# "*Carrying Many Small Stones*" – A Story of Foreshore Stabilisation in Lake Macquarie

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## Abstract

Stabilising eroding areas of the Lake Macquarie's extensive foreshore (over 170km) has presented ongoing challenges to Council and private landowners. Historically, stabilisation responses have involved engineering solutions, particularly the construction of vertical concrete seawalls. However, the construction of 'hard' structures is now known to come at a price, with impacts on nearshore ecology, and the transference of erosion to neighbouring properties being increasingly understood. This paper focuses on the alternative. 'soft engineering' foreshore stabilisation approach which was adopted by Council in 2004, and examines the successes and ongoing challenges of this approach.

A key feature of Council's 'soft engineering' approach has been the use of cobble beaches as a stabilisation treatment on both private and public foreshore land. The construction of cobble beaches, which exist naturally around the Lake, have proven successful in stabilising eroding shorelines, whilst maintaining recreational amenity and minimising impacts on local ecology.

An extensive program of cobble beach construction has taken place on eroding areas of 'public' land. These works, undertaken by the Office of the Lake Macquarie and Catchment Coordinator, have been well received by the local community, as residents are now enjoying the improved water quality and increased amenity that these beaches provide. This program has installed over 36km of beaches to date around the Lake's foreshore.

Providing suitable foreshore treatments on private land has also been an important component of Council's approach. The introduction of planning provisions and associated guidelines, and the successes/challenges of their implementation will also be discussed.

A Chinese proverb states that '*the man who moves a mountain begins by carrying many small stones'*. Perhaps the many small stones that make up our cobble beaches signify a start to improving the long-term management of Lake Macquarie's foreshore areas.

## Lake Macquarie Foreshores

Lake Macquarie is a large coastal lagoon, located on the NSW Central Coast, and has 174 km of estuarine foreshore. This foreshore land plays a significant role in influencing the ecology of the Lake, as well as having significant recreational and amenity value to local residents. Approximately 40% of the shoreline is privately owned (ie, properties with 'absolute water frontage'), and the remainder is either a Council reserve, Crown reserve or DECCW estate.


Erosion of lake foreshores is primarily driven by wind waves, particularly in areas where the locality has a relatively large fetch, thus allowing wave energy to impact on the shoreline. Wave heights of over 1mtr are often experienced, particularly on south facing shorelines. Other natural processes affecting foreshore erosion include long-shore drift and incoming stream-flows.

Despite these erosion processes, the incidence of 'naturally occurring' foreshore erosion are generally minimal, and isolated to a small number of sites. In general, foreshore erosion is normally a result of anthropogenic modifications, particularly the clearing of littoral/riparian vegetation, filling of foreshore land, and/or inappropriate stabilisation techniques.

The large proportion of privately owned waterfront properties have historically installed some type of vertical seawall, which are generally backfilled with soil to create a flat and level yard. These structures have often been installed with the purpose of 'landscaping' the property, and are generally not required to address a specific erosion problem on the site. These seawalls are known to cause many ecological issues, and

often create erosion problems on neighbouring properties, due to reflection/refraction of wave energy. These walls also significantly interfere with the natural movement of seagrass wrack, resulting in a determination of amenity and water quality issues.

Much of the foreshore land in public ownership had, in the early part of the last century, had also been filled and raised at the water's edge. The resultant vertical escarpment not only increased erosion but acted in a similar way to seawalls in interfering with natural processes. Seagrass wrack naturally washes out of the water to decompose aerobically and quickly in the littoral vegetation zone. The extensively modified vertical escarpments not only affected habitat but caused the wrack to be trapped in the water in the nearshore zone. The anaerobic conditions caused not only bad odours, but also killed off sea life, and resulted in community complaints about the "odorous ooze" in the nearshore zone.

## Adopting a "Soft Engineering" Approach

Council completed the Lake Macquarie Estuary Management Plan in 1997. Continuing community concern over deteriorating lake water quality led the then State Premier (the Hon. Bob Carr) to appoint the Lake Macquarie Task Force to review and make recommendations for improvements. The Office of the Lake Macquarie and Catchment Coordinator (OLM&CC) was established in July 1999 and undertook implementation of the Lake Macquarie Improvement Plan for 10 years until June 2009. This Project was an initiative of and funded by Lake Macquarie City Council, Wyong Shire Council and the State Government.

During the 10 year term of this integrated project, significant improvements were made in water quality (95% improvement in water clarity) and in combined seagrass species coverage (up 23%). The emphasis of both the Estuary Management Plan and The Lake Macquarie Improvement Project was on the use of 'a soft engineering' approach, by restoring or mimicking the natural processes that previously existed prior to European modifications and development.

This soft engineering approach was applied to Lake foreshore, commencing in 2004. A number of foreshore stabilisation techniques where trialled by the OLM&CC, including the creation of sloping 'cobble beaches' on eroding public foreshores in Northern Lake Macquarie. The use of 'cobble beaches' and associated littoral vegetation proved to be the most successful stabilisation methodology, and trial sites rapidly demonstrated improvements in amenity, recreational value, habitat value and nearshore water quality.

Following the successes of this soft engineering approach, Council commenced a program of implementing an extensive foreshore restoration works on public land, as well as adopting a new planning approach with regards to 'private' foreshore development proposals.

## A New Planning Approach for Foreshore Development

Following the success of the OLM&CC's foreshore restoration program on public land, Council implemented a new approach to 'private' foreshore development. This involved the adoption of variety of planning provisions relevant to foreshore development, including the:

1. Lake Macquarie Local Environment Plan 2004
2. Lake Macquarie Development Control Plan No. 1 2004
3. Lake Macquarie Foreshore Stabilisation and Rehabilitation Guidelines 2004
4. Lake Macquarie Estuarine Creekbank Stabilisation and Rehabilitation Guidelines 2004

These provisions and associated guidelines changed the focus of Council's approach to foreshore development from a 'hard engineering' approach, (with solutions such as filling, seawalls and concrete) to an approach that was focused on sustainable water cycle management, and used 'soft engineering' treatments to preserve the ecology and amenity of foreshores.

