

# CHALLENGES OF SALTMARSH REHABILITATION IN A NON-TIDAL ESTUARY – PERSPECTIVES ON DELIVERY OF ON-GROUND WORKS

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## Background

Saltmarshes are a unique component of coastal estuaries in Australia that exist at the land and water interface. Conditions in these areas are highly dynamic and biota must be adapted and specialised to cope with varying degrees of salinity, tidal inundation, competition and disturbance. Their unique position allows saltmarshes to function in several ways including flood and erosion control, storm surge buffering, water quality improvement and seagrass wrack assimilation. For these and many other reasons, not the least being biodiversity, saltmarshes need to be conserved as vital parts of the Australian coastline.

Saltmarshes are a diminishing habitat in the coastal biosphere of Australia. New South Wales in particular has the least amount of coastal saltmarsh remaining of any state. Saltmarsh occurs along the entire coastline of NSW, but is generally limited to small patches that have been highly modified. In recognition of the decline and uniqueness of saltmarsh in NSW, it has been listed as an Endangered Ecological Community in NSW under the Threatened Species Conservation Act. On the local scale, it is believed that approximately 85% of the saltmarshes around Tuggerah Lakes have been destroyed, degraded or fragmented since European settlement.

Saltmarsh recovery on rehabilitated sites can occur naturally, be assisted through active planting and/or bush regeneration or a combination of both. Natural recovery of saltmarsh communities occurs after disturbance via establishment of seedlings or vegetative expansion of remaining plants. The time that it takes for saltmarshes to recover naturally will depend on a number of factors including position on the shore, density of surrounding vegetation, level of disturbance, continued disturbance and time of year. Vegetative growth, reproductive growth and germination of saltmarsh species have been demonstrated to be greatest in spring.

The need to rehabilitate saltmarsh habitat within the Tuggerah Lakes estuary was highlighted in the Estuary Process Study as a high priority management issue. This recommendation was then carried through as a priority program under the Ecology Action Plan of the Tuggerah Lakes Estuary Management Plan (EMP) 2006.

Funding through a \$20M Australian Government's *Caring for our Country* grant, has allowed Wyong Shire Council the opportunity to implement a range of works in the Tuggerah Lakes catchment to improve water quality and the ecology of the estuary. This funding expires 30 June 2013 and, to date, has greatly assisted Council in implementing key programs from the EMP, including the saltmarsh program. This program consists of two sub-programs which aim to passively and actively rehabilitate the saltmarsh community around the foreshores of the Tuggerah Lakes estuary.

Implementation of the passive and active saltmarsh rehabilitation programs commenced in 2009 and has continued for the duration of the program. To monitor the rehabilitation, a scientific monitoring program has been devised and is being undertaken during the funding period.

## **Passive Saltmarsh Rehabilitation**

In 2009, Council sought to develop a management plan to rehabilitate and protect existing saltmarsh communities that were under threat from human interference. The Tuggerah Lakes Passive Saltmarsh Rehabilitation and Management Plan (PRSMP) was developed as part of the *Caring for our Country* grant.

Detailed maps were developed of the extent and species composition of saltmarsh in eight key locations in relatively undisturbed foreshore areas identified in the EMP. For each location, a suite of management recommendations were made based on the main threats identified.

Rapid assessment of the remaining foreshore locations in Council or Crown management was also undertaken and these sites ranked in terms of their value. Further recommendations for management of each of these isolated locations were made in the report.

Passive saltmarsh rehabilitation includes controlling localised threats to saltmarsh and supporting natural regeneration with the aim of increasing the long term viability and extent of existing saltmarsh. Identified threats to saltmarsh around Tuggerah Lakes include mowing, trampling, compaction, vandalism, weeds, altered hydrology and climate change. The passive rehabilitation program includes highly accurate mapping and demarcation of saltmarsh in susceptible areas, application of mowing restrictions, fencing and signage in some places, significant community and council staff education and control of semi salt tolerant weeds.

### ***Passive Saltmarsh Rehabilitation On-ground Works***

The eight key locations on undeveloped areas of the foreshore identified in the PSRMP supported 21.2ha of viable saltmarsh which constitutes 61% of the total area of remaining saltmarsh around the estuary. In most key locations on undeveloped areas of the foreshore, the saltmarsh is bound on the landward interface by a healthy estuarine swamp oak forest community which offers some protection to the saltmarsh in many cases.

