



Appendix C

Wetlands Management Plan

This page has been left intentionally blank

JAMES WARREN & Associates Pty Ltd

ECOLOGICAL CONSULTANTS



WETLAND MANAGEMENT PLAN

LOT 4 DP 1022342

NEW ENTRANCE ROAD
SOUTH WEST ROCKS

NOVEMBER 2010

A REPORT PREPARED FOR
SHANNON PACIFIC PTY LTD

Brisbane Office
28/115 Wickham Street
FORTITUDE VALLEY QLD 4006
PH: 07 3257 2703

Ballina Office
105 Tamar Street
BALLINA NSW 2478
PH: 02 6686 3858

Sunshine Coast Office
PH: 07 5437 0277



TABLE OF CONTENTS

1	Introduction	1
1.1	Background.....	1
1.2	Locality	1
1.3	Landuse Zones	2
1.4	The Proposed Development	2
1.5	Aims & Objectives	2
1.6	Wetland Management Focus Area	3
2	Summary of Wetland Management Actions/Commitments	4
3	Review of Relevant Literature	5
3.1	Introduction.....	5
3.2	Saltmarsh Ecosystems	5
3.3	Migratory Waders	6
3.4	Fish Breeding Grounds.....	7
3.5	Eastern Grey Kangaroos.....	7
4	Management Issues.....	9
4.1	Introduction.....	9
4.2	Stormwater and Restricted Tidal Flows	9
4.3	Protection of SEPP 14 Wetlands	9
4.4	Endangered Ecological Communities.....	10
4.5	Weeds.....	10
4.6	Fauna Pest Species.....	10
4.7	Bush Fire Management	11
5	Restoration of Tidal Flow	12
5.1	Introduction.....	12
5.2	System to Restoration Tidal Flow	12
5.3	Trail Phase	13
5.4	Monitoring.....	14
6	Management Areas	15
6.1	Introduction.....	15
6.2	Management Area 1.....	15
6.3	Management Area 2.....	17
6.4	Management Area 3.....	17
6.5	Management Area 4.....	18
6.6	Management Area 5.....	19
6.7	Management Area 6.....	19
6.8	Summary of Management Actions	21
7	Management Actions.....	22
7.1	Weed Control	22
7.2	Natural Regeneration.....	25
7.3	Enhancement planting - SEEP 14, Buffer and Landscaping Areas	26
7.4	Protective Measures	29
7.5	Pest animal control strategy	30
8	Maintenance Program.....	33
8.1	Introduction.....	33
8.2	Personnel	33



Wetland Management Plan

8.3	Management Area 1 - Constructed Wetland	33
8.4	Management Area 2, 3, 4, 5 and 6 - SEPP 14 Wetland	35
8.5	Timing of Maintenance	35
8.6	Maintenance of the Flood Gate	35
9	Monitoring	36
9.1	Introduction	36
9.2	Criteria for success	36
9.3	Management Area 2, 3, 4, 5 and 6 - SEPP 14 Wetland	36
9.4	Timing of Monitoring Visits	37
9.5	Reporting of Monitoring Results	38
9.6	Long Term Monitoring	38
10	Adaptive Management	39
11	Costing of Restoration Works	40
11.1	Introduction	40
11.2	Proposed flood gate	40
11.3	Weeding	40
11.4	Temporary Fencing	40
11.5	Permanent Fencing	41
11.6	Planting Costs.....	41
11.7	Monitoring Costs.....	41
11.8	Signage.....	42
11.9	Summary of Rehabilitation/Monitoring Costs.....	42
12	Summary	43
13	References.....	44
APPENDIX 1		46
	Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions - Endangered Ecological Community listing	46
	Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions - endangered ecological community listing	49
APPENDIX 2		56
	Personnel required carrying out work within Wetland Management Plan	56
APPENDIX 3		57
	Approximate timeline for rehabilitation works	57
APPENDIX 4		59
	WEED CONTROL METHODS	59
APPENDIX 6		62
	SUGGESTED SPECIES FOR THE REVEGETATION OF THE WETLAND FOCUS AREA	62



1 INTRODUCTION

1.1 Background

James Warren & Associates (JWA) have been engaged by Shannon Pacific Pty Ltd to complete a Wetland Management Plan (WMP) as part of an application for a Tourist Facility on land described as Lot 4 DP 1022342 New Entrance Road, South West Rocks.

The proposed tourist facility will be assessed as a Major Project in accordance with Part 3A of the Environmental Planning and Assessment Act 1979 (DA 09_0019). An Ecological Assessment (EA), in response to the Director General Environmental Requirements (DGEARs), has also been prepared by JWA. This WMP will accompany the EA and be submitted as part of the project application.

1.2 Locality

1.2.1 Introduction

The Locality is defined as the area within a 10km radius of the subject site and extends from Rainbow beach in the south to Stuarts point in the north and from Clybucca in the west to the Pacific Ocean in the east (**FIGURE 1**).

Prominent features include the townships of South West Rocks, and the villages of Arakoon, and Jerseyville. Prominent water bodies in the locality include the Macleay River, South West Rocks Creek, and the Pacific Ocean.

Dominant habitat types are eucalypt forest, swamp sclerophyll forest and intertidal communities. Land uses within the locality include forestry, tourism, grazing and agriculture.

1.2.2 The Subject site

The subject site covers approximately 23 hectares of low lying flat ground extending east from the south bank of the Macleay Arm of the Macleay River, near its mouth. The site is separated from the edge of the river by New Entrance Road. The Riverside Tavern is located within the site adjacent to the Macleay River (**FIGURE 2**). A road is situated along the northern boundary of the site which effectively acts as a bund preventing the inflow of tidal water. A pipe with a tidal flap is situated at the eastern end of the road, allowing floodwater to flow out (**FIGURE 2**). The construction of the road initiated a change within the wetland from a saline to a semi-saline condition resulting in gradual changes to the vegetation (Sainty 2005). The tidal flap is broken and is allowing a limited amount of tidal flow into the wetland.

1.2.3 The Study area

The Study area is defined as the Subject site and any proximate areas potentially affected by the proposed development. For this assessment, the study area extends:



Wetland Management Plan

- over the road/bund that forms the north boundary of the site;
- to the strip of vegetation that separates the site from residential areas to south and east; and
- to the river bank/riparian area along the Macleay River.

1.2.4 Significant conservation areas

There are three (3) significant environmental conservation areas in the locality:

- Hat Head National Park - 4kms to the south east;
- Arakoon State Conservation Area - 3kms east; and
- Yarrahapinni Wetlands National Park - 5kms west.

1.2.5 SEPP 14 Wetlands

State Environmental Planning Policy No. 14 - Coastal Wetlands (SEPP 14) protects wetlands of ecological significance. Several SEPP 14 Wetlands occur within 10km of the locality (**FIGURE 3**). The southern portion of SEPP Wetland number 436 occurs within the Subject site (**FIGURE 3**). This wetland area contains a mixture of mudflats / scalds, swamp oak forest and saltmarsh.

The south-western boundary of the SEPP 14 Wetland 436, within the subject site, was ground-truthed by the Department of Planning and Darkheart Eco-Consulting and surveyed by Amos & McDonald Surveyors in June 2009 (**FIGURE 4**).

1.3 Landuse Zones

The Subject site is currently zoned 7(d) Scenic Protection pursuant to the provisions of the Kempsey Local Environment Plan 1987 (**FIGURE 5**). The objective of a 7(d) zoning is to control development so that the environmental and scenic qualities of visually significant land is preserved.

1.4 The Proposed Development

The proposed development is a tourist facility, involving the construction of nine (9) self contained tourist cabins, internal roads and landscaping adjacent to the existing Riverside Tavern and outside the SEPP 14 Wetland area (**FIGURE 6**). The development also proposes to implement this Wetland Management Plan (WMP).

1.5 Aims & Objectives

1.5.1 Background

The Department of Environment and Climate Change (DECC 2008c) list the following recovery action measures that may aid in the rehabilitation of Saltmarsh communities. These actions have been adapted to the site in order to provide objectives that are to be assessed in the determination of the success or failure of this rehabilitation plan.

The objectives of the plan are as follows:



Wetland Management Plan

- Protect areas of Saltmarsh from runoff that contains high levels of nutrients or pollutants;
- Maintain buffer zones of terrestrial vegetation (rehabilitated) adjacent to Saltmarsh to allow for retreat of Saltmarsh;
- Allow areas of Saltmarsh to regenerate naturally where possible;
- Protect from clearing and development through fencing, signage and active management;
- Minimise human disturbance by preventing access by recreational vehicles, including four wheel drives;
- Erect educational signs to provide information to visitors and residents of the importance of coastal Saltmarsh;
- Undertake weed control programs;
- Prohibit grazing and burning;
- Monitoring and subsequent control of tidal regimes to allow the required number of tides per year onto the Saltmarsh.

1.5.2 Aim of this Wetland Management Plan

This WMP proposes a series of measures that will resolve environmental issues currently affecting the SEPP 14 Wetland and to mitigate for any potential impacts of the proposed development.

The main aim of this WMP is to direct the conservation, protection and management of SEPP 14 Wetland on the Subject site. The aims of the proposed restoration works include the following:

1. the reintroduction of tidal flows to the SEPP 14 Wetland;
2. the re-establishment of a healthy Saltmarsh ecosystem;
3. the protection of the SEPP 14 Wetland from storm water runoff with the establishment of a suitable vegetated buffer between the proposed development and the SEPP 14 Wetland (i.e. by way of a constructed freshwater wetland);
4. the management of the SEPP 14 Wetland area (including protection of Endangered Ecological Communities) through weed control and assisted natural regeneration; and
5. the preparation of a detailed monitoring and maintenance program.

1.6 Wetland Management Focus Area

This WMP will cover the SEPP 14 Wetland, on the Subject site, and a buffer area between the Wetland and the proposed for cabin development. The area is collectively referred to as the Wetland Management Focus Area (WMFA) (**FIGURE 7**).



Wetland Management Plan

2 SUMMARY OF WETLAND MANAGEMENT ACTIONS/COMMITMENTS

The following table provides a summary of the necessary actions to be undertaken during implementation of the Wetland Management Plan. References are also included as to where the detailed information can be in this document.

ACTION	REFERENCE FOR DETAILED INFORMATION IN CURRENT DOCUMENT (TITLE & SECTION)
Installation of Floodgate	Restoration of Tidal Flow - 5
Weed Control	Weed Control Measures - 7.1
Maintenance	Maintenance Program - 8
Temporary Fencing	Fencing to SEPP 14 Wetland - 7.4.1
Permanent Fencing	Fencing to SEPP 14 Wetland - 7.4.1
Enhancement planting	Enhancement Planting - 7.3
Monitoring	Monitoring Program - 9
Adaptive management	Adaptive Management - 10
Interpretive Signage	Educational Signage - 7.4.2



3 REVIEW OF RELEVANT LITERATURE

3.1 Introduction

The proposed development (i.e. cabins) will be located on part of the Subject site that is highly modified and consists of maintained opened grasslands. The cabins will be situated adjacent to the existing Tavern. Much of the remainder of the Subject site is a SEPP 14 Wetland. Several issues of concern have been raised by the Department of Planning (DoP) (Peter Nelson pers comm.) and are discussed in the context of the relevant literature.

1. The area is a SEPP 14 Wetland containing a mixture of mudflats/scalds, Swamp oak forest and Saltmarsh communities;
2. The SEPP 14 Wetland is considered to be potential habitat for Migratory waders;
3. The SEPP 14 Wetland is an inter-tidal area and is a potential fish breeding ground; and
4. The subject site forms part of the range of a local population of Eastern Grey kangaroos.

The following is a literature review and legislative discussion of the above issues.

3.2 Saltmarsh Ecosystems

Saltmarshes are a major, widely distributed, inter-tidal habitat. They are dynamic systems, responding to changing environmental conditions (Adam 2002). Saltmarshes have a high biodiversity and economic value, supporting threatened and migratory species and commercially important fish nurseries (Jaensch 2005). Coastal Saltmarsh occurs in the intertidal zone on the shores of estuaries and lagoons that are permanently or intermittently open to the sea. It is frequently found as a zone on the landward side of mangrove stands. Characteristic plants of saltmarsh on the NSW coast include *Baumea juncea*, *Juncus kraussii*, *Sarcocornia quinqueflora*, *Sporobolus virginicus*, *Triglochin striata*, *Isolepis nodosa*, *Samolus repens*, *Selliera radicans*, *Suaeda australis* and *Zoysia macrantha*. Occasionally mangroves are scattered through the Saltmarsh. Tall reeds may also occur, as well as salt pans (DECCW 2008).