Through implementing these provisions, Council effectively banned the construction of new private seawalls around the Lake (except under exceptional circumstances), and required new foreshore stabilisation works to be undertaken in accordance with the *Lake Macquarie Foreshore Stabilisation and Rehabilitation Guidelines 2004*.

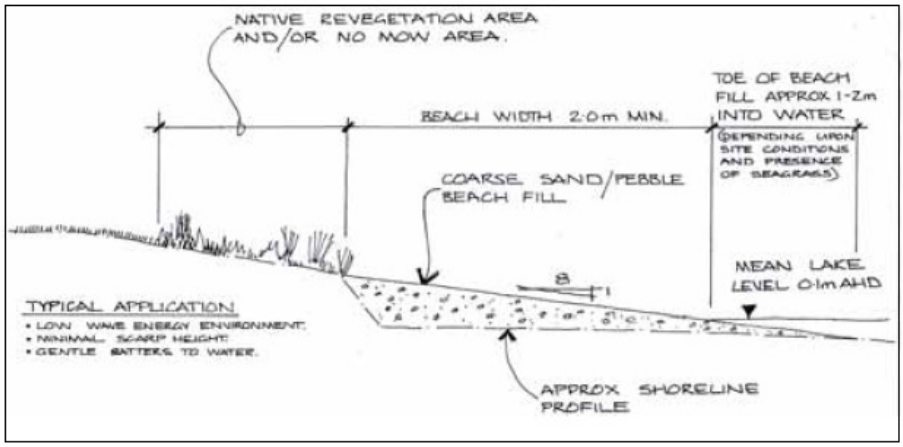



***Diagram 2 – Example of a Typical Beach Fill***

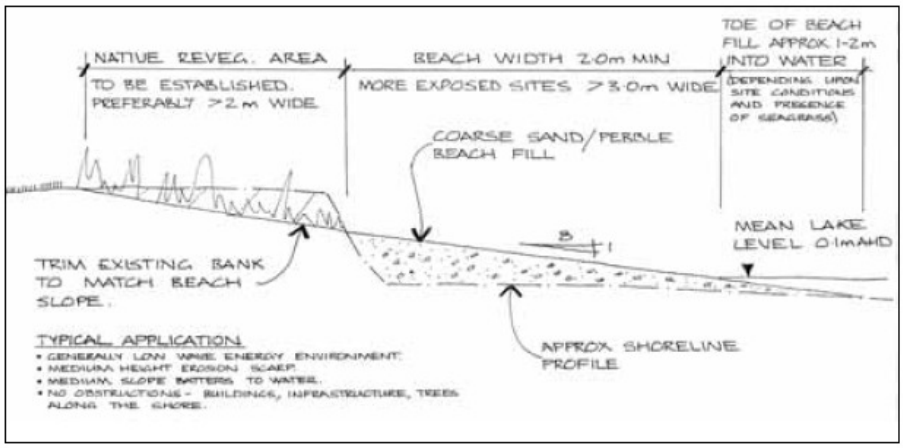



***Diagram 3 – Example of a Typical Beach Fill***

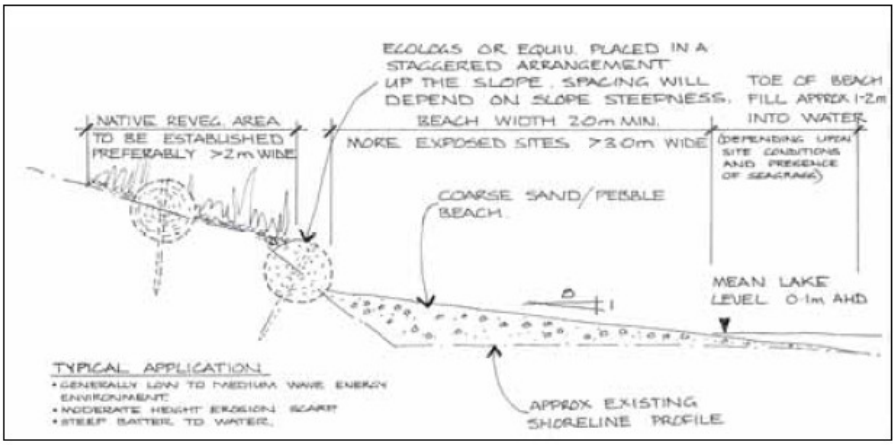
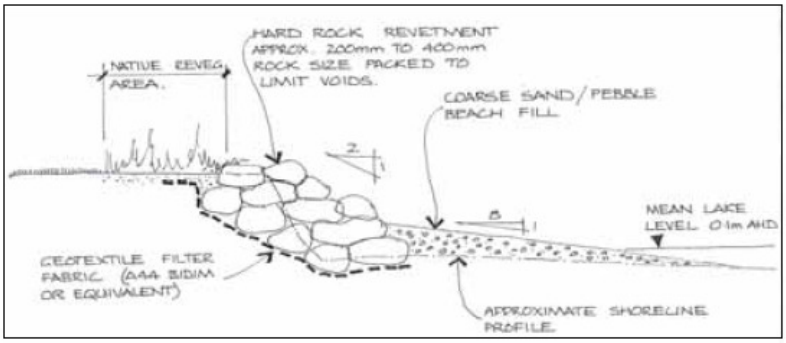