In addition to these key locations, the PSRMP also identified 13.8ha of saltmarsh on public foreshores which is bounded by residential and a recreational interface, creating many competing interests between high ecological protection and public recreation, including general access. These locations are usually bounded by exotic grasses and weeds and residential development.

The PSRMP recommends various techniques for rehabilitating and managing remaining saltmarsh areas including mowing exclusions, access control, weed control, native non-saltmarsh species management (i.e. competing casuarinas and introduced grasses), developing strong working relationships with the Office of Environment and Heritage (OEH) and other authorities, and education of Council staff, residents and visitors as to the importance of saltmarsh.

Implementation of the PSRMP has been undertaken as a series of projects targeting high priority areas identified in the report and attempting to develop links between passive and active rehabilitation areas to improve corridor linkages. Council has worked closely with NSW National Parks and Wildlife Service (NPWS) Officers, the Hunter-Central Rivers Catchment Management Authority, the Community Environment Network, Darkinjung Local Aboriginal Land Council and the local community to deliver these projects.

Development of good working relationships with these authorities and agencies has been

crucial in the delivery of these programs. Further to this, another real key to the success of this program was the excellent education, liaison and consultation with the community and land owners to build rapport. This led to some important and unexpected outcomes with many adjacent residents becoming real ambassadors for the program.

Projects to date have included:

- Further investigation of soil properties and management techniques at Tuggerah Bay.
- Extensive fencing & signage at Tuggerah Bay
- Foreshore saltmarsh mapping of Tuggerah Lake and Budgewoi Lake.
- Community workshops to support the on-ground works
- Saltmarsh rehabilitation using bush regeneration: Tuggerah Bay, Rocky Point, South Tacoma, Toukley Golf Course, Chittaway Point and Orooloo Point
- Interpretive and regulatory signage at key locations.
- Extensive access management at Tacoma.

A summary of the objectives and outputs of each project is provided below. Projects in subsequent years will build on the outcomes achieved to date.

### ***Further investigation of soil properties and management techniques at Tuggerah Bay***

The largest area of remaining saltmarsh in Tuggerah Lake is located at Tuggerah Bay. This site supports approximately 6.8ha of good quality saltmarsh and ranks as the highest priority site for restoration works. Tuggerah Bay consists of extensive sand flats scattered with saltmarsh patches of various sizes and conditions. The sand flat is a significant area of scald, devoid of any vegetation and can most likely be attributed to the historical use of the site by recreational vehicles, off road motor bikes, livestock and horse riders. The lake edge in contrast supports a large, well connected and diverse array of saltmarsh plants of high conservation value.

Previous research indicates that saltmarsh will expand laterally from the existing patches where an appropriate microclimate can be created using seagrass wrack. Whilst this research demonstrated the ability of saltmarsh to expand into buffer areas, the appropriateness of the compacted and highly saline saltpan for saltmarsh recolonisation had not been established. As part of this project, an environmental consultant was commissioned to undertake soil testing and field-based investigations into the soil characteristics of the Tuggerah Bay sand flat to assess this issue.

An investigation into the soils at Tuggerah Bay in 2010 included a comprehensive interpretation of the abiotic and biotic properties of the soil at 12 strategic sites (physico-chemical properties, flora and fauna characteristics), comparison of existing saltmarsh areas with areas of reduced cover and completely denuded areas, a literature review of existing saltmarsh revegetation techniques and a list of recommended actions for Tuggerah Bay. The recommendations from the report were programmed for implementation in 2010-11 and 2011-12 as part of the passive saltmarsh rehabilitation program.

To date works include two monitoring and an amelioration program:

1. A data analysis was conducted using both univariate and multivariate statistical procedures to report on the use of seagrass wrack as an amelioration medium to passively restore degraded saltmarsh at Tuggerah Bay. The mapping of existing saltmarsh within Tuggerah Bay using low-level aerial photographs to establish quantitative assessment of saltmarsh species richness and abundance was undertaken to provide an accurate baseline. A quantitative study has been completed and seagrass wrack has been placed within designated areas. A second quantitative assessment is scheduled for 2013 using the same locations sampled in 2012.

2. The role of saltmarsh in aiding the breakdown of seagrass wrack using field-based manipulative experiments was conducted supporting the hypothesis that wrack deposited on saltmarsh breaks down faster than wrack deposited on bare sediments.