Mangrove swamps and estuarine saltmarsh are generally considered to be highly productive of organic matter (Weeslake, 1963; Odum and Heald, 1972; Whittaker, 1975; Turner, 1976). The major pathways for nutrient cycling appear to occur through their leaf and root matter. It is argued that this important source of organic material for detrital food chains infers that the mangroves and saltmarshes are the nurseries for young fish and crustaceans and are thus an integral part of wetland food webs (Odum and de la Cruz, 1967; Odum and Heald, 1972; Odum and Heald, 1975).

Saline wetland communities utilize imported inorganic matter and export matter in the form of plant and animal detritus which then serves as food for marine food webs. Lugo and Snedaker (1974) state that matter transport is driven by physical



Wetland Management Plan

processes (daily tides, runoff and rainfall) as well as by biological processes (leaf fall, decomposition, mineral uptake rates and certain activities of the fauna).

Saltmarsh and other inter-tidal vegetation communities are of vital importance to the breeding cycle of several fish species. Saltmarshes play an important role as a juvenile habitat for species such as bream and mullet. Crabs are common in Saltmarsh communities, and are a significant food source for bream and other carnivorous species. Some species (e.g. Common galaxias - *Galaxias maculatus*), deposit their eggs in Saltmarsh vegetation (NSW Fisheries 2008).

Saltmarsh communities have ecological values that have been recognised at a Commonwealth, State and Local government level. However, anthropogenic influences, such as a road construction obstructing the tidal influence have altered the vegetation structure within the southern portion of SEPP Wetland 463 (i.e. Subject site). Salt tolerant species such as *Sarcocornia quinqueflora*, *Sporobolus virginicus* and *Juncus kraussii* are being outcompeted by less salt tolerant species such as *Casuarina glauca* (Sainty 2005).

3.3 Migratory Waders

The tide is the major influence on the behaviour of waders in estuaries. Most species spread out to feed on intertidal sand and mudflats at low tide, and concentrate at special roosting sites at high tide. In both situations they are susceptible to continual disturbance, which may come from a variety of sources, ranging from offshore power boats to people simply strolling along the foreshore. Continual disturbance of waders feeding on intertidal flats could seriously reduce their food intake.

Little is known of what levels of disturbance during feeding the birds can tolerate, what their response is to continual disturbance and what the effects are on their survival, particularly on subsequent migrations. The birds strongly favour roosting sites which are flat and open, where they have a clear view all around and can easily take off. Lawler (1995) notes that waders need at least a 30 metre distance to tall obstructions from view. This gives them enough time to escape if a predator runs at them from cover. Lawler (1994) provides recommended minimum buffer distances to feeding migratory shorebirds. It appears as though buffer distances vary between species i.e. some species disturb easily whilst others are more tolerant. An analysis of Lawler (1994) indicates that a standard buffer of 100 metres would appear to be sufficient to when all species are considered. Some species will tolerate disturbances only 25 metres away.

Lawler notes that three vegetation types, plus structures and rocks are used as roost habitat:

- bare (usually sandy) foreshores (beaches),
- saltmarsh, and
- mature mangroves.

Each of the above is important for different species:



Wetland Management Plan

- Beaches are either bare or with very sparse vegetation. Beaches are used by Godwit, Curlew, Whimbrel, Kats, Stints, Curlew and Marsh Sandpipers, Mongolian and other small Plovers.
- Saltmarsh areas used are open, with low (<200mm) vegetation and bare areas. Used by Curlew, Whimbrel, Greenshank, Golden Plover and small flocking shorebirds.
- Mangrove trees (old growth) provide roost habitat for Whimbrel, Tattler, Terek and common Sandpipers

Large populations of shorebirds can forage and roost in close proximity to human habitation and the subsequent disturbances. Holmes (1997) noted that about 1,000 shore birds and many other aquatic birds roost and forage in the Broadwater at Southport (Gold Coast).

3.4 Fish Breeding Grounds

The NSW Primary Industry Fisheries (DPIF) is responsible for managing fisheries and their habitat (including inter-tidal lands) along the coast of NSW. Any development that may impact on this environment invites comment from the DPI under the Fisheries Management Act 1994. Fisheries have published a document dealing Habitat Management (DPI 2008). These guidelines allow for removal of habitat in some instances but require compensation at rates varying between 2 and 5 times the loss due to development.

3.5 Eastern Grey Kangaroos

A population of Eastern grey kangaroos has been observed to utilise the site and surrounds as habitat. Mitigation of potential impacts on this population has been requested by the DoP (Peter Nelson pers comm.)

The Eastern grey kangaroo is found in areas of higher rainfall, including woodland, dry sclerophyll forest, mallee scrub, shrubland and heathland. It requires a combination of trees or scrub for cover and open areas for feeding, and can also occur in agricultural land, introduced grassland and other modified landscapes.

The Eastern grey kangaroo is mainly active at night, resting in shelter during the heat of the day (Dawson 1995, Cronin 2008). The diet consists of grasses, herbs, leaves and other low, shrubby vegetation (Cronin 2008). The Eastern grey kangaroo is one of the most social of the large kangaroos, often gathering in groups, or 'mobs', of ten or more animals, comprising mainly females and young. Larger, loose aggregations may form where food is abundant (Poole 1982).

There are not believed to be any major threats to the Eastern grey kangaroo, and the species has often benefitted from human activity, expanding its range where artificial watering holes have been provided for livestock. However, in some areas the Eastern grey kangaroo population is more limited, particularly in densely settled locations (Dawson 1995).

The interface between urban and conservation areas facilitates public encounters with kangaroos. Whilst these experiences are often pleasurable for members of the community, there can be animal welfare implications for kangaroos which become disorientated in within human spaces (i.e. car parks, back yards etc), are harassed



Wetland Management Plan

by domestic dogs, or flee into fences and dams or onto roads (A.C.T KAC 1997). Kangaroos are shy and retiring by nature, and in normal circumstances present no threat to humans. There are very few records of kangaroos attacking humans. However, there are cases of hand-reared kangaroos displaying pre-copulatory behaviour (interpreted as aggression) towards humans (A.C.T KAC 1997).



4 MANAGEMENT ISSUES

4.1 Introduction

This section discusses the various management issues relevant to the WMFA.

4.2 Stormwater and Restricted Tidal Flows

All wetlands depend on certain water conditions (hydrology) to maintain healthy habitats for plants, fish, and other forms of life. Anthropogenic influences can cause wetlands to become degraded or lost completely. In coastal areas, altered hydrology and wetland changes are frequently caused by tidal restrictions.

Historically, stormwater runoff, from areas around the Subject site, would have naturally fed into the SEPP 14 Wetland. The vegetation communities would have reflected a gradual transition from a freshwater to a saline condition (i.e. Swamp oak, Saltmarsh to Mangroves) (DECCW 2008a).

The construction of Government Road (**SECTION 1.2.2**) has restricted tidal flow and facilitated a condition, within the SEPP 14 Wetland on the Subject site, with a greater freshwater influence. Vegetation within the WMFA currently reflects the restriction of tidal flow over the past three decades. *Casuarina glauca*, probably previously restricted to smaller patches, has expanded as a response to less saline conditions (Sainty 2005). Under the current water regime fully salt tolerant species face competition from less salt tolerant species.

As mitigation for a potential increase in stormwater runoff, the proposed development will include the construction of a freshwater wetland to act as a sediment and filtration system for stormwater. This system will simultaneously act as a buffer to the SEPP 14 Wetland. This measure is likely to exacerbate the freshwater condition currently impacting on the Saltmarsh.

The cumulative effect of blocking the tidal influence and increasing freshwater can be mitigated by restoring the tidal flow, effectively resulting in a situation mimicking the former natural situation.

4.3 Protection of SEPP 14 Wetlands

A buffer is proposed between the development and the SEPP 14 Wetland (**FIGURE 6**). The buffer will be in the form of the expansive freshwater constructed wetland proposed as part of the Stormwater Management Plan.

The buffer will provide protection to the adjacent wetland by:

- Reducing surface water runoff from surrounding land into the wetland;
- Filtering sediment and nutrients;
- Preventing groundwater drawdown;
- Providing ecotone habitat (i.e. freshwater to saline condition);
- Contribute to wildlife corridors between the wetlands and adjacent wetland or bushland;



Wetland Management Plan

- Excluding edge effects (reduce disturbance to native fauna from surrounding development and minimise weed invasion) from the wetland;
- Provide a buffer area between residential areas and nuisance insects such as mosquitoes and midges.

The width of the buffer will vary from 40-50m. There is no detailed research in Australia for determining sound ecological guidelines for the determination of the minimum width of buffers for wetlands, however, the buffer width will facilitate all of the above protective measures.

4.4 Endangered Ecological Communities

The SEPP 14 Wetland, on the Subject site, contains two EECs:

1. Coastal Saltmarsh; and
2. Swamp Oak Floodplain Forest (**FIGURE 7**).

Saltmarsh areas are found in the marine inter-tidal zone. The Saltmarsh present today is probably a remnant of what would have existed prior to the restriction of the tidal flows. Swamp Oak (*Casuarina glauca*) often grows along the landward side of saltmarshes and would have also been present with the unrestricted tidal regime. However, the Swamp oak distribution has responded to less saline conditions and expanded (**SECTION 4.2**).

The NSW Scientific Committee's final determination for both Saltmarsh and Swamp Oak Forest is included as **APPENDIX 1**.

4.5 Weeds

The WMFA is currently degraded with the presence of several weed species. The most dominate species are Groundsel bush, Coastal morning glory, Wild aster and Farmer's friends (**FIGURE 8**). Coastal morning glory is prevalent along the southern border of the Subject site adjacent to the residential area. Wild Aster (*Aster subulatus*), an early colonising species, is dominant through the centre of the Subject site and is probably responding to the dieback the salt tolerant species in a less saline habitat.

4.6 Fauna Pest Species

With the exception of a cat, dog and house mouse no pest fauna species were recorded on the site. However, several species of animals deemed as pests are considered possible occurrences on the Subject site. These include:

- Wild dogs
- Feral cats
- Rabbits/hares
- Cane toads
- Foxes

A Pest Animal Control Strategy is discussed in Section 7.5.



4.7 Bush Fire Management

A Bushfire Hazard Assessment has been completed by GeoLINK (2010). Required asset protection zones have been assessed as follows:

- North - 10m
- East - 44m

No vegetation will be cleared for the asset protection zones (APZ). The area to the north will remain as a managed grassland and the 44m APZ to the east required for the cabins also comprises of grassland. The constructed wetland is proposed in this area and which will require little or no fuel reduction management.



5 RESTORATION OF TIDAL FLOW

5.1 Introduction

Tidal flow will be restored to the SEPP 14 Wetland by modifying the existing floodgate beneath Government Road along the northern boundary of the site. Re-establishment of a healthy SEPP 14 saline wetland ecosystem will result.

5.2 System to Restoration Tidal Flow

Currently a levee blocks tidal flow entering the SEPP 14 Wetland on the south side of the road (Government Road). An existing floodgate beneath Government Road allows flood or stormwater flows to discharge out of the Subject site to the north into Back Creek. The existing floodgate is broken, allowing a limited tidal flow into the Subject site.

It is proposed that tidal flow will be restored to the SEPP 14 wetland within the site by construction of a new 900 mm diameter culvert pipe beneath Government Road (adjacent to the existing pipe). The new pipe will be fitted with an automatic tide floodgate similar to the design shown in **Plate 1**. The automatic tide floodgate includes a secondary gate with an aperture that opens and closes with an adjustable floating arm to allow a degree of tidal flushing and fish passage whilst providing flood protection.



Plate 1. A pipe with an automatic tide floodgate.



Wetland Management Plan

The opening and closing of the aperture on the secondary gate is triggered by the water level on the downstream side (north side) of the system. When the water level drops below the float during low tide events, the weight of the float arm causes it to fall and the secondary gate to open, resulting in the exchange of water. This continues until the incoming tide lifts the float to its maximum height and causes the gate to seal. The gate is held closed by the rising action of the float and the back pressure applied to the gate once overtopped, providing protection against flood water flowing upstream (NSW Department of Industry and Investment, 2009:17).

The secondary gate can be manually adjusted to set the level at which the aperture closes during an incoming tide. This provides active water management or control on the amount of tidal inflow and the subsequent extent of inundation of the SEPP 14 Wetland in the subject site.