***Diagram 4 – Typical Beach using Coconut Fibre Log Fill***

***Diagram 5 – Revetment for low to moderate wave action.***



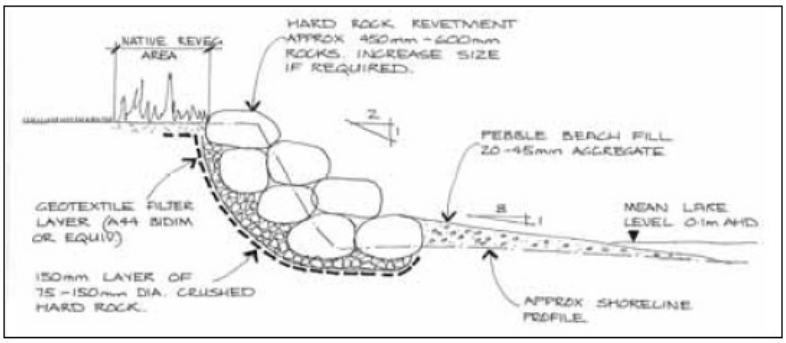
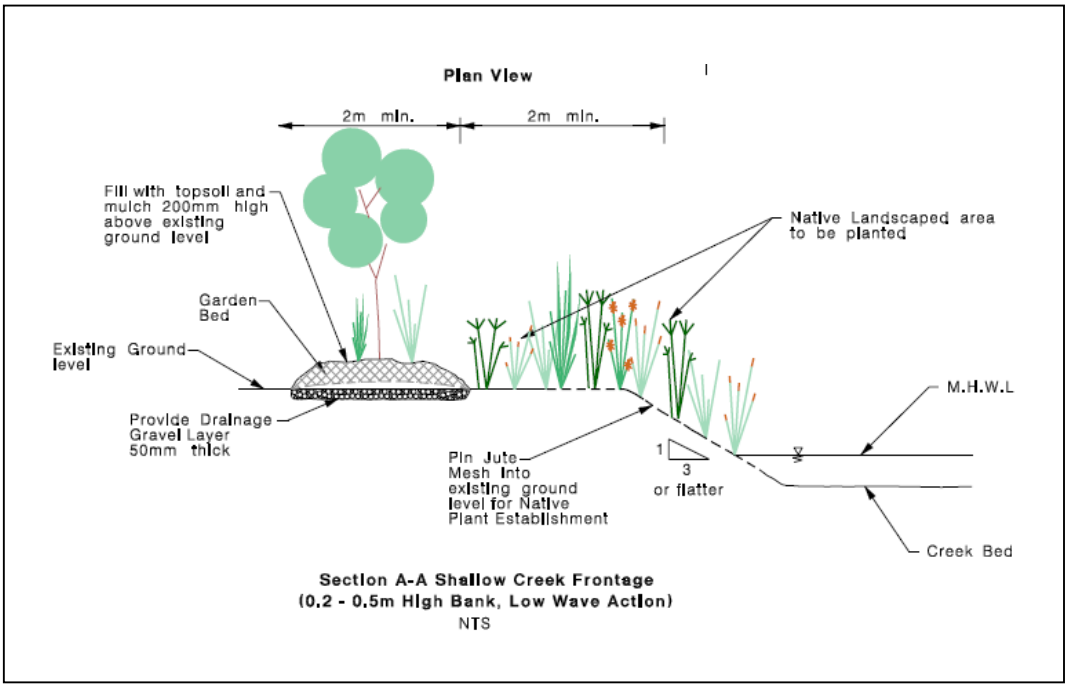



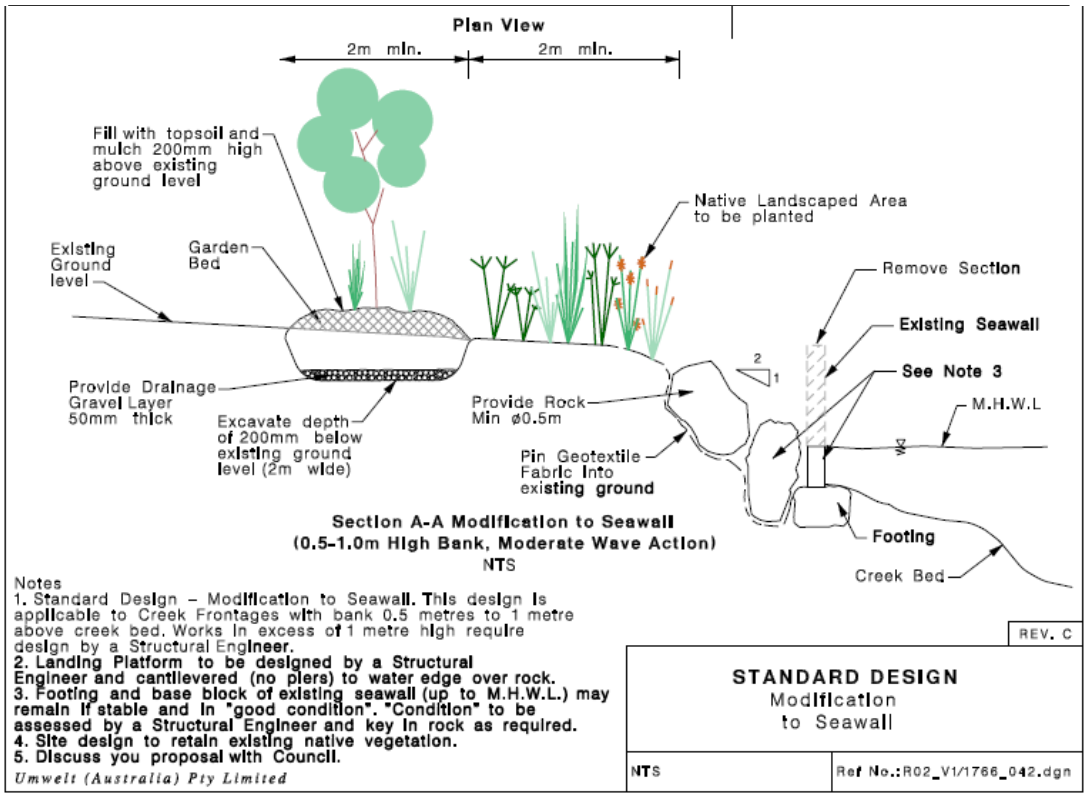

***Diagram 6 – Revetment for high wave action.***

Figures from the*: Lake Macquarie Foreshore Stabilisation and Rehabilitation Guidelines 2004 (*LMCC, 2004c*)*

These guidelines provide a number of 'typical' stabilisation designs, provided above, and include recommendations of foreshore profiles, the use of sloping 'cobble beaches', associated littoral vegetation plantings, and the use of sloping rock revetments.

