream to the Charles Street weir. Outline the pros and cons of each option including cost and environmental benefits / impacts.

5.3 Condition Assessment

5.3.1 Inspection Methodology

Visual inspections of natural foreshore areas experiencing erosion or recession were undertaken in August and September 2009. Most of the inspections were carried out by boat. Where boat access was not possible, inspections were undertaken from the shore. Inspections were carried out between mid and low tides to permit a visual inspection of most of the intertidal region.

A naming convention was derived based on the LGA in which the foreshore area was located and a sequential numbering system assigned from east to west along the LGA foreshore. The letters “NS” within the naming convention denote a natural shoreline. Each LGA code, and the number of discrete lengths of foreshore experiencing erosion or recession are presented in Table 5-1.

Table 5-1. Code and the number of foreshore areas experiencing erosion or recession

LGA	Code	No of eroding areas
Auburn	AUB_NS	1
Canada Bay	CAN_NS	13
Parramatta	PAR_NS	18
Ryde	RYD_NS	12

Areas of foreshore erosion were not evident in the Ashfield, Hunters Hill and Leichhardt LGAs.

An illustration of this naming convention is shown in Figure 5-5 showing the Putney foreshore located within the Ryde local government area.

Figure 5-5. Illustration of natural shoreline naming convention

5.3.2 Inspection Procedure

While undertaking the foreshore inspections the following information was recorded:

- The date, time, location (GPS coordinates) and tide level at the time of inspection;
- A description of the foreshore and land uses beyond and adjacent;
- The condition of the foreshore[6] (Table 5.2);
- Whether any assets are located on or in close vicinity to the eroding foreshore, and any potential hazards caused;
- Any other general observations or issues regarding the foreshore; and
- Representative site photographs for each foreshore area.

[6] The condition assessment has been made solely on the visual inspections carried out. As such, there may be hidden factors (such as subsurface disturbance) that may affect the condition of natural foreshore areas within the study area that could not be identified without more intrusive investigations.

Table 5-2. Foreshore erosion condition descriptions

Condition	Description
Good:	• Minor erosion scarp observed • Minor shoreline recession observed • Minor loss of fine sediments from between pneumatophores where mangroves are present
Poor:	• Moderate erosion scarp observed • Moderate shoreline recession observed • Where mangroves are present, fine sediment has been lost from between pneumatophores
Failed:	• Large erosion scarp observed • Extensive shoreline recession observed • All fine material has been lost from between pneumatophores where mangroves are present causing severe undermining and collapse of mangroves

5.3.3 Results

A total of 44 discrete areas of foreshore were erosion found in the study area, which equates to approximately 13 km of the study area's total shoreline (Table 5-3).

Table 5-3. Extent of foreshore erosion found in the study area

LGA	Good	Poor	Failed	Total Length of Foreshore Erosion in LGA (m)
Auburn	0.0	0.0	572.8	572.8
Canada Bay	1,035.7	1,131.8	142.1	2,309.6
Parramatta	0.0	369.2	8,212.30	8,581.5
Ryde	962.6	721.8	111.0	1,795.4
Total Length	**1,998.3**	**2,222.8**	**9,038.2**	**13,259.3**

Foreshore erosion is discussed further in the context of the entire study area in Section 5.4 and for each individual LGA in Section 9.0. All data collected is provided in the project GIS database.

Approximately 70% (9.2 km) of shoreline exhibiting erosion is located upstream of Silverwater Bridge. This section of the river is characterised by a narrow channel, shallow water depths and banks vegetated with mangroves, and is subject to long wave durations from Rivercat movements.

The majority of remedial options will apply to upstream of the Silverwater Bridge. Accordingly these are discussed first.

5.3.4 Foreshore Erosion Upstream of Silverwater Bridge

The Parramatta CBD has expanded over the past twenty years and many private companies and key NSW State Government agencies including Sydney Water and the NSW Police Force have moved their operations to the region. To service this growing metropolitan area, Sydney Ferries extended their service to the Parramatta CBD in 1992 (Sydney Ferries 2009). Prior to the extended ferry service commencing, comprehensive planning studies including vessel and route design and environmental evaluations were conducted. The ambient wave climate was quantified and the ferry vessels (Rivercats) were designed so that vessel wash would not exceed the prevailing wave climate (Macfarlane and Cox 2007).

Along with the commissioning of the vessels to service the route, ferry wharves were constructed at Rydalmere and Parramatta and extensive dredging was undertaken along the route to accommodate the design draught of the Rivercats.