Tidal flow could be further increased with the following strategies:

1. in addition to the installation of the 900m flood-gated pipe, the existing 375 mm pipe could be permanently opened; and
2. permanent flow from both pipes.

5.3 Trail Phase

A trial period of tidal inundation will be undertaken. The initial phase of tidal restoration will restrict the amount of tidal inflow to the extent of vegetation with a full salt tolerance. The following estimates of tidal inundation have been modelled based on the three scenarios described above (GeoLINK 2010). The following table provides an estimate of tidal inundation (i.e. AHD) based on these scenarios. Tidal flow can also be reduced by closing the secondary aperture gate on the newly fitted 900mm pipe. The inundation levels are shown in **FIGURE 7**.

Scenarios	Tidal inundation (AHD)
Manual adjustment of secondary gate aperture can be to set to reduce tidal inflow.	<0.41
Stage 1 - Installation of a new 900 mm diameter pipe with automatic tide floodgate adjoining the existing 375 mm pipe.	0.41
Stage 2 - Installation of the 900m flood-gated pipe and permanent flow from the existing 375 mm pipe.	0.44
Stage 3 - Permanent flow from both the new 900mm pipe and the existing 375mm pipe.	0.48



Wetland Management Plan

Gradual restoration of tidal inflow will reduce erosion as areas where Saltmarsh vegetation is already established are less likely to erode. However, scour protection will be provided on the upstream and downstream side of the floodgate/pipe to address scour issues associated with the reintroduction of tidal flows.

5.4 Monitoring

The aim of restoring the tidal flow is to re-establishment a healthy Saltmarsh ecosystem. A detailed tidal monitoring program will ensure an appropriate level of tidal inundation is established (**SECTION 9**).



6 MANAGEMENT AREAS

6.1 Introduction

This WMP will cover the WMFA which consists of the SEPP 14 Wetland, on the Subject site, and a buffer area between the SEPP 14 Wetland and the proposed for cabin development.

The Subject site has been divided into management areas to facilitate the implementation of the management actions. This section will provide a description of each management area including vegetation communities, occurrence of weed species and management actions. Management actions are described in detail in the next section (**SECTION 4**).

The Management areas are shown in **FIGURE 8** and will be referred to as:

- Management Area 1 (MA1) - The constructed freshwater wetland.

Management Areas 2, 3, 4, 5 and 6 will cover SEPP 14 Wetland number 436 on the Subject site.

- Management Area 2 (MA2) - Stormwater outlet dispersal area.
- Management Area 3 (MA3) - Buffer to adjacent residential area.
- Management Area 4 (MA4) - Area between Saltmarsh and Macleay River.
- Management Area 5 (MA5) - Central Swamp Oak Forest.
- Management Area 6 (MA6) - Saltmarsh and Mudflats.

6.2 Management Area 1

MA 1 currently consists of grassland with scattered trees. This area will become the buffer between the Cabin development area and the SEPP 14 Wetland. A wetland will be constructed in this area.

Plate 2 below shows the existing slashed grassed area where the wetland will be constructed in the foreground, and the Swamp she-oak forest in the background.

A Stormwater Management Plan has been prepared for the proposed development which includes a series of stormwater control devices (treatment trains). These will allow for adequate treatment of the stormwater before it is released into the SEPP 14 Wetland. These devices will become part of a constructed freshwater wetland (**FIGURE 6**).



Wetland Management Plan



Plate 2. Edge of Swamp she oak forest. A constructed wetland will occur in the foreground.

Stormwater management within the proposed development includes treatment within constructed wetlands as well as a combination of the following stormwater mitigation measures where appropriate:

- Rainwater tanks;
- Infiltration systems;
- Porous paving;
- Grassed filter strips;
- Vegetated swales; and
- Bio-retention trenches.

Specific measures for MA1 will include:

- A Stormwater Management Plan;
- Construction of a freshwater wetland;
- Fencing to restricted access to the SEPP 14 Wetland;
- Weed control (maintenance);
- Facilitation of natural regeneration;
- Enhancement plantings in and around the constructed wetland;
- General maintenance; and
- Educational signage.



6.3 Management Area 2

MA2 is the area directly between the proposed constructed wetland and the remainder of the site. At present the area consists primarily of Swamp Oak Forest with a Freshwater Wetland in the northern portion. Both these communities are considered to be EECs, however, both communities are probably artefacts. The Freshwater wetland is probably the result of conditions created by a stormwater outlet and the Swamp Oak to with the less saline conditions as a result of the tidal flat restricting tidal inflow. With the implementation of this WMP these communities will be preserved.

MA2 has significant weed infestations of Coastal morning glory and Groundsel bush in the north and south respectively.

Specific measures for MA2 will include:

- Re-establishment/maintenance of healthy Freshwater Wetland and Swamp Oak communities with the dispersal of clean stormwater from the constructed wetland in MA1;
- Control of Coastal morning glory and Groundsel bush;
- Maintenance and secondary weeding;
- Facilitation of natural regeneration; and
- Monitoring.

Adaptive management may include enhancement plantings.

6.4 Management Area 3

MA3 is an area along the southern boundary, adjacent to the established residential development. Saltmarsh, Swamp oak and Sedge communities occur in this area. There is also a significant weed problem with both Groundsel bush and Coastal morning glory (**Plate 3**).

Specific measures for MA3 will include:

- Control of Coastal morning glory and Groundsel bush;
- Maintenance and secondary weeding;
- Facilitation of natural regeneration; and
- Monitoring.

Adaptive management may include enhancement plantings.



Wetland Management Plan



Plate 3. Groundsel bush & Coastal morning glory infestation in Management Area 3.

6.5 Management Area 4

MA4 is situated in the north west of the Subject site, adjacent to the Macleay River. Saltmarsh and Swamp oak communities occur in along with significant infestations both Groundsel bush and Coastal morning glory (**Plate 3**).



Plate 3. Significant weed infestations occur within Management Area 4.



Wetland Management Plan

Specific measures for MA4 will include:

- Control of Coastal morning glory and Groundsel bush;
- Maintenance and secondary weeding;
- Facilitation of natural regeneration; and
- Monitoring.

Adaptive management may include enhancement plantings.

6.6 Management Area 5

MA5 is situated in the centre of the Subject site. It is predominately Swamp oak forest with a relatively small patch of Groundsel bush.

Specific measures for MA5 will include:

- Control Groundsel bush;
- Maintenance and secondary weeding;
- Facilitation of natural regeneration; and
- Monitoring.

Adaptive management may include enhancement plantings.

6.7 Management Area 6

MA6 is the largest management area and covers an area that primarily consists of mud flats and Saltmarsh (**Plates 4 & 5**). A large area, approximately one third of the management area, is infested with Wild aster (**Plate 6**).



Plate 4. Saltmarsh community within Management Area 6.



Wetland Management Plan



Plate 5. Saltmarsh community within Management Area 6.



Plate 6. Wild aster (*Aster subulatus*).

Specific measures for MA6 will include:

- Control of Wild aster;
- Maintenance and secondary weeding;
- Facilitation of natural regeneration; and
- Monitoring.

Adaptive management may include enhancement plantings.



Wetland Management Plan

6.8 Summary of Management Actions

The following table provides a summary of the management actions to be undertaken within each management area. Detailed information about each action is provided in SECTIONS 7, 8, 9, and 10.

MANAGEMENT AREA	1	2	3	4	5	6
Staging (order of management)	1st	2nd	3rd	4th	5th	6th
MANAGEMENT ACTION						
Temporary Fencing		✓		✓	✓	
Weed control		✓	✓	✓	✓	✓
Primary Weeding		✓	✓	✓	✓	✓
Secondary Weeding (Maintenance)	✓	✓	✓	✓	✓	✓
Natural Regeneration	✓	✓	✓	✓	✓	✓
Enhancement Planting	✓	To be determined	To be determined	To be determined	To be determined	To be determined
Monitoring		✓	✓	✓	✓	✓
Adaptive Management	✓	✓	✓	✓	✓	✓
Permanent Fencing		✓		✓	✓	
Interpretive Signage		✓				



7 MANAGEMENT ACTIONS

7.1 Weed Control

7.1.1 Introduction

The following sections provide instruction for rehabilitation personnel, a time line of works, an assessment of the weed on the Subject site, outline the strategy for weed control, in addition to the latest 'best practice' methods for weed removal of the species found on the site.

7.1.2 Personnel

All weed control activities will be carried out by a qualified Bush Regenerator or Regeneration Team (**APPENDIX 2**). All bush regeneration workers will be accredited in Bushland Conservation & Management (or equivalent) and will be experienced in up-to-date techniques for Native Vegetation restoration and/or management. All chemical users will be experienced and licensed in accordance with the relevant legislation.

7.1.3 Time Line of Works

A stage approach will be adopted by completing weed control activities in MA2 whilst the wetland is under construction, then MAs 1, 3, 4, 5, and 6 progressively. The tidal flap trial phase will be underway which may result in the elimination of weed species that are salt intolerant. This could substantially reduce the need for weed control in some areas.

A Gantt chart showing an approximate timeline of works is provided as **APPENDIX 3**.

7.1.4 Weed assessment

Currently, weed species are a major problem within the Subject site (**FIGURE 8**). The most prominent weed species present include:

- Groundsel bush;
- Coastal morning glory; and
- Wild aster.

TABLE 1 provides a comprehensive list of weeds found on the site providing the botanical and scientific names. Weed species are also separated in occurrence within each Management Area.



Wetland Management Plan

**TABLE 1
WEED SPECIES FOUND ON THE SUBJECT SITE**

SPECIES NAME	COMMON NAME	MANAGEMENT AREA					
		1	2	3	4	5	6
<i>Polypogon monspeliensis</i>	Annual beardgrass	√		√	√		
<i>Asparagus aethiopicus</i>	Asparagus fern		√	√	√		
<i>Gomphocarpus physocarpus</i>	Balloon Cotton Bush	√			√		
<i>Hydrocotyle bonariensis</i>	Beach pennywort			√	√		√
<i>Rubus anglocandicans</i>	Blackberry				√		
<i>Ageratum houstonianum</i>	Blue billygoat weed	√	√		√		
<i>Bromus sp.</i>	Brome grass	√			√		
<i>Xanthium orientale</i>	Californian burr			√	√		
<i>Cinnamomum camphora</i>	Camphor Laurel		√	√	√		
<i>Axonopus affinis</i>	Carpet grass	√	√	√	√		√
<i>Oenothera stricta</i>	Chilean evening primrose			√	√		
<i>Ipomoea cairica</i>	Coastal morning glory	√	√	√	√	√	√
<i>Bidens pilosa</i>	Cobbler's Pegs	√	√	√	√	√	√
<i>Eleusine indica</i>	Crowsfoot grass	√	√	√	√	√	√
<i>Taraxacum officinale</i>	Dandelion	√			√		
<i>Senecio madagascariensis</i>	Fireweed	√		√	√		√
<i>Hypochaeris radicata</i>	Flatweed	√					
<i>Conyza albida</i>	Fleabane	√			√		
<i>Baccharis halimifolia</i>	Groundsel Bush		√	√	√	√	√
<i>Phytolacca octandra</i>	Inkweed	√					
<i>Pennisetum clandestinum</i>	Kikuyu Grass	√			√		
<i>Lantana camara</i>	Lantana		√	√	√		
<i>Eragrostis sp.</i>	Lovegrass	√					
<i>Axonopus fissifolius</i>	Narrow-leafed Carpet Grass	√			√		
<i>Cyperus rotundus</i>	Nutgrass	√					
<i>Sida rhombifolia</i>	Paddy's Lucerne	√	√	√	√		
<i>Paspalum dilatatum</i>	Paspalum	√					
<i>Plantago coronopus</i>	Plantain	√					
<i>Verbena bonariensis</i>	Purpletop	√		√	√		
<i>Chloris gayana</i>	Rhodes grass	√			√		
<i>Setaria sphacelata</i>	South African Pigeon Grass	√		√	√		√
<i>Tagetes minuta</i>	Stinking roger	√	√		√		
<i>Schefflera actinophylla</i>	Umbrella Tree		√	√			
<i>Tradescantia albiflora</i>	Wandering jew	√					
<i>Andropogon virginicus</i>	Whisky Grass	√					
<i>Passiflora subpeltata</i>	White Passionflower	√		√	√		
<i>Aster subulatus</i>	Wild aster			√	√	√	√
<i>Solanum mauritianum</i>	Wild Tobacco Bush		√	√			
<i>Senna pendula</i> var. <i>glabrata</i>	Winter senna		√	√	√		



Wetland Management Plan

7.1.5 Methods

Weed will be controlled by various methods and the weed control program will be divided into two phases: primary and secondary weeding. Primary weeding involves the removal of established exotic weed species and secondary weeding involves the maintenance of the management areas to prevent subsequent weed infestations.