In addition to these guidelines for lakefront properties, a complementary set of guidelines was also developed for estuarine creekbank areas. It was determined that estuarine creekbanks behave in a differing manner to lakefront sites, and typically have steeper banks and greater water level variability. In response to these differing circumstances, the *Lake Macquarie Estuarine Creekbank Stabilisation and Rehabilitation Guidelines 2004* were also developed for creekbank applications. A number of 'typical' creekbank stabilisation techniques and provided below, including a 'typical' design for the removal of existing seawalls along creekbanks.




Figures from the*: Lake Macquarie Estuarine Creekbank Stabilisation and Rehabilitation Guidelines 2004* (LMCC, 2004d*)*

## Implementing the New Planning Approach

Following the adoption of the new planning provisions listed above, Council commenced the implementation of these provisions through the development application and assessment process. This process involves a number of referrals to other agencies, as Integrated Development. These referrals include the NSW Department of Lands (as landowners of the Lake bed), the Department of Environment Climate Change and Water DECCW (under the Water Management Act 2000) and often the Department of Primary Industries (under the Fisheries Management Act 1994, where seagrass or saltmarsh are impacted).

In addition to these external agency referrals, Council also implemented a procedure whereby all applications for foreshore development are referred to Council's Sustainability Department for comment prior to determination. In circumstances where impacts are considered to be potentially significant, the application is also referred to the Lake Macquarie Estuary and Coastal Management Committee for consideration. This committee comprises relevant Government Agency representatives involved in the management of Lake Macquarie, as well as representatives from relevant community groups, and has provided valuable input on numerous development proposals.

Based on the application of Council's planning provisions, a number of applications for concrete seawall were either significantly altered through the application process, or in some cases refused by Council.

Council's position of not approving vertical seawalls was challenged in NSW Land and Environment Court of New South Wales, when an appeal over a refusal was challenged in March 2004. The application was for the construction of a vertical concrete seawall on a property at Coal Point NSW, which was refused by Council as it failed to comply with the relevant Development Control Plan provisions and associated guidelines.

The Court heard from expert witnesses for both parties and also inspected foreshore stabilisation works (sloping pebble beach and littoral vegetation) that had been constructed by the Office of the Lake Macquarie and Catchment Coordinator (OLM&CC).

Often it is believed that some applications for seawalls are driven more by appearances, or a desire for the waterfront to be finished in a "neat and tidy" way with manicured lawns or paving down to the water's edge rather than a genuine need.

This was the finding of the Courts in this particular case, as there was no evidence of active erosion in front of the property, and further, if erosion had been found that there were alternative and more environmentally sound techniques that could be used rather than vertical seawalls (Land and Environment Court of New South Wales, 2004).

## Public Foreshore Restoration Program

To manage the continual degradation of the Lake's foreshore in areas of public reserve, a technique of installing a sloping foreshore beach was developed to mimic the natural profile of the Lake's edge. The main problem to be addressed was the transfer of wind/boat wave energy as they impacted the foreshore edge. As with a beach at the interface between the ocean and the shore, a sloping foreshore profile provides a platform for the dissipation of energy contained within the wave as it discharges its energy at the foreshore edge. Without this sloping beach profile, the wave energy discharges the majority of its energy at the same point in time on the foreshore where there is an abrupt change in water depth. The outcome of such energy exchange is movement of foreshore sediments if the impact of the wave is sufficient to destabilise the foreshore. As a result, erosion of the foreshore continues, and the mini-escarpment becomes larger (as the erosion moves landward) and the condition of the near-shore environment continues to degrade.

Eroding Lake foreshores provided two separate problems. The erosion not only washes sediments into the Lake, but the resulting vertical escarpment on the shoreline prevents dead seagrass wrack from washing out of the water. This causes a build up of odorous decaying vegetation and associated anaerobic conditions in the near shore zone. An innovative technique was utilised to address this problem and restore natural processes.

Initial attempts at stabilising this foreshore erosion included the use of Coir logs pegged in places to provide a buffer against the wave energy along the foreshore. Although the coir logs provided a barrier between the foreshore and the incoming waves, they failed to reduce the wave energy along the foreshore edge and subsequently in times of high winds they became dislodged and exposed the foreshore to the impacts of the wave energy. Consequently, this technique was discontinued and the sloping cobble beach technique became the preferred method of foreshore restoration around Lake Macquarie.

To augment the installation of the sloping beach the introduction of native vegetation to the terrestrial foreshore environment was also critical to the stabilisation of the foreshore. One of the major contributors to the erodibility of the foreshore was a loss in cohesive strength of the sediments provided by the presence of vegetation root mass. The importance of vegetation in providing cohesive strength to soil is well documented in the literature and has a major role in protecting against and reducing erosion. Combined with people movement into and out of the Lake, and historic vegetation clearing, many areas of the Lakes foreshore had/has little native vegetation cover. Consequently, all foreshore restoration projects included a significant quantity of foreshore vegetation establishment and maintenace.

A key consideration for all physical works was the need for integration with economic and social considerations, to ensure a holistic approach to each task. Examples of this approach involved leaving stretches of foreshore stabilisation works without vegetation to enable community access with canoes, or in another case for a commercial operator access for small sailing craft.