Following commencement of the service, it became apparent that the Rivercat did not meet the design wave climate specifications. The resulting long period waves (Figure 5-6) most likely have led to extensive erosion of the natural foreshore and mangrove stands on the river (Macfarlane and Cox 2007).

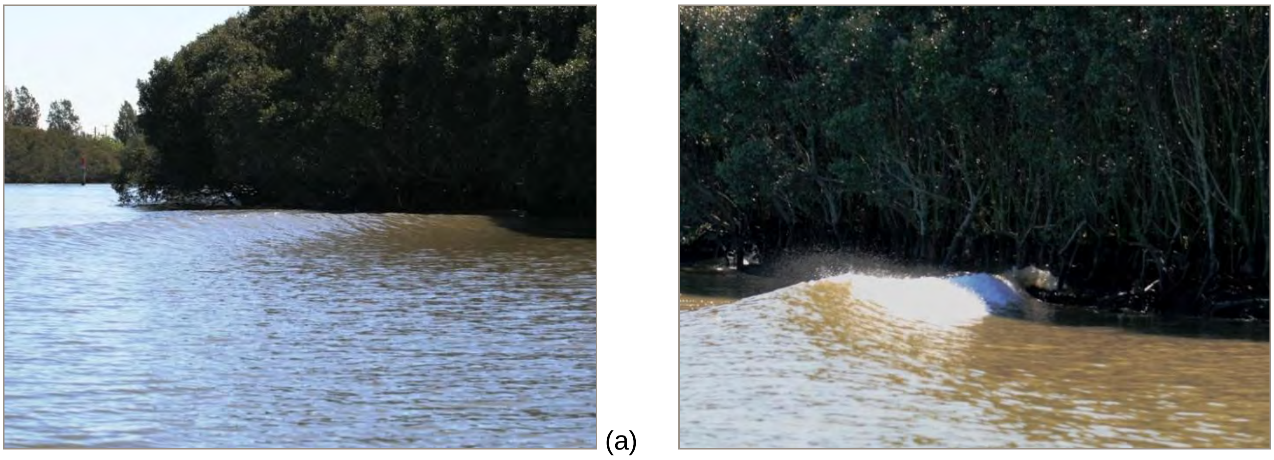
(a) (b)

Figure 5-6. Ferry wash at Rydalmere upstream of Silverwater Bridge

Severe shoreline erosion from Rivercat wash resulted in restrictions to vessel operations in an attempt to alleviate further shoreline impacts (Macfarlane and Cox 2007). Nielsen and Walker (2001) showed that shoreline sediments in the Parramatta River upstream of Silverwater Bridge are susceptible to re-suspension due to wave induced currents.

The Parramatta River Foreshore Plan (2009), as part of its management and improvement of foreshore open spaces noted:

> "*The operation of the Rivercat increases wave action and increased bank destabilisation…….*
>
> *Several areas of mangroves collapsing into the river as a result of erosion caused by the wash impacts of the Rivercat*."

The erosion observed in the upper areas of the Parramatta River cannot be wholly attributed to vessel wash. Wind induced waves, high river flow after rainfall and the loss of riparian vegetation also have contributed. In some locations, the upper bank structure has been weakened severely by the loss of riparian vegetation, exacerbating the impact of vessel wash (AMC 2009).

The locations of erosion, upstream of Silverwater Bridge, are shown in Figure 5-7.

Foreshore erosion
Estuarine mangrove

PARRAMATTA RIVER ESTUARY PROCESSES STUDY
FORESHORE EROSION UPSTREAM OF SILVERWATER BRIDGE

AUG 2010
60097281

0 0.1 0.2 0.4 km

Fig 5.7

5.4 Management Options

5.4.1 Upstream of Silverwater Bridge

The issue of vessel wash and the physical constraints of the river (i.e. narrow channel width, shallow depth, and proximity of foreshore development) present a significant challenge, and restrict the management options available.

A more recent trend in civil engineering of shorelines is the use of soft engineering, which employs ecological principles and practices to reduce erosion. Soft engineering is achieved by using vegetation and other materials to soften the land-water interface, thereby improving ecological features without compromising the engineered integrity of the shoreline or river edges.

In 2004, Lake Macquarie City Council embarked on a ‘soft engineering’ foreshore stabilisation approach for the management of the Lake Macquarie foreshore. The installation of traditional vertical seawalls throughout the lake had resulted in a loss of local ecology and the transference of erosion issues to adjacent properties. The key feature of this approach is the use of cobble beaches backed by larger armour rocks and the installation of native vegetation, a design which has been installed along over 30km of foreshore. Walpole *et al.* (2009) examined this approach and found that, generally, it had been successful. The exception has been at locations with an open fetch that experience a high energy wave climate. At these locations, cobble stones were lost and the backing armour stones dislodged exposing the soil bank to wave energy and ultimately erosion.