Control methods

Mechanical methods (e.g. hoe/rake, hand pulling and/or slashing), a chemical assault (e.g. Roundup Biactive ©) or a combination of both control methods will be used. The generally accepted method of removal for common weed species is shown in **APPENDIX 4**. However, methods specific to the micro-site and/or the species will be used at the discretion of the experienced Bush regenerator. For example, the restoration of the tidal inflow may kill off weeds such as Wild aster.

Careful consideration will be given to the use of herbicides. Low toxicity herbicides will be used such as Roundup Biactive® and Fusilade®. These herbicides will also biodegrade quickly upon entering a natural system (Mann 1998; Woodcock et al 1993).

Primary weeding

The rehabilitation areas are dominated by many species of weeds. Primary weeding is designed to target these exotic species. The following procedures will be followed:

- Before any primary weeding commences all native species within the treatment areas will be located and clearly marked for retention;
- Weed eradication will be undertaken on a progressive basis through localised treatment (i.e. management areas);
- Where appropriate primary weeding will be undertaken by hand to reduce the probability of damage to young regrowth or seedlings;
- Careful hand weeding will occur at least 50 cm around retained native species;
- Camphor laurel will be treated with a variety of methods (**APPENDIX 4**);
- Other persistent, woody weeds will be treated with herbicide using the “cut and paint” method;
- All plant genetic material (i.e. seeds, flowers and under ground rhizomes) will be removed and disposed of at an approved green waste facility; and
- Utmost care will be taken when utilizing chemicals ensuring drift does not occur outside the treatment areas.

Secondary weeding and maintenance

Regular follow up maintenance will be required. The regeneration team will be required to undertake the following duties:

- Control weeds and grasses by hand weeding;
- Apply supplementary mulch;
- Ensure adequate soil moisture and hand water if necessary;



Wetland Management Plan

- Prune or fell pioneer species that are inhibiting the growth of other species; and
- Stake any regenerating natives that have fallen.

Maintenance will be undertaken at the following times:

- 2 weeks after primary weeding;
- 1 monthly for the 1st year;
- 3 monthly for the 2nd and 3rd years; and
- 6 monthly in the 4th and 5th years.

7.2 Natural Regeneration

7.2.1 Facilitation of Natural Regeneration

Tidal flushing, removal of cattle and/or other activities causing physical damage to soil, combined with the existence or creation of appropriate saltmarsh morphology (i.e. elevation, slope, grade, substrate, etc.) will often be enough to rapidly revegetate a native Saltmarsh community (Sinicrope *et al* 1990). It is considered that the most appropriate method to regenerate large areas of the WMFA will be to use the principles of natural regeneration (APPENDIX 5).

Natural regeneration refers to the natural process by which plants replace or re-establish themselves. Cremer (1990) defines “natural regeneration as *“reproduction from self-sown seeds or by vegetative recovery”*. Temple and Bungey (1980) define it as *“regrowth which occurs naturally after stress or disturbance. It may be grown from seed of both pioneer and permanent species”*.

Natural regeneration ensures that plants established on a site are from parents that currently occupy the site. Natural regeneration is a powerful tool to be used to re-establish native vegetation which is capable of with-standing the long term condition variations and should do well, once established.

It is considered that with regular weed control and re-introduction of the appropriate tidal regime, natural regeneration will occur within the WMFA. The methods that are to be used to encourage the natural regeneration process will include:

- Construction of new tidal gates to ensure appropriate tidal flushing;
- Erection of fences and regular maintenance of the fencing;
- Primary weed control to be completed by a qualified bush regenerator;
- Regular maintenance & weed control;
- Monitoring and regular reporting; and
- Adaptive management.

Other regeneration methods have been considered in the preparation of this Management Plan, including:

- the application of clean, salvaged ‘bush soil’;
- brush matting (with local seed-bearing vegetation);



Wetland Management Plan

- direct seeding; and
- planting tubestock.

However, as there will be no clearing of vegetated areas during the construction on the site, no 'bush soil' or cleared vegetation will be available for regeneration purposes. Furthermore, direct seeding and planting of tubestock are relatively high impact regeneration techniques and will only be used if assisted regeneration techniques fail.

7.3 Enhancement planting - SEPP 14, Buffer and Landscaping Areas

7.3.1 Introduction

This section will provide detail on where enhancement planting will be completed, 'best practice' methods for plantings and a list of suitable species.

7.3.2 Enhancement Plantings

Enhancement planting will be undertaken in the following areas:

- MA1 - within and surrounding the constructed wetland;
- MAs 2, 3, 4, 5, and 6 (i.e. SEPP 14 wetland); and
- Landscape planting within the proposed development.

Enhancement planting will only be considered for the SEPP 14 area as an adaptive management measure following the failure of adequate natural regeneration. Salt tolerant species are included in the species list (**APPENDIX 6**).

Suggested species for each planting area are provided in **APPENDIX 6**.

Enhancement plantings

The Constructed Wetland will be planted with aquatic and terrestrial native species. The benefits of the buffer plantings will include the following:

- Provision of habitat for fauna;
- Provision of a wildlife movement corridor;
- Protection of areas of Saltmarsh from runoff that contain high levels of nutrients or pollutants; and
- Maintenance of buffer zones of terrestrial vegetation adjacent to Saltmarsh to allow for the gradual retreat of Saltmarsh in the event of sea-level rise.

Locally occurring terrestrial and aquatic plant species will be utilised in the buffer area (**APPENDIX 6**). Species are a guideline and advice from contracted bush regenerator will also be considered. A note as to the habitat of the species is provided which will assist in where within the wetland each species can be planted.



Wetland Management Plan

Planting methodology

All planting will be completed in accordance with best practice measures, specifications and principles as outlined in the codes and guidelines provided by Florabank (Florabank undated). In addition, the bush regeneration contractor will adhere to the following methods:

- All plantings are to be completed by a qualified bush regenerator (**APPENDIX 6**).
- Existing native trees will be retained wherever possible as the root zones of these trees are already established.
- All species selected for planting should be sourced locally and sun hardened.
- The preparation will consist of the preparing area by weed control as outlined in **SECTION 7.1**.
- Areas selected for planting should be prepared at least two (2) weeks before planting is to occur to allow for dieback of any grasses or weeds before planting.
- All trees should be well watered, fertilised and heavily mulched with organic material sourced from on-site. If conditions at the time of planting are particularly dry, the use of water crystals is recommended.
- Any plantings that fail will be replaced.

Planting methods are summarised in **TABLE 2**.



Wetland Management Plan

TABLE 2
A GUIDE TO PLANTING

Selecting plant stock
– Plants to be used will be acquired from a nursery that propagates plants using locally sourced seeds and cuttings (see Florabank guidelines). – Stock will be fully sun hardened and not planted direct from a shade house. – Tube stock is the best as it is a cost effective plant container size, light in weight and easy to handle. – Plants will have a strong stem and not be root bound or have yellowing or discoloured leaves.
Site preparation
– Trees will be planted at 2 metre centres for trees and 1m centres for small shrubs and ground cover. – Weed control will be undertaken before planting.
Planting
– Planting will begin when the weeds and grass cover have died after weed control measures. – Dead grass and weeds will be trimmed to ground level. – Holes will be dug in the centre of each circle at least 10 cm deeper than the tree container and twice as wide. – The soil at the base and sides of the hole will be loose to allow root penetration. – Plants will be watered well before planting to ensure a moist root ball. – A generous amount of water will be placed into each hole before planting (2-4 litres if the soil is dry), as losses are reduced by planting into a moist root zone. – The plant will be tapped out of its container and any pot bound or circular roots loosened. – Roots will be pruned if they are very bound up. – The plant will be put in the hole with the water and fertiliser and filled in with loose crumbly soil. – The tree will be firmed in well with the hands. This is very important for settling the tree roots in, and to provide a stress free start for each plant. – A slow release fertiliser (e.g. Osmocote/Nutricote, or plant fertiliser pills) will be incorporated into each planting hole and mixed well with the back filled soil, so that the roots are not in direct contact with concentrated fertiliser. – Straw or hay will be used for mulching the whole planting area. Mulch will be laid right up to the stem, but will be “fluffed up” rather than laid in heavy slabs.
Maintenance of the planting
– Weeds will be controlled in the planting area until canopy cover is established (approximately three (3) years). – Weed control will be carried out by suitably experienced persons. – Weed control is essential for strong healthy growth as grass and weeds compete for nutrients, water and light. – Weeds will be controlled on a regular basis. – Three or four visits a year will be adequate for weed control. – Re-fertilising and re-mulching is recommended in the second growth season.



7.4 Protective Measures

7.4.1 Fencing to the SEPP 14 Wetland

Exclusion of human traffic is vital for the continued regeneration of the WMFA. The following procedures are to be followed with regard to access to and exclusion from the WMFA:

- The WMFA will be fenced to exclude traffic and to clearly identify revegetation areas;
- Temporary fences must be erected upon the commencement of the enhancement planting works;
- The fencing will be fauna friendly and will consist of 1.2 m star pickets at 4 metre intervals and with three (3) strands of smooth galvanized wire. Alternatively, bollards may be placed at 2m intervals;
- Permanent post and rail fencing will replace star picket fence at the completion of the rehabilitation works;
- Any gates are to be locked and maintained/repared if gates or fences are damaged;
- Signage is to be erected on exclusion fencing stating: “No Entry - Native Plant Revegetation Area”. All contractors are to be made aware of restrictions applying to the exclusion zones;
- Buffer plantings are to be designed to provide a screen of trees that will reduce human access;
- Public access into adjoining areas of the development is to be limited to designated pathways and/or boardwalks;
- Educational signage is to be provided which informs visitors and residents of the importance of Coastal Saltmarsh. The signage is to be displayed along the boardwalk;
- Only authorised personnel will be allowed within the Rehabilitation area; and
- No fires will be permitted within the WMFA.

7.4.2 Educational Signage

Advisory and interpretive signage will be provided. Signs will be designed in consultation with JWA. Signage should comply with all Australian standards, be non-obtrusive and highly resistant to vandalism. The sign design will ideally incorporate the following elements:

- The purpose of the wetland.
- The physical and biological processes.
- Identifying any significant environmental features (such as habitat for a particular species).
- Appropriate safety warnings.
- Appropriate agency identification.



7.4.3 Erosion Control

Cabin Development Area

The proposed constructed wetland will be used as a sediment retention basin during the construction phase. Flows from the majority of the site will be directed to the basin. The location of the basin will facilitate interception of any sediment to the SEPP 14 Wetland. The large size of the sediment retention basin will adequately cater for settlement of the sandy soils of the site. The western fringe of the site may flow to New Entrance Road. Sediment control fences will be erected along this boundary to prevent any sediment loss to the road drainage system.

The Proposed sediment and erosion control plan is shown in **FIGURE 9**.

At the flood gate for the wetland

Scour protection will be provided on the upstream and downstream side of the floodgate / pipe to address scour issues associated with the reintroduction of tidal flows.

7.5 Pest animal control strategy

7.5.1 Introduction

Pest animals are those that have potentially negative environmental impacts. These species are generally non-native and pose a threat to biodiversity values within open space areas.

Several species of animals deemed as pests are considered possible occurrences on the Subject site. These include:

- Wild dogs
- Feral cats
- Rabbits/hares
- Cane toads
- Foxes

These species have the potential to impact negatively on the significant ecological values of the site, either directly through predation or through competition for resources.

Pest animals such as those listed above generally enjoy widespread distribution across a variety of habitat types, and typically have high mobility and reproductive rates. As such, eradication is not considered feasible, and management strategies should be focused on minimising populations in areas of high ecological value, where impacts are potentially greatest.



7.5.2 Control Strategies

Wild dogs

Wild dogs are a declared pest under the *Rural Lands Protection Act 1998*. Difficulties in the control of wild dogs have arisen from their ability to hybridise with native Dingos, which are not always readily distinguishable from their feral counterparts.

Wild dogs may also negatively impact on Dingo (and potentially other native animal) populations by acting as vectors for disease, and are also likely to prey on indigenous fauna. They pose a significant economical problem by killing livestock (such as sheep and cattle) belonging to farmers, and may also pose a threat to public safety in some circumstances.