### ***Fencing and signage at Tuggerah Bay***

The main cause of damage at Tuggerah Bay is trampling and compaction by vehicles, stock and people. Council has previously attempted to exclude these activities from the site by strategic placement of fencing and random visits by Council Rangers during high risk periods (weekends, public holidays). Even with these measures in place, vehicles were still able to gain access to the site. Unfortunately, the site only needs to be breached every now and then to significantly impact any rehabilitation that may be naturally occurring at the site.

To protect this valuable site, this project has invested in significant security upgrades at key access points including:

- Two reinforced 6mm steel gates with security locks at the two main entry points to the site;
- 300 metres of fencing along the remaining exposed perimeter including interlinked 18mm steel ferry cable between 1.2 tonne concrete blocks which are recessed into the ground to prevent dragging. Fencing was also fortified either side of the gate entry points;
- Placement of large 1.5 tonne sandstone boulders at sensitive breach zones where concrete blocks were not used; and
- Placement of eight Coastal Saltmarsh EEC environmental education and regulatory enforcement signs at strategic locations around the site.

The fencing installed in late January 2010 has proven successful to date. No vandalism or interference with the new security infrastructure, signs or fencing has occurred during this time. A final remaining access point has been identified with assistance from NPWS officers. This area is earmarked for security upgrades in the final year of the program.

All activities have been undertaken in close consultation with OEH, local NPWS officers, the NSW Police and Council's Rangers.

### ***Foreshore saltmarsh mapping and demarcation works***

To allow Council to accurately identify all saltmarsh under its management, an environmental consultant was engaged to physically map the foreshore locations using a highly accurate digital GPS and at the same time, install "no-mow" markers to delineate the landward boundary of the saltmarsh. This activity was completed for a total of 12km of foreshore reserve.

Saltmarsh patches were mapped by walking the boundary of the patch and taking automatic waypoints at 1m intervals. Polygons were created in real-time by the Trimble GPS Pathfinder Office software within the DGPS. For each saltmarsh patch where mowing was evident, the boundary of the mown area was also captured in the above manner. Species composition and cover of native and weed plants were recorded for each polygon. Other condition attributes were assessed in accordance to PSRMP criteria. Site photographs were taken from representative vantage points.

The consultant was also required to provide a current snapshot of the mowing practices around the Tuggerah Lake foreshore by measuring the extent of saltmarsh currently mown and unmown in the mapped locations. These figures will be used to estimate the amount of

saltmarsh protected through passive saltmarsh management activities.

Approximately 65% of foreshore sites investigated had some form of mowing impact, with several landscape/gardening contractors observed actively slashing or mowing saltmarsh.

Information gained from the mapping program will allow Council to better manage the foreshore through adjusting and regulating current mowing practices undertaken by both residents and Council outdoor staff. Mapping will also allow Council to better manage the foreshore by assisting with the physical demarcation of saltmarsh and engaging the community in education activities.

A series of photo monitoring points were also established to help monitor changes in condition and extent over time.

The project was expanded to include the entire public foreshore of Tuggerah Lake and Budgewoi Lake. To date a perimeter of 77km totalling 269 saltmarsh patches have been mapped using a differential GPS.

In addition to demarcation works, educational material explaining the importance of saltmarsh and the intent of the project was sent to every landholder adjoining recreational foreshore zones containing saltmarsh. This localised information was complemented by a broader saltmarsh education program targeting other members of the community who use the foreshore reserves.

This program resulted in mowing exclusions to 0.9ha of saltmarsh between Long Jetty and Chittaway Point.

### ***Saltmarsh rehabilitation using bush regeneration techniques – Chittaway Point***

The key site at Chittaway Point represents 1.7 hectares of some of the most intact saltmarsh adjacent to development of the Tuggerah Lake foreshore. The site is somewhat fragmented and offered an excellent opportunity to connect a substantial population from the mouth of Wyong River to the mouth of Ourimbah Creek including the Tuggerah Nature Reserve and Tuggerah Bay.

Chittaway Point was selected as the first location to undergo mowing restrictions through physical demarcation of the saltmarsh boundary and bush regeneration through the transition zone between either saltmarsh and swamp oak forest, or saltmarsh and reserve.

The site was divided into two contract areas to create manageable sized parcels with similar localised issues. In each area, on ground activities included weed control using bush regeneration techniques to remove noxious and environmental weeds. The two contract areas have been rehabilitated to maintenance level which has improved the condition and biodiversity value of the saltmarsh.

In addition, “no mow” markers installed at this location provide residents and mowing contractors with a clear indication of the saltmarsh boundary and are intended to reduce the rate of foreshore mowing. After only two months, positive results were observed along the foreshore edge with most (but not all) mowers having ceased mowing in the saltmarsh. On-going monitoring of this site will examine changes in community abundance, structure and species diversity in response to the modified mowing regime.