Brisbane City Council developed the Brisbane City Plan in (2000) a component of which was the inclusion of the Brisbane River Corridor Planning Scheme Policy. This policy outlines Council’s preferred approach to managing the Brisbane River Corridor. The river was divided into a number of precincts and preferred management options outlined for each. Where development constrains the installation of sloping environmentally friendly options, Council adopted a pragmatic approach to foreshore management. In these locations the installation of traditional protection would be allowed provided it is offset by the provision of public access where possible. In all precincts, retaining and enhancing riparian vegetation is encouraged.

The vessel wash experienced upstream of Silverwater Bridge on the river preclude the use of soft engineering techniques (including coir logs, jute matting, cobble stone beaches and wave attenuators or floating breakwaters). These options can generally only be used where wave periods are less than three seconds. Wave periods upstream of Silverwater Bridge are seven seconds and greater.

Additionally, the physical constraints of the channel prevent the use of large footprint environmentally friendly options. In light of these constraints and limited number of management options available, three potential solutions have been considered:

- Option 1 – Plastic Sheet Piles
- Option 2 – Rock/Concrete Armour
- Option 3 – Slatted Breakwater with Alternate Low Wash Vessel[7]

5.4.2 Option 1 –Sheet Pile

Ferry wash at the shoreline can be attenuated by the installation of sheet piles. Sheet piling can be traditional steel or alternative construction materials, such as Plastipile™ Recycled Plastic Sheet Piling (Figure 5-8a, manufactured by Vonmac Engineering) or SuperLoc™ Composite Sheet Pile System (Figure 5-8b, distributed by Australia Pacific Seawall).

[7] This option is reliant on a reduced wave climate. In theory reducing wave periods would significantly increase the range of remedial options available.

(a) (b)

Figure 5-8. (a) Plastipile and rubble installation, Dawson Reserve, SA (Vonmac 2009) and (b) SuperLoc™ used as a seawall allowing for reclamation and / or regeneration of vegetation

It is envisaged that two intermittent rows of sheet pile wall could be used to retain intertidal exchange and maintain natural habitat (Figure 5-9). A porous rubble rock structure would be used between the pile wall segments to control water flow while providing channels for fish movement at high tide.

This option would require validation by physical model testing and it is recommended that a section be installed along the river for *in-situ* proof of concept testing.

The pros, cons and environmental benefits/impacts of this option are presented in Table 5-4.

Table 5-4. Option 1, plastic sheet piles pros, cons and environmental benefits/impacts

Pros	Cons	Environmental Benefits / Impacts
• Easy installation • Minimal disturbance to river bed • Alternative construction material without the many performance disadvantages of conventional materials such as aluminium, concrete and wood (i.e. will not corrode, decay or spall) thereby reducing maintenance costs and future replacements).	• Sheet pile wall probably needs to be installed from a barge. It is likely that this can only be achieved close to high tide • Generation of noise during construction • The gaps between the sheet piling may be a region of scour (model testing is recommended to refine design concept)	• Allows marine fauna migration through gaps in sheets • Habitat provision (artificial reef habitat) provided by rubble and gaps between various sized rock • Prevent further erosion scour of river banks and promote the settling of fine sediments in the mangrove zones