### *Foreshore Restoration Designs*

Variability in the extent of foreshore erosion has required the development of a variety of foreshore restoration treatment types. The predominant consideration in determining which technique to use is the height of the eroded foreshore. Many factors combine to influence the rate of foreshore erosion, including exposure to prevailing winds, length of wind fetch, boating activity, foreshore use, presence, or absence of vegetation and soil type. Whatever the combination of factors may be contributing to the erosion the resultant foreshore height will determine the treatment to be adopted.

Council has a number of standard drawings/plans to address foreshore erosion as shown below. The plans show a gradation of foreshore heights in which suitably sized rock is used to provide a solid structure to build the sloping foreshore up to. An important design aspect of the sloping beach is the grade at which the cobble is placed. Experience has shown that the natural self-levelling processes of wave action results in a slope of 1:8. This slope angle provides the most efficient grade for wave action to dissipate energy before hitting the armour rock.

A sloping pebble beach using washed river gravel allows seagrass wrack to wash out of the water naturally and break down quickly in the vegetation zone. This approach has proved very successful ,and popular, with the community. Not only did the pebble beach stand up well to wave attacks during large storms, but also the reversed or new aerobic conditions in the near shore zone encouraged sea life to return.

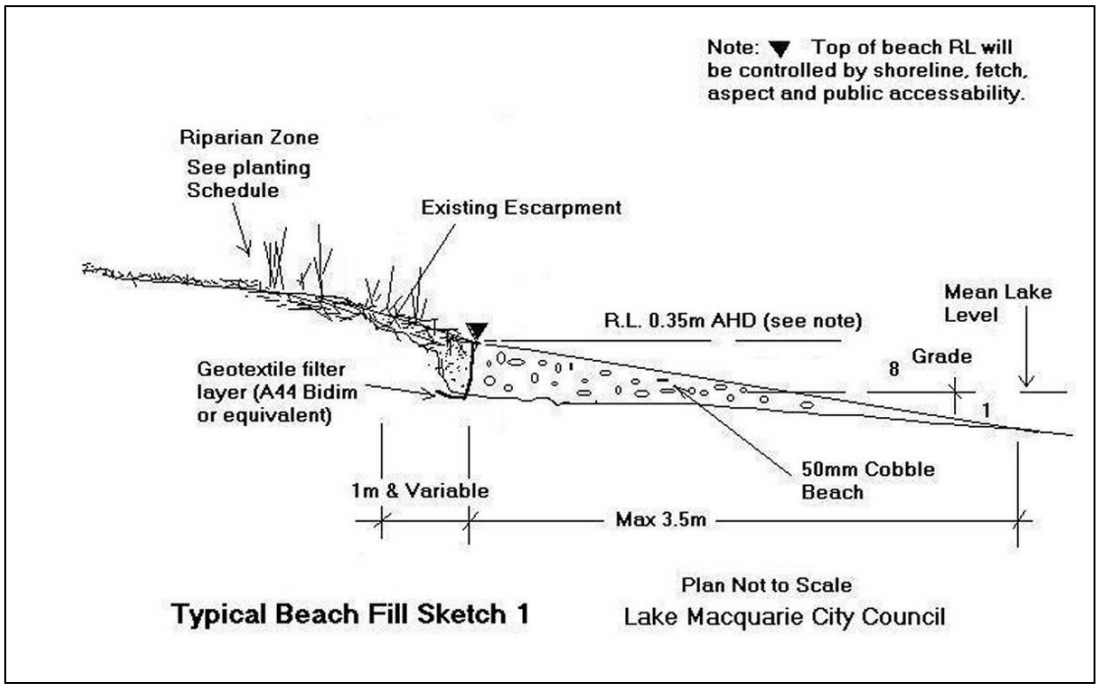



Fig 1 – Typical foreshore profile for eroding foreshore with minimal foreshore erosion.

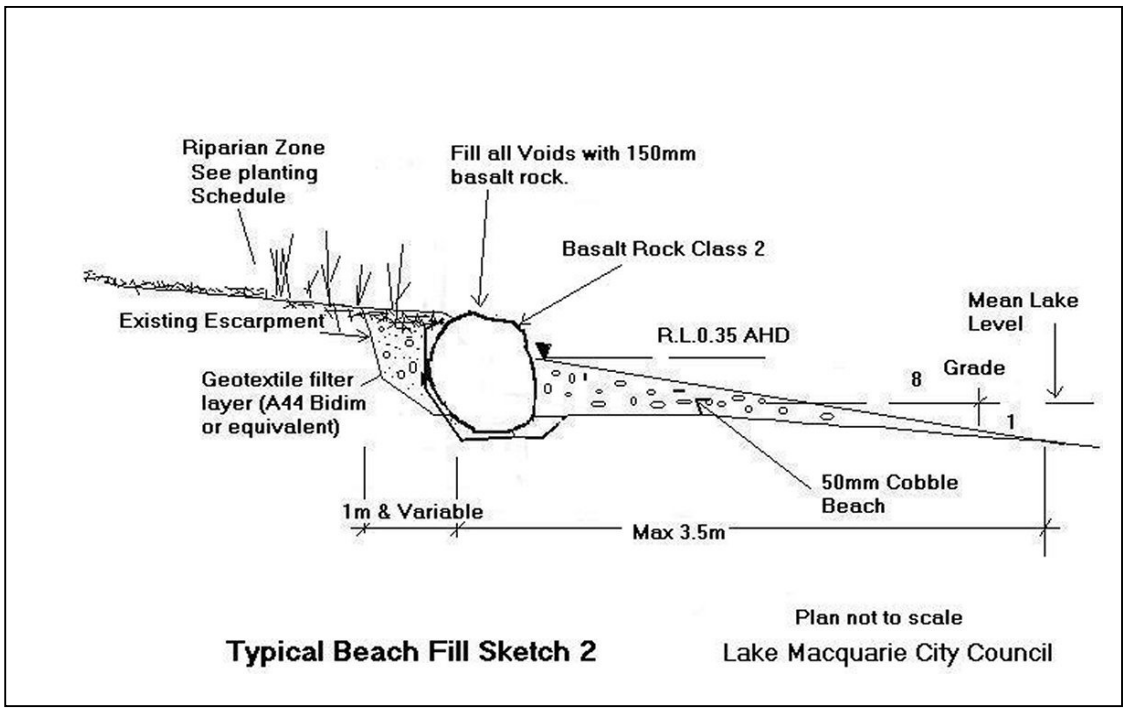



Fig 2 – Typical foreshore profile for eroding foreshore with moderate foreshore erosion.