- Domestic dogs are to be prohibited.
- Residents/visitors should be encouraged to contact the Body Corporate if Wild dogs are sited.
- If wild dogs are sited, Leg-hold traps/baiting regimes within the conservation area should be undertaken in cooperation with the NPWS and/or Council.

Feral cats

Feral cats are predominantly nocturnal and occupy a home range of up to 280 hectares. They are most common in open environments (e.g. grasslands) in close proximity to urban or rural areas.

Feral cats prey on a large range of native animals. They appear to have the largest impacts on small mammals, however will also catch birds, amphibians, reptiles, fish and insects. They may also act as vectors for disease that affect native wildlife and humans (e.g. toxoplasmosis, sarcosporidiosis).

- Domestic cats are to be prohibited.
- Residents/visitors should be encouraged to contact the Body Corporate if Feral cats are sited.
- If Feral cats are sited, a cage trapping regimes within the conservation area in cooperation with the NPWS and/or Council.

Rabbits/Hares

Rabbits and hares are common across a variety of habitats. They are a major prey item for other pest animals such as cats, dogs and foxes and can contribute to higher populations of these species. Through selective grazing upon palatable vegetation species they can be responsible for the alteration of flora assemblages and habitats. Burrowing activities may cause soil disturbance, resulting in erosion and in some cases preventing the regeneration of native flora.

- Residents/visitors should be encouraged to contact the Body Corporate if Rabbits or Hares are sited.



Wetland Management Plan

- If Rabbits or Hares are sited, a trapping/baiting regime should be undertaken within the conservation area in cooperation with the NPWS and/or Council.
- Monitoring strategies are to involve visual and spotlighting techniques (*N. Hing 2009, pers. comm., 30 Mar.*).

Cane toads

The Cane toad, a native of central/south America, is toxic at all stages of its life cycle, posing a threat to native fauna that may attempt to prey on it. They are superior competitors, being able to survive in a range of temperatures and environments. They prey on native frogs, insects and small reptiles and compete with native frogs for food and breeding sites.

- Any water features to be constructed as part of the development should incorporate dense fringing vegetation (e.g. Lomandras, sedges) in order to restrict access to the water by Cane toads.
- Periodic collection (either manual or through use of specialised traps) and humane disposal of Cane toads should be conducted by the Body Corporate, during times of high rainfall or when large numbers of toads are evident.
- Water will not be permitted to pool in disturbed areas during construction in order to eliminate further breeding opportunities for toads.
- Any mulch for use in rehabilitation or landscaping projects should be inspected, by the Body Corporate, for presence of Cane toads.

Foxes

The Red fox can have significant impacts on a variety of native wildlife through predation, most notably small and medium mammals, ground-nesting birds and freshwater turtles. Foxes, along with wild dogs, can also carry and transmit diseases to livestock.

- Residents/visitors should be encouraged to contact the Body Corporate if Foxes are sited.
- If wild dogs are sited, Leg-hold traps/baiting regimes within the conservation area should be undertaken in cooperation with the NPWS and/or Council.



8 MAINTENANCE PROGRAM

8.1 Introduction

Maintenance or follow up works are vital for the continuing rehabilitation of the WMFA. This section discusses the maintenance requirements as well the timing of the maintenance visits, and the personnel responsible for the implementation of this maintenance plan.

8.2 Personnel

Maintenance within the WMFA is to be completed by the relevant suitably qualified persons (i.e. bush regenerator and/or fencing contractor). Maintenance will be organised and funded by the proponent. Maintenance will occur within all management areas.

8.3 Management Area 1 - Constructed Wetland

8.3.1 Introduction

Wetlands require ongoing inspection and maintenance to ensure they establish and operate in accordance with the design intent. Potential problems that may arise as a result of poor maintenance include:

- Decreased aesthetic amenity;
- Reduced treatment performance;
- Public health and safety risks; and
- Decreased habitat diversity (e.g. dominance of exotic weeds).

8.3.2 Plant establishment

Strong healthy vegetation plays a key role in maintaining the treatment performance of a wetland. The most intensive period of maintenance is during the plant establishment period (initial one to two years) when weed removal and replanting may be required.

To maximise the chances of successful establishment of vegetation, it may be necessary to manipulate the water level of the wetland in the early stages of vegetation growth. When first planted, vegetation in the marsh zones may be too small for their prescribed water depths. Seedlings intended for inundated zones should ideally have half their stem height above water level, and must not have any less than one-third of their stem above the water level. If planting stock is immature, this may not be possible without manipulating the water levels.

The water depth can be controlled at the outlet pipes. The normal water level can be established when it is clear the wetland plants have matured to the point where at least half of the stem is above the normal water level.



Wetland Management Plan

Regular watering of wetland vegetation is essential for successful establishment and healthy growth. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water holding capacity of the soil.

In the absence of rain, it is recommended that each plant receives 2.5-5.0 litres per week during the first six weeks to retain a muddy substrate (40 mm of watering per week during establishment). After an initial four-month period, watering may still be required within the ephemeral zones of the wetland and on the batters, particularly during the first winter / spring or dry period.

8.3.3 General ongoing maintenance

Inflow pipes, headwalls, outlets and weirs require regular inspection, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of litter and debris should be done regularly.

General maintenance will include:

- Routine inspection of the wetland to identify any areas of increased sediment deposition, scouring from storm flows, litter build up and blockages.
- Routine inspection of inlets, outlets and weirs to identify, clean and repair any areas of scour, litter build up and blockage.
- Repairing damage to the wetland profile resulting from scour or rill erosion by replacement of appropriate fill and revegetation.
- Removal of sediment from the inlet zone(s).
- Removal of sediment and litter where it is smothering the vegetation.

Maintenance of wetland vegetation will include:

- Regular watering/irrigation of vegetation until plants are established and self sustaining. The watering schedule will be as follows:
 - Week 1 - 6: 5 waterings / week
 - Week 6 - 10: 3 waterings / week
 - Week 11 - 15: 2 waterings / week
- Ensuring adequate soil nutrient levels within revegetation zones through periodic fertilising;
- Removal and management of invasive weeds.
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation and to stimulate growth.

Regular inspections are required, as well as inspections following intense storm events to check for scour and other damage. Major maintenance involving machinery should only occur after a reasonably rain free period when the wetland is relatively dry.



8.4 Management Area 2, 3, 4, 5 and 6 - SEPP 14 Wetland

The maintenance of the SEPP 14 Wetland and natural regeneration areas is likely to involve spraying of invasive grasses and other exotic species.

Continued monitoring will ensure that adaptive management techniques are used in the natural regeneration areas. Some of the adaptive management techniques that may be employed include the following:

- Potential planting of Saltmarsh species within areas which have failed to colonise;
- Reconfiguration of the tidal gates to allow for a more appropriate tidal regime; and
- Various other adaptive management techniques that will need to be implemented in the case of failure.

8.5 Timing of Maintenance

After primary weeding and revegetation works, regular follow up maintenance will be required. The Bush Regeneration Team will complete regular maintenance of the natural regeneration & buffer areas (i.e. once every three (3) months) for a period of two years. For the 3rd, 4th, and 5th years of the plan, weed re-growth control and other general maintenance tasks will be completed every six (6) months.

8.6 Maintenance of the Flood Gate

Regular operational checks, of the flood gate mechanism, will be undertaken and any necessary maintenance expeditiously completed. All cost will be born by the proponent.



9 MONITORING

9.1 Introduction

A well-designed restoration monitoring program will allow project managers to detect results months, years, or decades following implementation of a plan. This section outlines the monitoring for the WMFA -MAs 2, 3, 4, 5, and 6 and will include a description of the general monitoring of the naturally regenerating Saltmarsh areas.

Long term monitoring of the overall vegetation communities will be completed using aerial photography and ground truthing of the vegetation composition. A plan for the long term monitoring is also included in this section. Monitoring data can be used by project managers to demonstrate the ability of the project to meet stated goals and objectives.

9.2 Criteria for success

Indicators for the success of natural regeneration in MAs 2, 3, 4, 5, and 6 are:

- Restoration of tidal inflow to the SEPP14 wetland area;
- No encroachment of HAT into freshwater wetland;
- Re-establishment of healthy Saltmarsh community in degraded areas;
- Colonisation of Saltmarsh species within the boundaries of the highest tidal mark (i.e. 0.048m ADH);
- None or very little mangrove recruitment within the SEPP 14 area on the Subject site;
- Arrest of Swamp oak colonisation outside existing Swamp oak community boundaries;
- Maintenance of healthy freshwater wetland within the constructed wetland (i.e. no saline water encroachment);
- Quality freshwater entering the SEPP 14 Wetland; and
- Absence of significant weed growth.

9.3 Management Area 2, 3, 4, 5 and 6 - SEPP 14 Wetland

9.3.1 Tidal Inundation

To ensure the re-establishment of a healthy saltmarsh ecosystem, through the re-introduction of a tidal regime, a detailed monitoring programme will be required. After the installation of a new floodgate, a trial period of tidal inundation will be undertaken limiting high tide to a boundary represented by the present occurrence of vegetation with a full salt tolerance (i.e. Stage 1 - approximately equivalent to 0.41 m AHD). Tidal inundation will be monitored by a suitable qualified person in the context of the aim of this WMP (i.e. re-establishment of a healthy saltmarsh ecosystem).

9.3.2 Vegetation

The monitoring of natural regeneration areas will include regular monitoring by a qualified ecologist who is to complete the following:



Wetland Management Plan

- **Transects**

- Five (5) transects are to be evenly placed across the WMFA;
- Transect locations are to be permanently marked;
- Transects are to be 100 metres in length;
- During monitoring visits tape measures are to be placed on the ground and the specific measurable features recorded along the transects. The zero distance is to be placed at the marker that is most near the development site;
- Specific measurable features include:
 - Areas of vegetation cover (Saltmarsh species);
 - Areas of vegetation cover (other native species);
 - Areas of weed cover;
 - Areas of salt pans/bare ground/mud;
- Results are to be shown in a table which is to be presented in the monitoring reports.

- **Quadrats**

- Five (5) Quadrats (1m²) are to be placed along each of the transects;
- Quadrats must be placed 20m apart along the length of the transect;
- Quadrats are to be placed semi randomly within five (5) meters of the transect line;
- The boundary of the quadrat with respect to the tape measure (e.g. between 3.5 - 4.5 metres on tape measure) will be recorded;
- For each quadrat the following specific measurable features will be recorded:
 - Plant species occurring
 - Percentage cover
 - Height
 - Relative abundance of Saltmarsh species
 - Weed cover
- Results are to be shown in a table which is to be presented in the monitoring reports.

- **Fixed Photo points**

- The transect markers which occur closest to the development are to be used as permanent photo stations for photographic monitoring;
- Four (4) photos are to be taken from each transect. Photos are to be taken to the north, south, east and west;
- Photos will be taken at low tide;
- Photos will be labelled with the:
 - Transect code
 - Direction of view
 - The date & time
 - The tide
- Photos must be supplied in the monitoring reports in a form of prints no smaller than 4" x 6" and must be colour.

9.4 Timing of Monitoring Visits

The monitoring is to be completed by a suitably qualified ecologist (**APPENDIX 2**). Site visits will occur:



Wetland Management Plan

- Six (6) weeks after primary weeding;
- Six (6) weeks after initial plant-out;
- Every three (3) months thereafter until plants are sufficiently established (i.e. between two (2) - three (3) years)
- Every six (6) months after establishment until the end of the 5 year monitoring program.

9.5 Reporting of Monitoring Results

Following each inspection by the qualified ecologist, a report will be prepared that will include tables and photographs from the monitoring visits. At the end of each year a detailed report will be prepared. The report will discuss the following:

- Works undertaken;
- Progress of regeneration/revegetation areas using photos and tables showing the results of the monitoring visits;
- Significant problems encountered (death of seedlings, broken fences, vandalism etc.) and the effect of these on the plantings and aims of the revegetation or regeneration strategy;
- Success or failures of measures implemented to rectify previously identified problems; and
- Measures to be taken to rectify new problems.

9.6 Long Term Monitoring

Along with the regular monitoring within the revegetation and regeneration areas, the overall vegetation composition within the WMFA is to be regularly assessed and recorded. Long term monitoring will use both aerial photos and yearly assessments (ground truthing) of the vegetation communities using a hand held GPS.