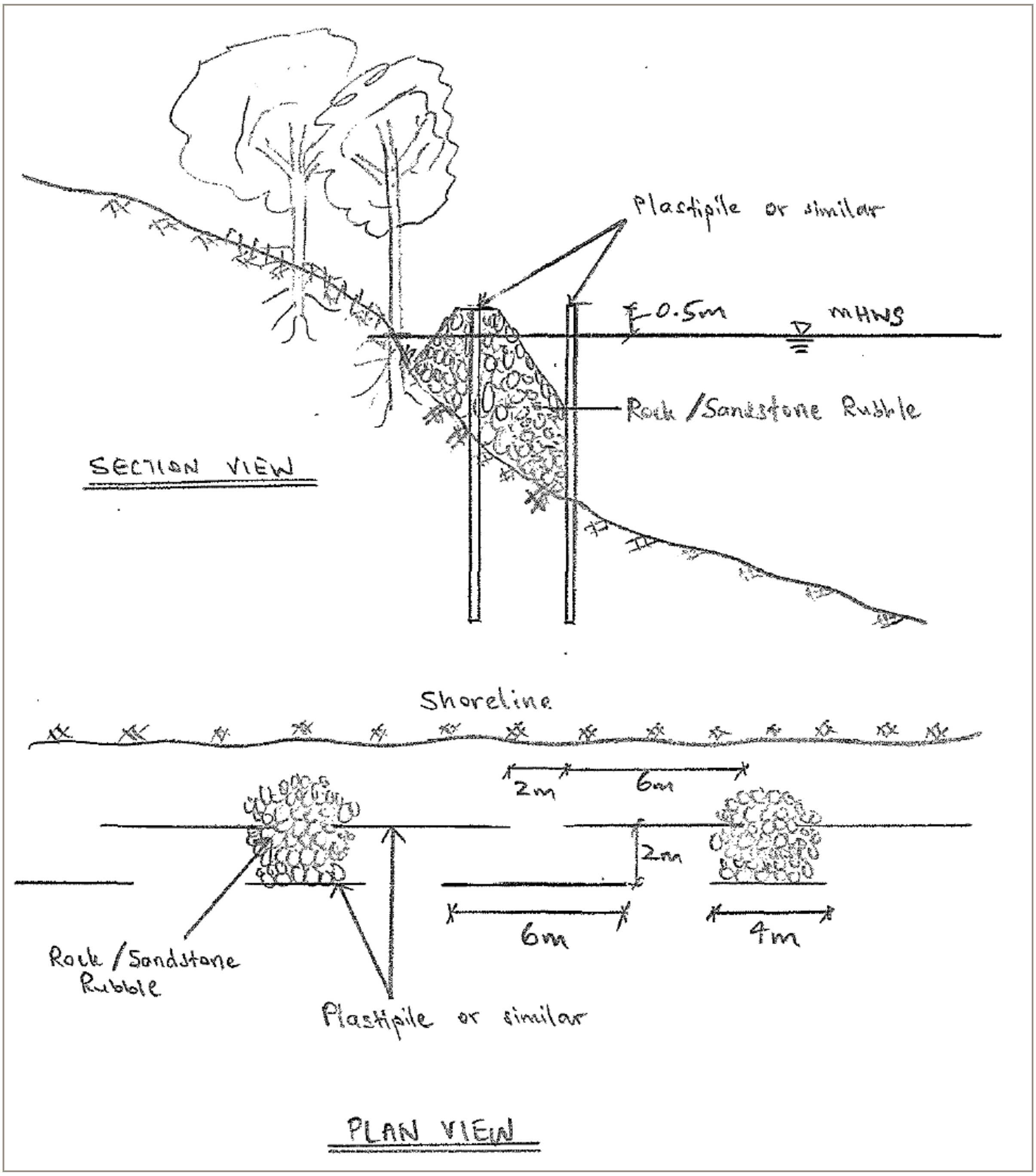

Figure 5-9. Option 1 – Plastic Sheet Pile indicative design

5.4.3 Option 2 –Rock/Concrete Armour

The installation of rock or concrete armour units would protect the shoreline. The structure would need to consider typical engineering detail and include appropriate underlayers. Sediment would be allowed to accumulate naturally behind the structure encouraging mangrove re-growth and eventually concealing the structure. Experience in Queensland has found that fish may become stranded behind the structure necessitating the inclusion of ‘Fish Pipes’ to allow access back to the main channel at low tide (Derbyshire 2006).

This option has been employed at discrete locations upstream of Silverwater Bridge using A-Jack armour units (Figure 5-10). Prior to additional structures being recommended or installed, a detailed study of the performance of these existing structures should be undertaken. A-Jacks have also been used on the Coomera River in Queensland (Figure 5-11, Derbyshire 2006).

The pros, cons and environmental benefits/impacts of this option are presented in Table 5-5.

Figure 5-10. A-Jack units installed in front of mangroves on the Parramatta River upstream of Silverwater Bridge

Figure 5-11. A-Jack units installed in front of mangroves at Charles Holm Park on the Coomera River QLD (Derbyshire 2006)