Bush regeneration and continued weeding in this area has greatly assisted with public compliance and support.

## ***Saltmarsh rehabilitation using bush regeneration: Tuggerah Bay, Rocky Point, South Tacoma***

To date an area of 22.1 ha has been rehabilitated using bush regeneration and weed targeting in coastal saltmarsh and allied ectones. The activities have strengthened the resilience of formerly degraded coastal vegetation communities from the threatening process of coastal vines and smothering exotic ground covers.

The establishment of a repressed native seed bank has been overwhelming with species such as the bangalow palm (*Livistona australis*), *Eucalyptus robusta*, *Melaleuca stypheloides*, *Melaleuca quinquinervia* regenerating in areas that have not recorded these species for over 20 years.

Extensive fencing, installation of fire trail gates with combined regulatory and interpretive signage in areas such as Tacoma have greatly assisted in the restoration of degraded sites by reducing human impacts such as trampling and compaction, damage to seedling recruitment, dumping and weed dispersal. A coordinated program of public education has greatly reduced the impacts of vandalism on plantings and protective infrastructure.

Success of a passive saltmarsh program is very dependent on community consultation and education. Community concerns regarding weed growth and casuarina colonisation have been largely resolved by ensuring that bush regeneration and weeding techniques demonstrated Councils commitment to ongoing management of the areas. This has been instrumental in gaining the communities compliance regarding no mow zones.

In addition, the effectiveness of access controls can be greatly improved by consulting the community regarding their access needs for a variety of recreational uses (this was equally important for the active rehabilitation program). Provision of improved controlled access points in consultations with stakeholders from the community has greatly improved the effectiveness of access controls. It has also ensured that in some areas simple delineation of no-go zones with signage has been sufficient to reduce tramping and compaction of restoration areas.

### **Active Saltmarsh Rehabilitation**

Reconstruction of saltmarshes in non-tidal estuaries is a largely untested activity in Australia. Around the Tuggerah Lakes estuary, Council has previously attempted small-scale saltmarsh rehabilitation projects at the mouth of Tumbi Creek and at Rocky Point using natural regeneration as the primary mechanism for recolonisation.

In 2007, an Active Saltmarsh Rehabilitation Plan (ASRP) was prepared highlighting elevated foreshore areas that may be appropriate for saltmarsh reconstruction. The sites identified were located on foreshore reserves on land reclaimed in the late 1980s/early 1990s as part of the Tuggerah Lakes Restoration Project. In the process of reclaiming the land the profile of the lakes foreshore was changed from having a gentle grade to an elevated step. This change in foreshore profile has resulted in the saltmarsh community being compressed into a narrow band along the foreshore.

The active saltmarsh rehabilitation program aims to recreate an appropriate saltmarsh habitat by regrading elevated foreshore areas to reinstate hydrological links with groundwater, overland flow and most importantly, inundation from the estuary. Once an appropriate grade is established, local provenance native saltmarsh plants are replanted and then carefully maintained for up to five years to support complete re-establishment.

With support from the *Caring for our Country* funding, nine of the locations identified in the

ASRP as potential active rehabilitation works sites around the estuary were completed under the program.

### ***Process and methodology***

The process used to achieve rehabilitation under the ASRP involved a number of distinct stages, as described below.

#### *Design to construction*

A range of activities were undertaken to take the concept designs from the ASRP to a stage where they were able to be constructed. These included:

- site investigations, survey, soil testing and saltmarsh demarcation
- detailed design drawings
- detailed rehabilitation plans
- community information and consultation
- preparation of a Review of Environmental Factors
- preparation of a Construction Environmental Management Plan
- seed collection and propagation, to maintain the existing genetic diversity of saltmarsh plants at all locations
- establishment of photo monitoring points
- scientific monitoring of saltmarsh diversity and abundance before works commenced
- expert advice sought to ensure mosquito habitat was not created, and
- preparation of operations and maintenance plans.

Planning approval was granted by Council and the relevant NSW authorities (OEH, DPI, Crown Lands) under Part 5 of the Environmental Planning and Assessment Act, 1979 allowing works to commence on the first site in November 2009.