The Long term monitoring of the vegetation composition with the WMFA will include:

- A detailed vegetation map at a scale of 1:5,000 is to be completed within the WMFA every twelve (12) months;
- Each year, after completion of vegetation mapping, a report is to be completed showing the changes in the composition of the vegetation communities within the WMFA. The results are to be shown in a table that shows the vegetation community and the area of the vegetation community as a percentage of the WMFA.



10 ADAPTIVE MANAGEMENT

The principles of adaptive management have been incorporated into the administration of restoration projects within a variety of governmental funding authorities and programs (Thom 1997). Comprehensive, long-term monitoring is a component of adaptive management, which relies on the accumulation of evidence (via long-term monitoring) to support a decision that demands action. If established early in the project planning phase and implemented during successive monitoring and management phases, adaptive management can be a powerful method to systematically assess and improve the performance of restored ecosystems (Thom 2000).

Adaptive management will be an important tool for the implementation and success of this WMP. Monitoring, as described above, will provide an indication as to whether the 1st stage of tidal flow restoration (i.e. to AHD 0.41m) is sufficient to restore a healthy saltmarsh ecosystem.

Examples of other potential adaptive management actions that may be required in the future include:

- Areas of natural regenerating Saltmarsh might reveal encroachment by Phragmites or other invasive plant species and weed control measures devised;
- Manual harvesting or chemical control may be periodically required to control the spread of invasive plants; and
- Enhancement plantings in MAs 2, 3, 4, 5 and 6.



11 COSTING OF RESTORATION WORKS

11.1 Introduction

This section provides a rough estimate of the costs involved with the implementation of the WMP. All costs will be born by the proponent.

11.2 Proposed flood gate

An estimated cost of \$25,000.00 has been provided for the installation of the proposed flood gate.

11.3 Weeding

A cost estimate for weeding (primary and secondary) has been prepared. The estimate was produced based on approximately 17 hectares of land to be rehabilitated, considering the weed densities and the efforts that will be required to remove the exotic species and allow natural regeneration and prepare for enhancement planting (TABLE 4)¹.

TABLE 4
REHABILITATION WORKS COSTS

Works	Cost per hour (\$)	Requirement (hours)	Cost (\$)
Primary Weed Control	35	900	31,500
Secondary weed Control - (5 years)	35	600	21,000
Total			52,500

11.4 Temporary Fencing

The total costing for the fencing has been calculated based on approximately 700m of required fencing (TABLE 5). The costs have been calculated from prices obtained from A.R.C Fences Ballina.²

TABLE 5
TEMPORARY FENCING COST

MATERIALS	Cost (\$)
Single Star pickets each	4.60
200m of galvanised wire	32.00
MATERIALS AND LABOUR	Cost (700m)

¹ This is an **estimate only** and quotes from licensed Bush Regenerators, closer to the date of commencement, will provide a more accurate guide to costs.

² This is an **estimate only** and quotes from local hardware suppliers should be obtained.



Wetland Management Plan

175 star pickets for 700 metres of fencing	805.00
Four lines of wire (i.e. 14 x 200m rolls)	448.00
Labour cost approximately \$3.50 per meter	2,450.00
Total	2,906.05

11.5 Permanent Fencing

The total costing for the fencing has been calculated based on approximately 700m of required fencing (**TABLE 5**). The costs have been calculated from prices obtained from The Log Factory.³

TABLE 6
PERMANENT FENCING COST

MATERIALS	Cost (\$)
Fence - Rural Posts 125x75x1.8 - 2 Rail	19.26/m
Rapid set concrete	7.50/bag
MATERIALS AND LABOUR	Cost (700m)
700 metres of fencing	13,482.00
390 x bags rapid set concrete (1 bag every 1.8m)	2,925.00
Labour cost approximately \$3.50 per meter	2,450.00
Total	18,857.00

11.6 Planting Costs

Planting within the SEPP 14 wetland will only be undertaken as an adaptive management measure if natural regeneration does not occur after weed control and restoration of the tidal regime.

Based on a planting area of 3000m², approximately 3000 plants will be required for the constructed wetland. Tube stock will average at about \$1.50 per unit including planting. Total costs will be approximately \$4500⁴.

11.7 Monitoring Costs

The monitoring is to be completed by a qualified ecologist and will consist of an initial visit 6 months after planting and subsequent visits, twice a year for 5 years (**APPENDIX 2**).

³ This is an **estimate only** and quotes from a Fencing Contractor should be obtained.

⁴ This is an **estimate only** and quotes from licensed Bush Regenerators, closer to the date of commencement and/or after primary weeding, will provide a more accurate guide to costs.



Wetland Management Plan

Monitoring visits will take approximately one (1) hour (excluding travel time). The total number of visits required will be 9, at an approximate cost of \$330 per visit (i.e. \$2970). Seven monitoring reports should also be submitted at an average estimated cost of \$500 per report (i.e. \$3500).

11.8 Signage

Interpretive signage will be placed in at least one position along the wetland. A medium to large (approximately 2.5m high), colourfast and vandal proof sign will cost approximately \$4000⁵.

11.9 Summary of Rehabilitation/Monitoring Costs

Component	Costs
Primary Weed Control	31 500
Secondary Weed Control	21 000
Temporary Fencing	2 906
Permanent Fencing	18 857
Planting Costs - SEPP 14	?
Planting Costs - Constructed Wetland	4 500
Signage (including artwork, printing and installation)	4 000
Monitoring	2 970
Reports	3 500
TOTAL	89 233

⁵ The variable available for interpretive signage is enormous, so the above cost should strictly be considered as a rough estimate only. Quotes from a local sign company should be obtained upon completion of works.



12 SUMMARY

James Warren & Associates (JWA) have been engaged by Shannon Pacific Pty Ltd to complete a Wetland Management Plan (WMP) as part of an application for a Tourist Facility on land described as Lot 4 DP 1022342 New Entrance Road, South West Rocks.

The WMP provides guidelines for the re-introduction of tidal flows to the SEPP 14 Wetland and the management of this area through weed control and assisted natural regeneration. This area will provide protection and quality habitat for Migratory waders and the resident population of Eastern grey kangaroos.

As mitigation for a potential increase in stormwater runoff, the proposed development will include the construction of a freshwater wetland to act as a sediment and filtration system for stormwater. This system will simultaneously act as a buffer to the SEPP 14 Wetland.

A Stormwater Management Plan will provide for the construction of the freshwater wetland (MA1) and the WMP will provide guidelines for plantings, fencing, signage, monitoring and maintenance within MAs 1, 2, 3, 4, 5, and 6.

At present the SEPP 14 wetland contains two EECs Swamp oak and Saltmarsh. The distribution of Swamp oak has responded to less saline conditions and expanded over the last three decades with the exclusion of tidal water. The re-establishment of a healthy Saltmarsh ecosystem incorporating both these EECs will depend on a balance between stormwater discharge and tidal inflow.

To ensure the re-establishment of a healthy Saltmarsh ecosystem, through the re-introduction of a tidal regime, a detailed monitoring programme will be required. Tidal inundation will be monitored. Water quality both within and at discharge points from the freshwater wetland (i.e. buffer area) will also be completed to ensure high quality water discharge into the SEPP 14. Adaptive management procedures may need to be developed and/or initiated.



13 REFERENCES

- A.C.T KAC (1997) Living with Eastern Grey Kangaroo in The ACT - Public Land. Third Report to the Minister for The Environment, Land and Planning. A.C.T. Kangaroo Advisory Committee. October 1997.
- Adam P (1981) Australian saltmarshes. *Wetlands (Australia)* 1, 8-10.
- Adam P (1990) Saltmarsh ecology. Cambridge University Press, Cambridge.
- Adam P, Wilson NC, Huntley B (1988) The phytosociology of coastal saltmarsh vegetation in New South Wales. *Wetlands (Australia)* 7, 35-85.
- Harty C, Cheng D (2003)
- Adam, P 2002 Saltmarshes in a time of change, *Environmental Conservation* (2002), 29: 39-61 Cambridge University Press
- Cremer, K.W. (ed), (1990), Trees for Rural Australia, Inkata Press
- Cronin, L. (2008) Cronin's Key Guide Australian Mammals. Allen & Unwin, Sydney.
- Dawson, T.J. (1995) Kangaroos: Biology of the Largest Marsupials. UNSW Press, Sydney.
- DECC (2008c) Best practice guidelines for coastal saltmarsh. Department of Environment and Climate Change. Located at http://sydney.cma.nsw.gov.au/index.php?option=com_remository&Itemid=116&func=startdown&id=335 viewed in 3rd May 2010.
- DECCW (2008a) Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions - endangered ecological community listing NSW Scientific Committee - final determination NSW Department of Environment, Climate Change and Water. Located at <http://www.environment.nsw.gov.au/determinations/CoastalSaltmarshEndSpListing.htm> viewed on 1st April 2010.
- DECCW (2008b) Swamp Oak Floodplain Forest in the NSW North Coast, Sydney Basin and South East Corner bioregions - endangered ecological community listing NSW Scientific Committee - final determination NSW Department of Environment, Climate Change and Water. Located at <http://www.environment.nsw.gov.au/determinations/SwampOakFloodplainEndSpListing.htm> viewed on 1st April 2010.
- DPI (2008) Department of Primary Industry - Aquatic Habitat Management and Fish Conservation 1999 Update. Located at http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/202691/Policyand-Guidelines-for-aquatic-habitat-management-and-fish-conservation-1999.pdf viewed on 3rd May 2010
- Florabank (undated) Florabank. Guidelines and Code of Practice. Located at http://www.florabank.org.au/default.asp?V_DOC_ID=877
- Jaensch (2005) Managing Queensland's saltmarsh wetlands
- JWA (2010) Ecological Assessment Lot 4 DP 1022342 New Entrance Road, South West Rocks. A Report prepared for Pike & Fenwick April 2010.
- Lugo, A.E and Snedaker, S.C (1974). The ecology of Mangroves. Annual review of ecology and systematics. 5: 39-64.



Wetland Management Plan

Mann, Reinier 1998, *Acute Toxicity of Herbicide- Formulation Surfactants to Four Species of Western Australian Frogs*. Report prepared for the Water Corporation of Western Australia at Curtin University of Technology, Western Australia.

NSW Fisheries (2008) NSW Department of Primary Industry - Fisheries - Estuarine habitats located at http://www.fisheries.nsw.gov.au/aquatic_habitats/estuarine

Odum, W.E and and Heald, E.J (1975). Mangrove forests and aquatic productivity. In Jacobs, J (ed.). Coupling of land and water systems Ecological studies No. 10 International Assoc. for ecology, Springer, Verlag, New York pp 129-136.

Odum, E.P. and de la Cruz, A.A. (1967). Particulate organic detritus in a Georgia Saltmarsh - estuarine ecosystem. In Lauff, G.H. (ed)Estuaries. Publication 83, AAS, Washington.

Odum, W.E and and Heald, E.J (1972) Trophic analyses of an estuary mangrove community. Bulletin of Marine Science. 22(3) ;671-738

Poole, W.E. (1982) *Macropus giganteus*. *Mammalian Species*, **187**: 1 - 8.

Sainty (2005) South West Rocks caravan Development Proposal - Wetland Issues

Temple, J.M. & Bungey, D., (1980), Revegetation: Methods and Management, State Pollution Control Commission, NSW.

Thom, Ronald M. 1997. From Advanced Habitat Restoration Training materials, presented at Norrie Point Environmental Center, Staatsburg, NY, June 1997.

Turner, R.E (1976). Geographic variations in saltmarsh macrophyte production: a review. Contrib. Mar. Sci 20 47-68

Westlake, D.F. (1963). Comparisons of plant productivity. Biol. Rev. 38:385-425

Whittaker, R. H (1975). Communities and Ecosystems. 2nd edn. Macmillan, New York.

Woodcock, S. Rose, T. Trayler, K. Chalmers, C. 1993, *A Trial to Determine the Effect of the Herbicide Fluazifop- Butyl on Flora and Fauna of the Swan River System*. A report to the Swan River Trust, Western Australia.



APPENDIX 1

Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions - Endangered Ecological Community listing

NSW Scientific Committee - final determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions, as an ENDANGERED ECOLOGICAL COMMUNITY in Part 3 of Schedule 1 of the Act. Listing of endangered ecological communities is provided for by Part 2 of the Act.