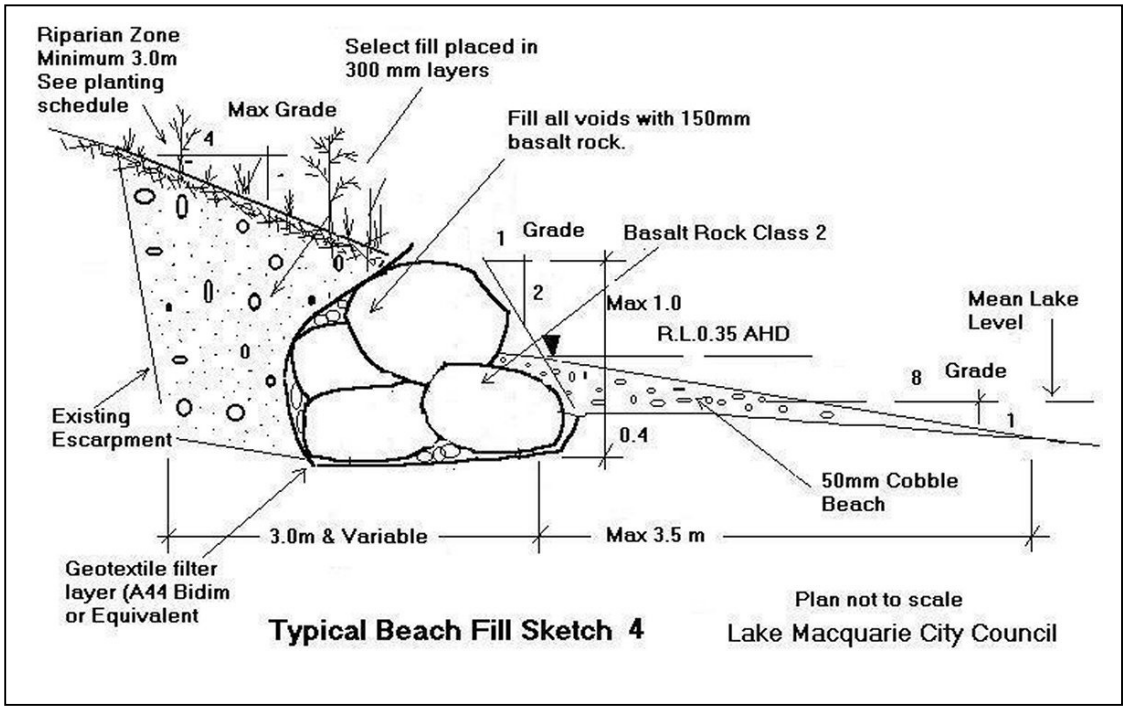


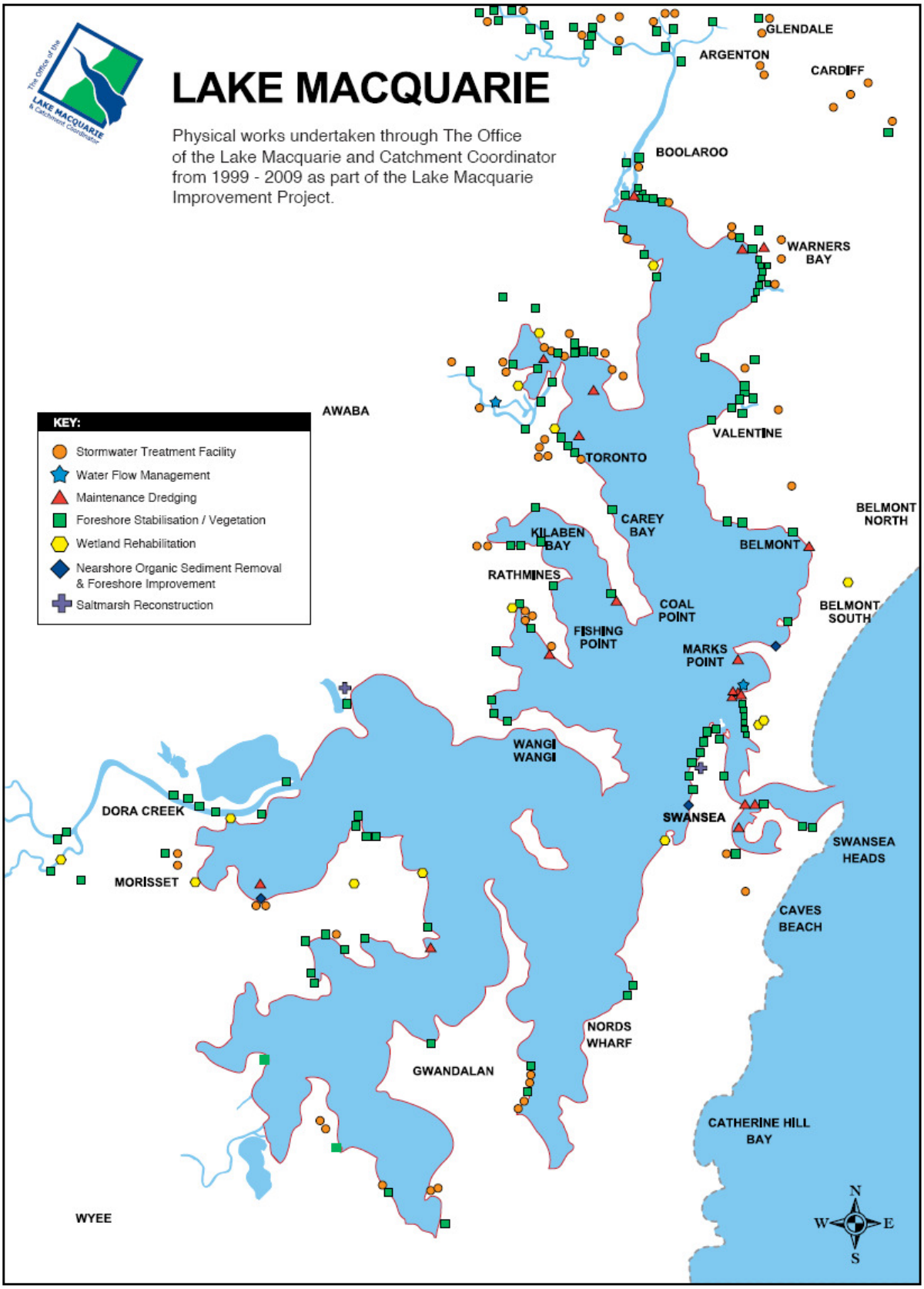

Fig 3 – Typical foreshore profile for eroding foreshore with extensive foreshore erosion.

***Extent of 'public' foreshore works in Lake Macquarie***

During the ten year operation of the Lake Improvement Project in excess of 36 kilometres of Lake foreshore has been rehabilitated using the described foreshore restoration technique. The extent of works is shown in Map 1, which shows that the concentration of foreshore restoration projects occurs around the highly populated areas such as Warners Bay, Speers Point, Swansea and the Toronto area.

The selection of project sites was based on a list of criteria shown below, used to identify priority sites and to rank the priority order in which they were constructed.

- Evidence of active foreshore erosion.
- Presence of foreshore mini-escarpment limiting movement of seagrass wrack onto the terrestrial environment.
- Presence of seagrass wrack accumulation in the near shore environment. Such accumulation may vary in width and depth, sites of a higher priority will be those with a wider and thicker deposition area.
- Wind fetch and foreshore orientation – those sites exposed to a large wind fetch and having exposure to the prevailing winds (SE / NE) will be of higher priority as they have greater potential for wrack accumulation and generation of wind waves contributing to foreshore erosion.
- Littoral vegetation – foreshore areas void of any native littoral vegetation will be of a higher priority than sites with remnant vegetation cover. Lack of littoral vegetation increases the foreshore erosion potential and further development of mini-escarpment.
- Sites of high public usage – such areas may suffer from vegetation loss, soil disturbance, and constant use all contributing to instability of the foreshore environment. These area may be considered a high priority if, when combined with the above-mentioned factors, foreshore erosion is occurring. If such a site is considered a high priority access areas should be incorporated into the design to facilitate public use of the area.
- Saltmarsh protection – remnant saltmarsh may be found behind eroding foreshores in areas of suitable habitat (low lying, inundated foreshore areas). These areas should be considered a priority to protect the remnant saltmarsh from disturbance and loss due to foreshore retreat.




Map 1 – Summary of Lake Macquarie Improvement Project works 1999-2009. Note foreshore restoration projects identified by ▮ .

Since the conclusion of the Lake Macquarie Improvement Project, Lake Macquarie City Council has continued to restore priority foreshore locations using the sloping beach method. With a total foreshore, length of 174km, many sites remain that could benefit from foreshore restoration techniques previously implemented. However, as experience has shown, there are limitations associated with the technique, and careful consideration should be made as to the suitability of the technique chosen, and prevailing site condition.