#### *Construction*

Works undertaken on the first six sites constructed between 2009 and 2011 were undertaken using the methodology proposed in the ASRP and included large scale excavation. Works included:

- trenching to determine soil characteristics and enable Acid Sulphate Soil (ASS) / Potential Acid Sulphate Soil (PASS) testing
- primary weed control by use of spray six weeks prior to excavation, using approved herbicide methods
- installation of offshore wrack fences to prevent intrusion of wrack into the site during construction and establishment
- installation of eco-logs at the front of the saltmarsh to dissipate wave energy and act as a sediment bund
- removal of healthy saltmarsh to Council's nursery for later re-establishment at the site as transplants
- excavation of the site to form an even gradient of 1-2% from 0.2m AHD
- treatment of excavated ASS/PASS with lime to achieve correct pH prior to disposal
- mulching the site with seagrass wrack
- planting transplanted and propagated saltmarsh
- creation of viewing areas
- installation of low line chain and wire fences to delineate the completed site and

reduce access.

Work on the final three sites were scaled back following surveys that showed an increase in average elevation at which saltmarsh was naturally occurring from when the ASRP was developed; the change in methodology also addressed the difficulty in re-establishing healthy saltmarsh on the lower levels of the earlier sites.

At the final three sites the healthy fringe of saltmarsh was retained, the area behind it treated for weeds and minor excavation undertaken to achieve a better grade, remove any high points and fill depressions. The sites were then mulched with seagrass wrack, planted with local provenance tubestock and fenced in the same manner as the previous sites.

A key lesson learnt during the active program was that the method of determining an appropriate elevation for establishment of saltmarsh is extremely difficult in a non tidal estuary. Tuggerah Lakes experience minimal tidal variation due to a constrained entrance and fluctuations in water levels are dependent on prevailing winds and rainfall events. Much of the design work for the ASRP was carried out in a time of extended drought and resulted in very low design levels being adopted. This led to extensive inundation of some newly constructed sites following change to more regular rainfall patterns.

### *Establishment*

Following completion of construction and the initial planting, the sites then moved into their establishment phase. During this phase the saltmarsh plants were cared for by Council's skilled bush regeneration crew. Weeds and competitive non-saltmarsh native species (such as *Casuarina glauca*) were removed and seagrass wrack mulch reapplied when available and as needed. Trials were undertaken pinning down the wrack using open weave jute to prevent it from lifting and smothering the plants when heightened lake levels were experienced with excellent results seen.

Weed control forms a critical part of the establishment phase whilst saltmarsh plants expand across the soil surface. Salt-tolerant weeds can easily outcompete juvenile saltmarsh plants before they are advanced enough to adequately compete for space.

This type of management enables regular monitoring of the sites to pick up any issues and allows the bush regeneration crew to determine when the site is well enough established to remove the protective wrack fences. The trigger for removal of the wrack fences is 70% saltmarsh vegetation cover in a 1m<sup>2</sup> quadrat. This is generally achieved 1.5 - 2 years after construction but can be longer in the lower saltmarsh zones or those sites submerged for extended periods of time.

### **Key learnings and adaptive management made to the active saltmarsh program**

One of the most important factors to consider in any environmental management project, and particularly saltmarsh rehabilitation, is seasonal timing. Planting prior to spring to allow good vegetative and reproductive growth and germination through this period is crucial to establishment success.

The active rehabilitation program also utilised innovative techniques not before used in the estuary and faced a number of challenges from its inception.

During the construction and early stages of rehabilitation, methods needed to be developed to manage erosion from the disturbed site and protect new saltmarsh plants from excessive wind driven wave erosion and deposition of wrack. To address this, a combination of ecologs

and a purpose built wrack fence were utilised on most sites to address these issues. In later parts of the program it was possible to retain a fringe of original vegetation to assist in this process.

The freshly harvested wrack used in controlled amounts to act as a soil conditioner during establishment of the saltmarsh plants also presented some logistical issues. Difficulties occurred due to minor flooding events which remobilised the wrack mulch, depositing it in clumps which smothered sections of the area under rehabilitation. This required manual re-spreading and highlighted the need for on-going maintenance during the establishment period to permit plants to reach viable size and coverage for on-going resilience.

Trials were undertaken using open weave jute mesh to prevent movement of the wrack when lake levels were higher – to date, this appears to be successful, however rehabilitation in these areas will be monitored in relationship to the surrounding areas.

Another key learning in the early stages of construction was the timing and breadth of stakeholder consultation and engagement. To ensure all expectations had been considered, consultation needed to happen earlier in the design stage. For example, lack of timely liaison with a local scout hall meant Council did not initially factor in access for watercraft at the first rehabilitation site. Access was eventually provided at this site and at subsequent sites following a more comprehensive and timely consultation process.