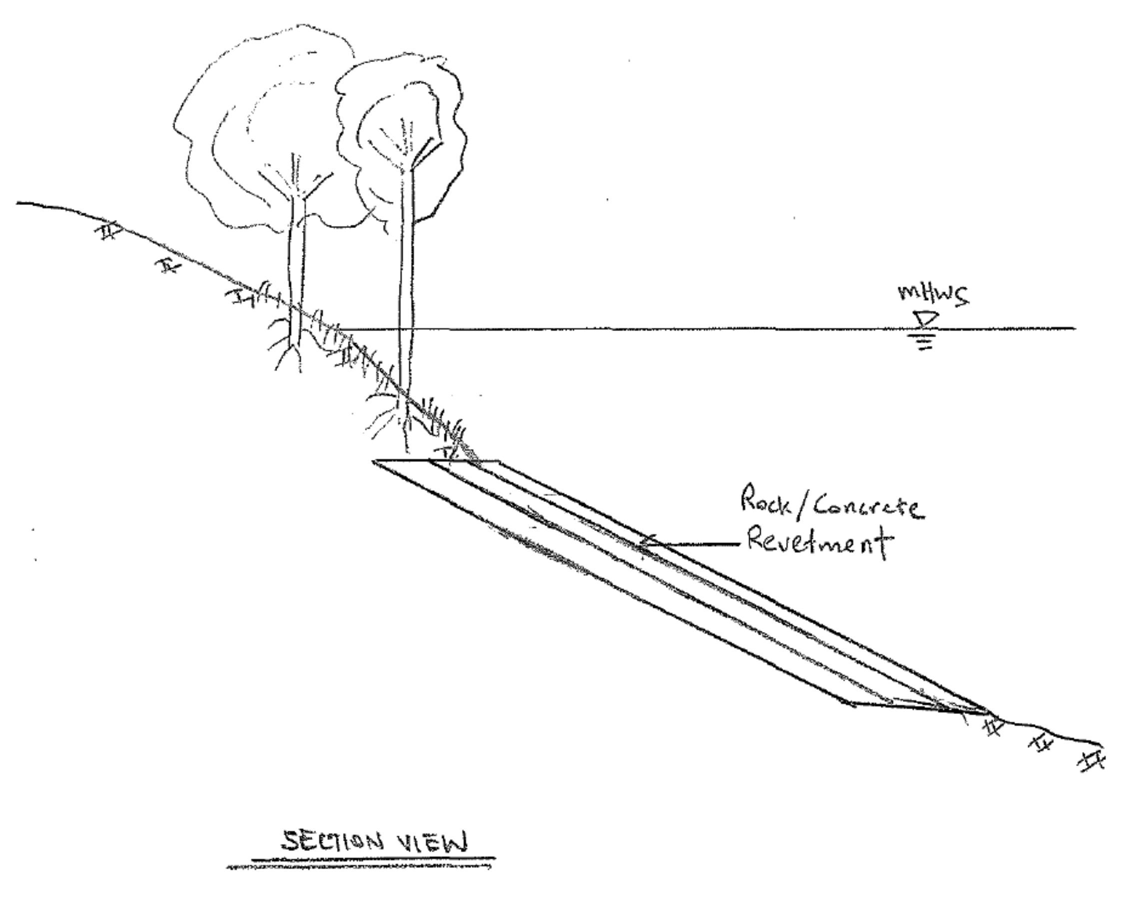

Figure 5-12. Option 2 –Rock/Concrete Armour

Table 5-5. Option 2, rock/concrete armour revetment pro, cons and environmental benefits/impacts

Pros	Cons	Environmental Benefits / Impacts
• Rock revetments are used extensively along river banks • Flexible structure accommodating differential settlement • Easy to maintain/repair	• Requires excavation of river bank • Soils potentially contaminated • Construction access difficult • Generation of noise during construction	• Habitat provision (artificial reef habitat) provided by rubble and gaps between various sized rock • Provides some scour protection for mangroves (but not complete protection)

5.4.4 Option 3 – Slatted Timber (Wavescreen) Breakwater with Alternate Low Wash Vessel

Vertical timber slats installed parallel to the foreshore have been shown to attenuate wave energy (Coghlan *et al.* 2009 and Bettington & Cox 1997). As the breakwater does not extend to the full length of the water column, water circulation and flow regimes can be maintained.

These breakwaters are only effective for short period waves (less than 3s) and for this option to be viable, the current vessels would need to be replaced with a low wash (short wave period) alternative. Prior to consideration of this option a commitment would need to be made to replace the Rivercat vessels. Studies of the wash produced by the proposed alternate vessel would be required to ensure that wash is within acceptable limits.

Wavescreen breakwaters have been successfully installed at Brotherson Dock in Port Botany and at the Royal Prince Alfred Yacht Club in Pittwater (Figure 5-13) and at many other locations in and around Sydney.

A sketch of Option 3 is shown in Figure 5-14. The pros, cons and environmental benefits/impacts of this option are presented in Table 5-6.