### *Examples*

The following photographs show examples of the foreshore restoration technique in practice. The before photos are typical of the condition of many foreshore area around Lake Macquarie. They illustrate the range of factors previously discussed, such as vegetation loss, public use and increased wave action due to boating activities.

**Figure 2 - Speers Point Reserve foreshore (before). Note degradation of foreshore, lack of littoral vegetation, seagrass wrack accumulation and general lack of amenity.**


**Figure 1 - Speers Point (after). Note sloping beach installation, protection of foreshore bank toe, native plants, and improved amenity.**


**Figure 4 - Valentine Cres Valentine foreshore (before).**


**Figure 3 - Valentine foreshore (after). Note improved foreshore slope angle designed to facilitate wave energy dissipation to prevent 'mini-escarpment' development.**

**Figure 6 - Wippi Reserve, Coal Point. Note height of upper bank and lack of foreshore area.**

**Figure 5 - Wippi Reserve, Coal Point (after). Note foot of bank stabilised with rock, extended foreshore run & accumulation of wrack on foreshore out of the water.**

**Figure 8 - Nords Wharf Reserve (before). Note height of foreshore, undercutting of bank and accumulation of seagrass wrack.**

**Figure 7 - Nords Wharf Reserve (after). Note return of foreshore slope, protection of toe of bank and seagrass wrack on the cobble beach.**


**Figure 10 - Swansea Channel (before). Note 'mini-escarpment' along foreshore edge, accumulation of sea grass and failing foreshore revetment (logs).**

**Figure 9 -Swansea Channel foreshore (after). Note removal of 'mini-escarpment', return of foreshore profile and movement of wrack onto cobble beach.**

**Figure 11 - Side view of Wippi Reserve foreshore profile after restoration. Note the effect the cobble beach has on moving sea grass wrack up the foreshore. Prior to installation of the cobble beach the 'mini-escarpment' would trap the wrack in the Lake water limiting the breakdown of the wrack. The cobble beach has created a zonation of stages of wrack decomposition from the near shore to upper foreshore. (Note this photograph was taken at a time of low lake level exposing sea grass beds usually inundated by Lake water.**

***Lessons Learnt***

The demonstrated foreshore restoration technique has been very successful in the management of foreshore reserves in Lake Macquarie. However, in the years since its introduction, a number of lessons have been learnt highlighting the fact that a single approach to management of a dynamic environment is not always the most appropriate method.