In addition to these management changes, there may have been unforeseen issues with the original designs. The ASRP was completed in 2007 and while this strategy utilised years of data collected by Council, the estuary had been facing drought conditions for the previous decade and subsequently the vegetation communities around the lake had adapted to these conditions.

Due to the continued low water level in the lake during the drought, the healthiest saltmarsh was growing at around 0.2m AHD; this resulted in the designs for the active sites being regraded from this elevation to around 0.5m AHD (in some cases less). A number of the active rehabilitation sites had been constructed using this specification when the drought broke in 2010/2011.

During 2011 and early 2012, the estuary received more frequent and larger rain events causing a higher average lake level. This higher level caused the two most recently constructed sites to be submerged for extended periods immediately after planting and has contributed to their slow rehabilitation. The majority of the site is under water and the plants do not have a large area of higher elevation to grow into and recolonise from.

These challenges resulted in a redesign of the methodology for the remaining three sites (as aforementioned). Surveys of healthy saltmarsh in 2011 showed that the ideal elevation during the frequently higher rainfall was between 0.4m AHD and 0.5m AHD with saltmarsh species present up to 0.8m AHD. The majority of these elevations were not captured in the original designs.

Adopting lower levels of intervention has greatly reduced construction costs for acid sulphate soil treatment and spoil disposal and has permitted existing healthy saltmarsh to be retained in situ. The reduced excavation has allowed these sites to include higher elevation areas which will facilitate healthy bands of saltmarsh which can migrate landward or towards the lake edge in response to changes in rainfall patterns/climate.

Early observations in these elevated saltmarsh areas have, however, initially shown increased levels of weed species, predominantly introduced grasses and casuarinas.

This may be due to the lack of recent inundation of saline/brackish water from reduced lake levels experienced of late allowing the terrestrial weeds to compete with the newly planted saltmarsh. Monitoring and maintenance activities over the next few months should show if these sites are likely to become resilient over time. Trials are in the early stages of

development for irrigating the saltmarsh and fringing exotics with lake water to help reduce the competing weeds.

## Results

The saltmarsh rehabilitation monitoring program has been running in tandem with both the active and passive rehabilitation programs. Monitoring began prior to the commencement of on-ground works and has been continuing since then. The results to date are showing that rehabilitation of the active sites in most areas is progressing well, particularly in the upper zones.

In the upper rehabilitation zones there has been a significant increase in saltmarsh cover and a large reduction in weed cover. The most recent monitoring update, until end June 2012, has suggested that the percentage of saltmarsh cover at two rehabilitation sites in Lake Munmorah have increased to the levels observed at the reference locations.

However, the lower zones of the first two rehabilitation sites in Tuggerah Lake (Berkeley Vale and Long Jetty) to be constructed are showing a reduction in saltmarsh cover. This is possibly due to these areas being inundated with lake water too frequently as they were designed and constructed using elevations determined in drought conditions. The changes implemented at the most recently construction sites as described in the methodology should counteract this issue. It remains to be seen if the upper zones of these sites respond as well as those of the older sites.

## Conclusion

As noted previously, saltmarsh rehabilitation in a non-tidal estuary is largely untested. As a result, many issues were encountered during on-ground works that required an adaptive management approach to be embraced.

The major obstacle to negotiate when re-constructing saltmarsh in a non-tidal system is that it is difficult to alter the hydrological regimes as is done in saltmarsh rehabilitation programs in other estuaries. Instead, management options include:

- planting at the appropriate time of year
- creating the appropriate grade and elevations
- allowing for movement of saltmarsh both landward and towards the lake depending on average water levels
- manual and chemical removal of competition from saltmarsh communities
- use of transplanted and local provenance tube stock
- soil treatment or improvement

When looking at the saltmarsh rehabilitation programs undertaken by Council, the passive program has employed techniques that are in widespread use for natural areas rehabilitation. This program has achieved large areas of rehabilitation where ecological and social improvements have been made and has suffered from very few unexpected complications.

A range of techniques and elevations have been used throughout the active saltmarsh program. It is clear that there is a trade-off between cost, levels of intervention and the potential to reduce long term maintenance. Continued monitoring of the sites will provide important data on the response of the saltmarsh rehabilitation over time. In a non-tidal estuary, correlation of this data with data from other sources on variations in lake level (with climate) will provide valuable learnings for future management.