Figure 5-13. Slatted Breakwater, Royal Alfred Yacht Club, Pittwater

Table 5-6. Option 3, slatted breakwater pros, cons and environmental benefits/impacts

Pros	Cons	Environmental Benefits / Impacts
• Environmentally friendly using timber structures • Easy installation	• This system is only viable if there is a change in vessel operation criteria upstream of Silverwater Bridge. *Existing vessels would need to be replaced by smaller vessels with significantly reduced wash* • Construction requires barges. It is likely that this can only be achieved close to high tide. • Generation of noise during construction	• Allows marine fauna migration • Prevents further erosion and scour of the river bank

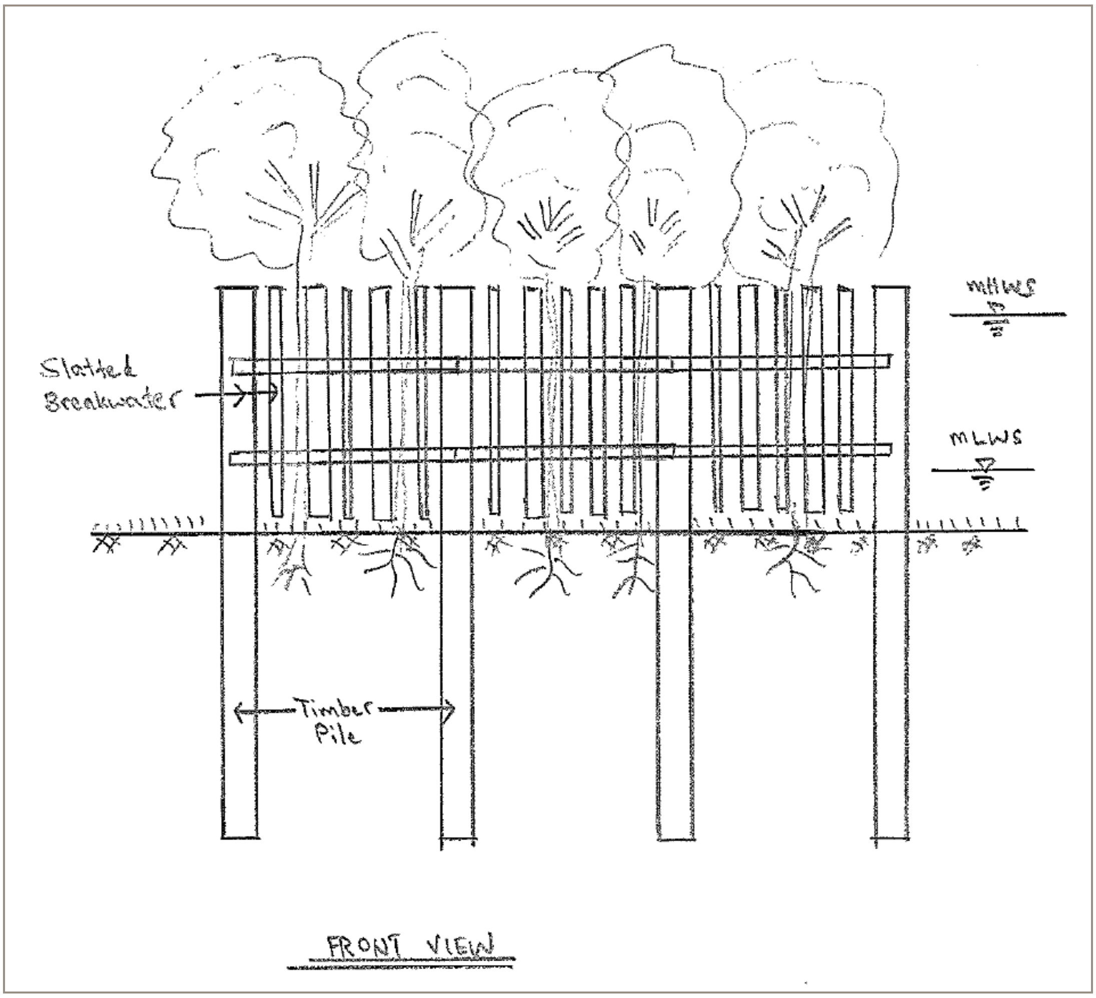

Figure 5-14. Option 3 – Slatted Breakwater

5.4.5 Cost Considerations

The estimated length of shoreline requiring protection upstream of Silverwater Bridge is 8km. Initial cost estimates for each option have been prepared and are presented in Table 5-10.

Table 5-7. Indicative costs for management options upstream of Silverwater Bridge

Option	Indicative Cost $/m
1) Plastic Sheet Pile	$3,000-$5,000
2) Rock/Concrete Armour	$3,000-$5,000
3) Slatted Breakwater*	$1,500-$3,000

*N.B. Option 3 requires an alternate low wash vessel. The costs associated with this are not included.