The amount of wave energy the foreshore is exposed to in extreme events (ie: storms) has threatened the integrity of the sloping beach foreshore technique. In Lake Macquarie, foreshores with a south-easterly orientation with a subsequent large fetch can experience very high wave energy in times of storms. As a result, cobble can be lost and the toe protection rock can be dislodged. As example of such is illustrated below at Green Point. Green Point has a SE aspect and a large fetch it has also suffered foreshore erosion as the foreshore was filled in the past to provide passage way for a light railway line.

**Figure 12 - Green Point foreshore (before). Note height of bank due to historic deposition of fill material.**

**Figure 13 - Green Point foreshore (after). Note installation of toe protection.**

**Figure 14 -Green Point foreshore during large storm event. Note change in lake level and waves breaking directly on toe protection rocks.**

As shown above, the modified morphology of the Green Point foreshore (due to historical placement of fill) has created an environment prone to the effects of high-energy events. The abrupt change in angle to an almost vertical face does not provide adequate foreshore distance for the foreshore to sufficiently dissipate wave energy in storm events. Subsequently the toe of the bank receives energy from the waves and as a result, experiences accelerated erosion.

In this situation, the armour rock placed to protect the toe has not performed well, as the waves have penetrated behind the rock causing them to move, exposing the toe of the bank. During construction, the toe armour was not keyed into the foreshore therefore reducing the ability of the rock to withstand the wave energy. In retrospect this site mat not have been an ideal site for the sloping beach technique due to the extremely altered condition of the foreshore (the vertical face so close to the lakes edge).

To protect this bank from further erosion (during storm events) a greater investment in infrastructure may be required to construct a revetment wall several rocks high and wide to provide adequate protection from storm events.

### *Vegetation Management*

The installation of vegetation is a key component in the restoration of foreshore areas. However, it can prove difficult to establish vegetation due to pressures from the lake using public. Typically, many restored foreshore areas have become degraded due to the use of the area by the public. Subsequently, foreshore restoration can sometimes impede on the once unrestricted use of the foreshore by the public. Early projects in which vegetation was planted throughout the foreshore experienced elevated numbers of plant loss. This came about simply by the public retracing their steps to gain access to the Lake as they did prior to the foreshore restoration.

To counter this, in areas of high public use adequate access is provided to allow access to the Lake (particularly where high boat use occurs). Gaps are left in the planted vegetation the width of which is dependant upon the type of access required.

It is also important to note that the ongoing maintenance of the vegetated areas requires an adaptive management approach. In the early stages of establishment, lost plants require replacement and mulch applied to reduce weed growth and to increase soil moisture. The goal of these replanted areas is to develop a self-sustaining area of vegetation, which after time will require only minimal maintenance. However, this can only be achieved if this situation is allowed to develop. In the past, maintenance activities have focused on the continual placement of mulch to vegetated areas at the expense of plant replacement. Although this approach makes the site look aesthetically appealing, this appeal does not last long and gaps appear in the vegetation, as lost plants are not replaced. This maintenance approach will not result in the desired self-sustaining system but will only create increased on-going maintenance costs.

## Conclusions

The combined pressures on Lake Macquarie from factors such as population growth, expanding development and increasing and intensified recreational use, have had a detrimental effect on the fragile foreshore areas of Lake Macquarie. In highly populated areas, where the community enjoys a direct interface with the Lake and its recreational attributes, foreshore areas became degraded due to a number of factors. The most obvious influences on foreshore areas came about because of the loss of native littoral vegetation, historic filling and inappropriate foreshore treatment, the foreshore edge became unstable, because of people movements into and out of the lake, increased boating activity produced a higher energy input onto the foreshore. The combined effect of such pressures onto the foreshore resulted in an altered foreshore profile and the formation of a mini-escarpment along the foreshore edge which itself created a number of other problems all combining to reduced the ecological, functional and recreational value of the Lakes foreshore areas.

An extensive program of cobble beach construction has taken place on eroding areas of 'public' land around Lake Macquarie. These works have been well received by the local community, as residents are now enjoying the improved water quality and increased amenity that these beaches provide.

The introduction of planning provisions and associated guidelines on private land has also been an important component of Council's approach. The implementation of these provisions is now resulting in improved foreshore development outcomes, and hopefully the construction of 'vertical concrete seawalls' will only be a legacy of the past, and continually improved solutions will be implemented into the future.

As in the Chinese proverb '*the man who moves a mountain begins by carrying many small stones'*. Perhaps the many small stones that make up our cobble beaches signify a start to improving the long-term management of Lake Macquarie's foreshore areas.

## Appendices

Land and Environment Court of New South Wales (2004) *Judgement on Bizon S v Lake Macquarie City Council 2004.* Available at www.austlii.edu.au/cgi-bin/sinodisp/au/cases/nsw/NSWLEC/2004/129.html?query=bizon

LMCC (2004a) *Lake Macquarie Local Environment Plan 2004,* Lake Macquarie City Council, March 2004.

LMCC (2004b) *Lake Macquarie Development Control Plan No. 1,* Lake Macquarie City Council, March 2004.

LMCC (2004c) *Lake Macquarie Foreshore Stabilisation and Rehabilitation Guidelines,* Lake Macquarie City Council, April 2004.

LMCC (2004d) *Lake Macquarie Estuarine Creekbank Stabilisation and Rehabilitation Guidelines,* Lake Macquarie City Council, November 2004

Land and Environment Court of New South Wales (2004) *Judgement on Bizon S v Lake Macquarie City Council 2004.* Available at www.austlii.edu.au/cgi-bin/sinodisp/au/cases/nsw/NSWLEC/2004/129.html?query=bizon