These costs are indicative, a number of factors including; material requirements, ground conditions, access, maintenance requirements and site hydrodynamics may influence the initial capital and ongoing costs of each management option.

5.4.6 Downstream of Silverwater Bridge

Several areas of erosion located downstream of Silverwater Bridge would be suited to soft engineering stabilisation techniques, particularly where shorelines are located in embayments away from high energy environments. Techniques considered suitable for many of these locations are illustrated in the following figures:

Low Profile Sill (LPS)

Low profile structures (continuous or vented sills) can protect the shoreline from wave action while allowing vegetation to establish and movement of aquatic biota. They work by creating an area of still water in front of the eroding bank, which allows sediments to drop out and accumulate. Structures are place roughly parallel to and about 3 to 5 m in front of the eroding bank to dissipate wave action, and built to a height that corresponds with the mean high water level (Wiecek, 2009).


(a)


(b)

Figure 5-15. Rock fillet work allowing mangrove seedlings to regenerate, (a) Hastings River (b) Dumaresq Island, Manning River


(a)


(b)

Figure 5-16. (a) Low profile sill and newly created marsh (b) Low profile sill, marsh and stabilised cliff (MDE, 2008)

Vented Sill (VS)

It is essential that low profile sills (also known as rock fillets) be constructed in such a way that allows for flushing and wildlife access to the shore. However, vents can facilitate erosion where the wave action is persistent. This can be overcome by staggering sill placement in a linear manner (Figure 5-17).

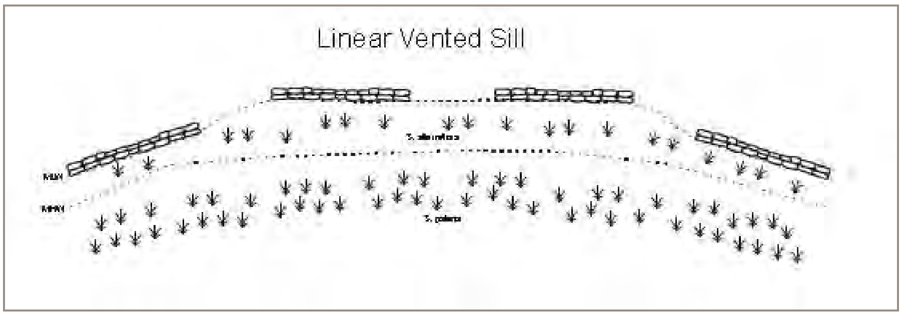

Figure 5-17. Staggered and vented sill (MDE, 2008)

Coir Log (CL)

Coir logs, also known as coir rolls and coconut fibre rolls, are densely packed coconut fibre tubes bound together with coir netting. The coconut fibre is biodegradable, gradually breaking apart through exposure to water movements and weather. Coir logs are anchored along the toe of riverbanks to provide short-term protection for establishing vegetation, as shown in Figure 5-18(a).

Because coir logs do not provide long term bank stabilisation, they should be used only in situations where revegetation will provide all necessary long-term bank strength. Coir logs are not recommended with revegetation in areas with high water velocities or in actively incising reaches. In these situations they need to be used with other stabilisation techniques. Coir logs may locally enhance wave reflection and scour in areas susceptible to wind waves and boat wakes as they have limited porosity. Coir logs placed in high wave conditions are susceptible to undercutting and removal.


(a)


(b)

Figure 5-18. (a) Coir logs installed on the banks of the Lower Murray River and (b) Tidal riverbank restoration using mangroves (Southern Rivers CMA)

Mangrove Establishment (ME)

Mangrove seedlings can be planted as a fringing strip in front erosion scarps to provide habitat and encourage sediment deposition and toe protection. Mangrove plantings will require protection from waves and from flotsam and jetsam in order to successfully establish. Temporary wave barriers such as mesh fencing can be used, as shown in Figure 5-18(b).

In order to prioritise where repair / mitigation rehabilitation works should be undertaken, areas of foreshore erosion were further assessed to determine whether any assets, recreation or other public amenity, and / or ecological values would be affected in the absence of management intervention (i.e. if erosion continued would any of these aspects be adversely impacted upon or potentially lost).

Table 5-8 summarises sections of foreshore which were categorised as ‘failed’ or ‘poor’ due to the severity of erosion and indicates appropriate stabilisation techniques. All areas of foreshore erosion are discussed on a site by site basis in Section 9.0 LGA management summaries.

Table 5-8. Prioritised shoreline erosion in study area

Priority	Asset Name	Locality	LGA	Condition	Asset	Access	Recreation value	Ecological value	Technique
Very High	CAN_NS21	Concord Hospital Watergate, Rocky Point	Canada Bay	Failed	√	√	√		Seawall (CAN_S66)
High	PAR_NS08	James Ruse Dr to west of Macarthur St	Parramatta	Failed			√	√	Options 1-3
High	PAR_NS12	East of James Ruse Drive Bridge	Parramatta	Failed	√			√	Options 1-3
High	PAR_NS15	Southeast of Rydalmere Rail Bridge	Parramatta	Failed	√			√	Options 1-3
High	CAN_NS03	Henley Marine Drive, Iron Cove	Canada Bay	Poor	√	√	√	√	LPS
High	CAN_NS04	Henley Marine Drive, Iron Cove	Canada Bay	Poor	√	√	√	√	LPS
Med-High	PAR_NS14	East of James Ruse Drive Bridge	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS17	Thackeray St Bridge to Duck River confl.	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS05	Thackeray St to Rydalmere Rail Bridge	Parramatta	Failed				√	Options 1-3
Med-High	RYD_NS15	East of West Ryde Wharf	Ryde	Failed				√	Options 1-3
Med-High	PAR_NS02	George Kendall Reserve, Ermington	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS04	West of Thackeray St Footbridge	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS06	Rydalmere Rail to James Ruse Drive	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS07	Beneath James Ruse Drive	Parramatta	Failed	√				Options 1-3

Priority	Asset Name	Locality	LGA	Condition	Asset	Access	Recreation value	Ecological value	Technique
Med-High	PAR_NS13	Beneath James Ruse Drive, South Bank	Parramatta	Failed		√			Options 1-3
Med-High	PAR_NS16	West of Thackeray St Footbridge	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS18	Duck River to Parramatta River confl.	Parramatta	Failed				√	Options 1-3
Med-High	PAR_NS03	Eric Primrose Reserve, Ermington	Parramatta	Failed				√	Options 1-3
Med-High	AUB_NS01	Duck River Eastern Bank	Auburn	Failed				√	Options 1-3
Med-High	RYD_NS07	Kissing Point Park, Putney	Ryde	Poor	√	√	√		LPS, Seawall (RP)
Med-High	RYD_NS13	Meadowbank, adjacent to rail bridge	Ryde	Poor	√	√	√		Seawall (ARH at RYD_S23)
Medium	PAR_NS09	West of Macarthur St Bridge, South Bank	Parramatta	Poor			√	√	Options 1-3
Medium	PAR_NS10	West of Macarthur St Bridge, South Bank	Parramatta	Poor			√	√	Options 1-3
Medium	PAR_NS11	East of James Ruse Drive Bridge	Parramatta	Poor	√			√	Options 1-3
Medium	CAN_NS20	Concord Hospital, Yaralla Bay	Canada Bay	Poor			√	√	RE
Medium	CAN_NS22	West of Concord Hospital Watergate	Canada Bay	Poor	√			√	Seawall (CAN_S66)
Medium	RYD_NS08	Adj. Ryde & Concord Sailing Club, Putney	Ryde	Poor			√	√	VS
Low	RYD_NS11	Settlers Park, Putney	Ryde	Poor				√	VS

Priority	Asset Name	Locality	LGA	Condition	Asset	Access	Recreation value	Ecological value	Technique
Low	RYD_NS14	Korpie Reserve, Melrose Park	Ryde	Poor				√	Options 1-3
Low	PAR_NS01	West of West Ryde Wharf	Parramatta	Poor				√	Options 1-3
Low	CAN_NS19	Yaralla Bay	Canada Bay	Poor				√	RE

Options 1-3	Long period waves preclude use of most stabilisation techniques, refer to Option 1(s. 5.4.2), Option 2 (s.5.4.3), and Option 2 (s.5.4.4)
LPS	Low Profile Sill (refer Figure 5-15 and Figure 5-16)
VS	Staggered and Vented Sill (refer Figure 5-17)
ARH	Artificial reef habitat (refer Section 4.8.1 Habitat Creation Options)
RP	Rock pools (refer Section 4.8.1 Habitat Creation Options)
RE	Riparian establishment: establishment of riparian or saltmarsh plantings to stabilise soils
Seawalls	Refers to either of (a) site specific seawall replacement / repair recommendations which should include area of foreshore erosion, or (b) technique described for habitat creation in seawall repairs or replacement (Section 4.8.1 Habitat Creation Options).