The Scientific Committee has found that:

1. Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions is the name given to the ecological community occurring in the intertidal zone on the shores of estuaries and lagoons including when they are intermittently closed along the NSW coast. Coastal saltmarsh has been recorded from sites along the NSW coast. (NSW North Coast, Sydney Basin and South East Corner Bioregions).
2. Characteristic vascular plant species of Coastal Saltmarsh are:

- *Baumea juncea*
- *Isolepis nodosa*
- *Juncus kraussii*
- *Samolus repens*
- *Sarcocornia quinqueflora*
- *Selliera radicans*
- *Sporobolus virginicus*
- *Suaeda australis*
- *Triglochin striata*
- *Zoysia macrantha*

The total list of species is larger, with many species present in low abundance or at few sites. A more extensive list of species is provided by Adam et al. (1988). The sediment surface may support a diversity of both micro-algae and macro-algae.

3. Communities with similar floristic composition, but with a different fauna, are found supratidally on exposed headlands (Adam et al. 1988). These headland communities and those of inland saline areas are not included within this Determination of the Coastal Saltmarsh Ecological Community.

4. Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions provide habitat for a diverse invertebrate fauna, which includes both marine (crabs and molluscs) and terrestrial (insects and spiders) elements. During tidal flooding a number of fish species utilise saltmarsh habitats. Grazing by macropods may occur between tidal events. Some coastal saltmarshes provide important high tide roosts for migratory wading birds, and a range of other birds also utilise coastal saltmarsh as



Wetland Management Plan

habitat. Diversity of macrofauna in mangrove forests adjacent to saltmarsh has been found to be greater than in mangroves that do not border saltmarsh (Yerman & Ross 2004)

5. Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions is frequently found as a zone landward of mangrove stands. Occasional scattered mature *Avicennia marina* trees occur through saltmarsh at some sites, and *Avicennia* (and less frequently *Aegiceras corniculatum*) seedlings may occur throughout saltmarsh. In brackish areas dense stands of tall reeds (*Phragmites australis*, *Bulboschoenus* spp., *Schoenoplectus* spp., *Typha* spp.) may occur as part of the community.

6. West et al. (1985) estimated the total area of coastal saltmarsh in NSW was approximately 5700 hectares distributed in fragmented patches mostly less than 100 hectares. Since this estimate, further reduction and fragmentation have occurred.

7. Species composition within Coastal Saltmarsh varies with elevation. *Sarcocornia quinqueflora* dominates at lower, and hence more frequently flooded, levels than *Sporobolus virginicus* which dominates the mid saltmarsh, while *Juncus kraussii* and *Baumea juncea* are upper saltmarsh species. There is also geographic variation, with much more extensive stands of *Sporobolus virginicus* being found in northern NSW, and conversely more extensive *Sarcocornia quinqueflora* stands in the south. Coastal Saltmarsh in southern NSW is generally more species rich than further north, with *Austrostipa stipoides*, *Gahnia filum*, *Limonium australe* and *Sclerostegia arbuscula* forming a characteristic southern suite of species. A number of other species with restricted distribution in Coastal Saltmarsh include *Distichlis distichophylla* (endangered), *Halosarcia pergranulata* subsp. *pergranulata*, *Wilsonia backhousei* (vulnerable) and *Wilsonia rotundifolia* (endangered).

8. Saltmarshes are globally threatened, and many of the threatening processes identified by Adam (2002) operate in NSW including infilling, modified tidal flow, weed invasion, damage by domestic and feral animals, human disturbance, altered fire regimes and climate change.

9. Historically, substantial areas of saltmarsh have been infilled for roads and aerodromes and for residential, recreational, waste disposal, industrial and agricultural purposes. With increased recognition of the ecological value of saltmarshes, the threat of further large-scale reclamation is less, but smaller scale infilling still occurs (Harty and Cheng 2003).

10. Patterns of tidal flow have been restricted by artificial structures in many NSW saltmarshes (Williams and Watford 1997), while discharge of stormwater alters salinity regimes, increases nutrient levels and facilitates the spread of *Phragmites* and weeds.

11. In recent decades there has been widespread invasion of saltmarsh in southeast Australia by mangroves (Mitchell and Adam 1989, Saintilan and Williams 1999, 2000). The factors driving mangrove invasion are still unclear. The mangrove invasion limits the use of saltmarshes by birds that would normally make use of this habitat and has been a factor in their decline (Saintilan 2003, Straw 1999, 2000).

12. A large number of weed species occur in NSW saltmarshes (Adam 1981, Adam et al. 1988). In terms of change to the community structure and function, the most serious weed is *Juncus acutus*; other major weeds include *Baccharis halimifolia*, *Cortaderia*



Wetland Management Plan

selloana and *Hydrocotyle bonariensis*. The upper saltmarsh zone may be dominated by introduced annuals or shortlived perennials, including *Parapholis incurva*, *Plantago coronopus* and *Polypogon monspeliensis*.

13. Damage to saltmarshes by recreational vehicles, including four wheel drives, is widespread, and deep wheel ruts persist for many years even after exclusion of vehicles. Use of BMX and mountain bikes is increasing, and even saltmarshes within conservation reserves have been seriously damaged (Adam 2002).

14. Grazing and trampling by domestic stock and feral herbivores occurs at a number of sites. Stock grazing has been shown to substantially change the vegetation composition and structure (Adam 1990), while on muddy substrates trampling can cause loss of plant cover and modify drainage patterns.

15. Saltmarshes have frequently been used for casual rubbish dumping and are at risk from waterborne pollution - including oil and chemical spills, both from shipping and road accidents, and catchment runoff of nutrients and agricultural chemicals.

16. Upper saltmarsh stands dominated by *Juncus kraussii* and *Baumea juncea* have high flammable fuel loads. While the natural incidence of fire in saltmarshes is likely to have been low, a number of saltmarshes have been burnt in recent years. The recovery of these sites is relatively slow and the long-term impacts of burning are uncertain.

17. Global warming and increased relative sea level are likely to pose an increasing threat to the survival of many areas of Coastal Saltmarsh (Adam 2002, Hughes 2003).

18. Coastal Saltmarsh occurs in a number of conservation reserves including the Ramsar listed sites at Towra Point and Kooragang Island Nature Reserves. Reserve status, however, does not confer protection from mangrove and weed invasion, recreational vehicles, pollution, fire or sea level rise without active management.

19. In view of the above the Scientific Committee is of the opinion that the Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions is likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival cease to operate.

Dr Lesley Hughes
Deputy Chairperson
Scientific Committee

Proposed Gazettal date: 04/06/04
Exhibition period: 04/06/04 - 16/07/04

References:

Adam P (1981) Australian saltmarshes. *Wetlands (Australia)* 1, 8-10.

Adam P (1990) Saltmarsh ecology. Cambridge University Press, Cambridge.

Adam P (2002) Saltmarshes in a time of change. *Environmental Conservation* 29, 39-61.



Wetland Management Plan

Adam P, Wilson NC, Huntley B (1988) The phytosociology of coastal saltmarsh vegetation in New South Wales. *Wetlands (Australia)* 7, 35-85. Harty C, Cheng D (2003) Ecological assessment and strategies for the management of mangroves in Brisbane Water - Gosford, New South Wales, Australia. *Landscape and Urban Planning* 62, 219-240.

Hughes L (2003) Climate change and Australia: Trends, projections and impacts. *Austral Ecology* 28, 423-443.

Mitchell ML, Adam P (1989) The decline of saltmarsh in Botany Bay. *Wetlands (Australia)* 8, 55-60.

Saintilan N (2003) The less obvious impacts of human settlement. In 'Straw P. (Ed). Status and Management of Migratory Shorebirds in Sydney. Sydney Olympic Park Authority.

Saintilan N, Williams RJ (1999) Mangrove transgression into saltmarsh environments in south-east Australia. *Global Ecology and Biogeography* 8, 117-124.

Saintilan N, Williams RJ (2000) The Decline of Saltmarshes in Southeast Australia: Results of Recent Survey. *Wetlands (Australia)* 18, 49-54.

Straw P (1999) Hunter River Estuary Wader Habitat Investigation. Unpublished report to NSW National Parks and Wildlife Service.

Straw P (2000) Hunter River Estuary Wader Habitat Investigation Stage 2. Unpublished report to NSW National Parks and Wildlife Service.

West R, Thorogood CA, Walford TJ, Williams RJ (1985) An estuarine inventory for New South Wales. Department of Agriculture, NSW. Fisheries Bulletin 2, Sydney

Williams RJ, Watford FA (1996) An inventory of impediments to tidal flow in NSW estuarine fish habitats *Wetlands (Australia)* 15, 44-54.

Yerman MN, Ross PM (2004) Landscape issues for the macrofauna in temperate urban mangrove forests. In "Urban Wildlife more than meets the eye". (Ed. D Lunney and S Burgin) pp. 205-210. (Royal Zoological Society of NSW, Mosman, NSW).

Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions - endangered ecological community listing

NSW Scientific Committee - final determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East



Wetland Management Plan

Corner bioregions, as an ENDANGERED ECOLOGICAL COMMUNITY in Part 3 of Schedule 1 of the Act. Listing of endangered ecological communities is provided for by Part 2 of the Act.

The Scientific Committee has found that:

1. Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains. Floodplains are level landform patterns on which there may be active erosion and aggradation by channelled and overbank stream flow with an average recurrence interval of 100 years or less (adapted from Speight 1990). Swamp Oak Floodplain Forest generally occurs below 20 m (rarely above 10 m) elevation in the NSW North Coast, Sydney Basin and South East Corner bioregions. The structure of the community may vary from open forests to low woodlands, scrubs or reedlands with scattered trees. Typically these forests, woodlands, scrubs and reedlands form mosaics with other floodplain forest communities and treeless wetlands, and often they fringe treeless floodplain lagoons or wetlands with semi-permanent standing water (e.g. Pressey 1989a).

The composition of Swamp Oak Floodplain Forest is primarily determined by the frequency and duration of waterlogging and the level of salinity in the groundwater. Composition also varies with latitude. The community is characterised by the following assemblage of species:

<i>Acmena smithii</i>	<i>Alphitonia excelsa</i>
<i>Alternanthera denticulata</i>	<i>Baumea juncea</i>
<i>Blechnum indicum</i>	<i>Callistemon salignus</i>
<i>Carex appressa</i>	<i>Casuarina glauca</i>
<i>Centella asiatica</i>	<i>Commelina cyanea</i>
<i>Crinum pedunculatum</i>	<i>Cupaniopsis anacardioides</i>
<i>Cynodon dactylon</i>	<i>Dianella caerulea</i>
<i>Entolasia marginata</i>	<i>Elydra fluctuans</i>
<i>Flagellaria indica</i>	<i>Gahnia clarkei</i>
<i>Geitonoplesium cymosum</i>	<i>Glochidion ferdinandi</i>
<i>Glochidion sumatranum</i>	<i>Hypolepis muelleri</i>
<i>Imperata cylindrica</i> var. <i>major</i>	<i>Isolepis inundata</i>
<i>Juncus kraussii</i> subsp. <i>australiensis</i>	<i>Juncus planifolius</i>
<i>Juncus usitatus</i>	<i>Lobelia alata</i>
<i>Lomandra longifolia</i>	<i>Lophostemon suaveolens</i>
<i>Maundia triglochinosides</i>	<i>Melaleuca alternifolia</i>
<i>Melaleuca ericifolia</i>	<i>Melaleuca quinquenervia</i>
<i>Melaleuca styphelioides</i>	<i>Myoporum acuminatum</i>
<i>Oplismenus imbecillis</i>	<i>Parsonsia straminea</i>
<i>Persicaria decipiens</i>	<i>Persicaria strigosa</i>
<i>Phragmites australis</i>	<i>Selliera radicans</i>
<i>Smilax australis</i>	<i>Stephania japonica</i> var. <i>discolor</i>
<i>Viola banksii</i>	

2. The total species list of the community is considerably larger than that given above, with many species present at only one or two sites or in low abundance. The species composition of a site will be influenced by the size of the site, recent rainfall or drought conditions and by its disturbance (including fire, grazing, flooding and land clearing) history. The number and relative abundance of species will change with time since fire, flooding or significant rainfall, and may also change in response to changes in grazing regimes. At any one time, above-ground individuals of some species may be absent, but the species may be represented below ground in the soil seed banks or as dormant structures such as bulbs, corms, rhizomes, rootstocks or lignotubers. The list of species given above is of vascular plant species, the community also includes micro-organisms, fungi, cryptogamic plants and a diverse fauna, both vertebrate and invertebrate. These components of the community are poorly documented.

3. Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions is known from parts of the Local Government Areas of Tweed, Byron, Lismore, Ballina, Richmond Valley, Clarence Valley, Coffs Harbour, Bellingen, Nambucca, Kempsey, Hastings, Greater Taree, Great Lakes, Port Stephens, Maitland, Newcastle, Cessnock, Lake Macquarie, Wyong, Gosford, Pittwater, Warringah, Hawkesbury, Baulkham Hills, Hornsby, Lane Cove, Blacktown, Auburn, Parramatta, Canada Bay, Rockdale,



Wetland Management Plan

Kogarah, Sutherland, Penrith, Fairfield, Liverpool, Bankstown, Wollondilly, Camden, Campbelltown, Wollongong, Shellharbour, Kiama, Shoalhaven, Eurobodalla and Bega Valley but may occur elsewhere in these bioregions. Bioregions are defined in Thackway and Creswell (1995). Major examples once occurred on the floodplains of the Clarence, Macleay, Hastings, Manning, Hunter, Hawkesbury, Shoalhaven and Moruya Rivers.

4. Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions has a dense to sparse tree layer in which *Casuarina glauca* (swamp oak) is the dominant species northwards from Bermagui. Other trees including *Acmena smithii* (lilly pilly), *Glochidion* spp. (cheese trees) and *Melaleuca* spp. (paperbarks) may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. Tree diversity decreases with latitude, and *Melaleuca ericifolia* is the only abundant tree in this community south of Bermagui (Keith and Bedward 1999). The understorey is characterised by frequent occurrences of vines, *Parsonsia straminea* (common silkpod), *Geitonoplesium cymosum* (scrambling lily) and *Stephania japonica* var. *discolor* (snake vine), a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter. The composition of the ground stratum varies depending on levels of salinity in the groundwater. Under less saline conditions prominent ground layer plants include forbs such *Centella asiatica* (pennywort), *Commelina cyanea*, *Persicaria decipiens* (slender knotweed) and *Viola banksii*; graminoids such as *Carex appressa* (tussock sedge), *Gahnia clarkei* (a saw-sedge), *Lomandra longifolia* (spiny-headed mat-rush), *Oplismenus imbecillis*; and the fern *Hypolepis muelleri* (batswing fern). On the fringes of coastal estuaries, where soils are more saline, the ground layer may include the threatened grass species, *Alexfloydia repens*, as well as *Baumea juncea*, *Juncus kraussii* subsp. *australiensis* (sea rush), *Phragmites australis* (common reed), *Selliera radicans* and other saltmarsh species. The composition and structure of the understorey is also influenced by grazing history, changes to hydrology and soil salinity and other disturbance, and may have a substantial component of exotic grasses, vines and forbs.

5. Unlike most other coastal floodplain communities, Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions are not a significant habitat for waterbirds (Goodrick 1970). However, they do sometimes provide food resources for the Glossy Black Cockatoo (*Calyptorhynchus lathami lathami*), and Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*) (Marchant and Higgins 1990). The fauna of Swamp Oak Floodplain Forest also includes the Squirrel Glider (*Petaurus norfolcensis*) and several species of frogs in the families Myobatrachidae (southern frogs) and Hylidae (tree frogs).

6. Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions forms part of a complex of forested wetland and treeless wetland communities found throughout the coastal floodplains of NSW. A recent analysis of available quadrat data from these habitats identified a distinct grouping of vegetation samples attributable to this community (Keith and Scott 2005). The combination of features that distinguish Swamp Oak Floodplain Forest from other endangered ecological communities on the coastal floodplains include: its dominance by a tree canopy of either *Casuarina glauca* or, more rarely, *Melaleuca ericifolia* with or without subordinate tree species; the relatively low abundance of *Eucalyptus* species; and the prominent groundcover of forbs and graminoids. It generally occupies low-lying parts of floodplains, alluvial flats, drainage lines, lake margins and fringes of estuaries; habitats where flooding is periodic and soils show some influence of saline ground water. This latter habitat feature sets it apart from other floodplain communities.

7. Swamp Oak Floodplain Forest may adjoin or intergrade with several other endangered ecological communities, which collectively cover all remaining native vegetation on the coastal floodplains of New South Wales. These include Lowland Rainforest on Floodplain in the NSW North Coast bioregion, Subtropical Floodplain Forest of the NSW North Coast bioregion, River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (including the formerly listed Sydney Coastal River-Flat Forest in the Sydney Basin bioregion), Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (including the formerly listed Sydney Coastal Estuary Swamp Forest in the Sydney Basin bioregion) and Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions. For example, in less saline habitats, Swamp Oak Floodplain Forest may adjoin or intergrade with several other endangered ecological communities including River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions and Subtropical Floodplain Forest of the NSW North Coast bioregion. The most saline forms of Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions may adjoin or intergrade with Coastal Saltmarsh of the NSW North Coast, Sydney Basin and South East Corner bioregions. The boundaries between these communities are dynamic and may shift in response to changes in hydrological regimes, fire regimes or land



Wetland Management Plan

management practices (e.g. Johnston *et al.* 2003). The Determinations for these communities collectively encompass the full range of intermediate assemblages in transitional habitats.

8. A number of vegetation surveys and mapping studies have been conducted across the range of Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions. This community includes 'Sheoak Swamps' in the general coastal wetlands classification of Goodrick (1970). In the Tweed valley lowlands, this community includes '*Casuarina glauca* tall to very tall open to closed forest' (F10) of Pressey and Griffith (1992) and parts of the 'Floodplain Wetland Complex' (FL) that include *Casuarina glauca* with *Melaleuca* spp. (Pressey and Griffith 1992). In the Comprehensive Regional Assessment of the north-eastern NSW (NPWS 1999), areas mapped as 'Forest Ecosystem 143, Swamp Oak', fall within this community. In the lower Hunter valley, 'Swamp Oak - Rushland Forest' (map unit 40) and 'Swamp Oak Sedge Forest' (map unit 41) of NPWS (2000) fall within this community. On the Cumberland Plain, 'Riparian Woodland' (map unit 5) of Tozer (2003) and parts of 'Alluvial Woodland' (map unit 11) dominated by *Casuarina glauca* (Tozer 2003) are included within this community, while those parts of Benson's (1992) 'River Flat Forest' (map unit 9f) dominated by *C. glauca* also fall within this community, as do parts of the 'River-flat forests' of Benson and Howell (1990) and Benson *et al.* (1996) that are dominated by *C. glauca*. On the Illawarra Plain, 'Coastal Swamp Oak Forest' (map unit 36) of NPWS (2002) occurs within this community. In the Comprehensive Regional Assessment of southern New South Wales (Thomas *et al.* 2000), this community includes 'Coastal Wet Heath Swamp Forest' (forest ecosystem 24), 'South Coast Swamp Forest' complex (forest ecosystem 25) and those parts of 'Ecotonal Coastal Swamp Forest' (forest ecosystem 27) dominated by *Casuarina glauca*. In the Sydney - South Coast region, this community includes parts of 'Floodplain Swamp Forest' (map unit 105) dominated by *Casuarina glauca*, 'Estuarine Fringe Forest' (map unit 106) and 'Estuarine Creek Flat Scrub' (map unit 107) of Tindall *et al.* (2004). In the Eden region, this community includes 'Estuarine Wetland Scrub' (map unit 63) of Keith and Bedward (1999) and parts of 'Floodplain Wetlands' (map unit 60) that include *Casuarina glauca* or *Melaleuca ericifolia* (Keith and Bedward 1999). Swamp Oak Floodplain Forest South East Corner is included within the 'Coastal Floodplain Wetlands' vegetation class of Keith (2002, 2004). There may be additional or unmapped occurrences of Swamp Oak Floodplain Forest within and beyond these surveyed areas.

9. The extent of the Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions prior to European settlement has not been mapped across its entire range. However, one estimate based on a compilation of regional vegetation maps suggests that Coastal Floodplain Wetlands, which include Swamp Oak Floodplain Forest, currently cover 800-1400 km², representing less than 30% of the original extent of this broadly defined vegetation class (Keith 2004). Compared to this combined estimate, the remaining area of Swamp Oak Floodplain Forest is likely to be considerably smaller and is likely to represent much less than 30% of its original range. Major occurrences include: less than 350 ha on the Tweed lowlands in 1985 (Pressey and Griffith 1992); less than 650 ha on the lower Clarence floodplain in 1982 (Pressey 1989a); less than 400 ha on the lower Macleay floodplain in 1983 (Pressey 1989b); less than 3200 ha in the lower Hunter - central Hunter region in the 1990s (NPWS 2000); less than 5200 ha in the Sydney - South Coast region in the mid 1990s (Tindall *et al.* 2004), including up to 4700 ha on the Cumberland Plain in 1998 (Tozer 2003) and less than 250 ha on the Illawarra Plain in 2001 (NPWS 2002); and less than 1000 ha in the Eden region in 1990 (Keith and Bedward 1999).

10. Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions has been extensively cleared and modified. Large areas that formerly supported this community are occupied by exotic pastures grazed by cattle, market gardens, other cropping enterprises (e.g. sorghum, corn, poplars, etc.) and, on the far north coast, canefields. On the Tweed lowlands, Pressey and Griffith (1992) estimated that less than 3% of the original Floodplain Wetlands and Floodplain Forest remained in 1985. Similar estimates are likely to apply to Swamp Oak Floodplain Forests in other parts of the NSW North Coast bioregion (Pressey 1989a, 1989b, NPWS 1999). In the lower Hunter - central coast region, less than 30-40% was estimated to have remained during the 1990s (NPWS 2000), while approximately 13% remained on the Cumberland Plain in 1998 (Tozer 2003). In the Sydney - South Coast region, less than 20% was estimated to remain in the mid 1990s (Tindall *et al.* 2004), in the Eden region about 30% was estimated to remain during the 1990s (Keith and Bedward 1999).

11. Land clearing continues to threaten Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions. A small minority of the remaining area occurs on public land (e.g. Pressey 1989a, b; Pressey and Griffith 1992), with most occurring on productive agricultural land or in close proximity to rural centres. The remaining stands are severely fragmented by past clearing and further threatened by continuing fragmentation and degradation, flood mitigation and drainage works, landfilling and earthworks associated with urban and industrial development, pollution from urban and agricultural runoff, weed invasion, overgrazing, trampling and other soil disturbance by domestic livestock and feral



Wetland Management Plan

animals including pigs, activation of 'acid sulfate soils' and rubbish dumping (e.g. Pressey 1989a, b; Pressey and Griffith 1992, Boulton and Brock 1999, Johnson *et al.* 2003). Anthropogenic climate change may also threaten Swamp Oak Floodplain Forest if sea levels rise as predicted or if future flooding regimes are affected (IPCC 2001, Hughes 2003). Localised areas, particularly those within urbanised regions, may also be exposed to frequent burning which reduces the diversity of woody plant species. Clearing of native vegetation; Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands; Invasion of native plant communities by exotic perennial grasses; Predation, habitat destruction, competition and disease transmission by feral pigs; Anthropogenic climate change and High frequency fire are listed as Key Threatening Processes under the Threatened Species Conservation Act (1995).

12. Large areas of habitat formerly occupied by Swamp Oak Floodplain Forest have been directly drained by construction of artificial channels (e.g. Pressey 1989a, Boulton and Brock 1999). By the early 1900s, drainage unions or trusts were formed on the major floodplains to enable adjacent landholders to arrange for co-ordinated drainage systems, which were designed and constructed by the NSW Department of Public Works. Additional areas that have not been directly drained may have been altered hydrologically by changed patterns of flooding and drainage following flood mitigation works, particularly the construction of drains, levees and floodgates (Pressey and Griffith 1992). On the north coast of NSW, expansion of *Melaleuca quinquenervia* and *Casuarina glauca* into open floodplain swamps has been attributed to artificial drainage and shortening of the hydroperiod (Johnston *et al.* 2003, Stevenson 2003). There have also been anecdotal reports of recruitment by *Casuarina glauca* in pastures during extended dry periods, though not necessarily by other components of the community. These changes appear to be closely associated with enhanced acidity, altered ionic ratios, increased dissolved organic carbon and sulfide oxidation in the soil profile (Johnston *et al.* 2003). Alteration of tidal flows may have lead to decreased soil salinity and localised expansion of *Casuarina glauca* into areas that previously supported Coastal Saltmarsh or mangroves (Stevenson 2003).

13. Very few examples of Swamp Oak Floodplain Forest remain unaffected by weeds. The causes of weed invasion include physical disturbance to the vegetation structure of the community, dumping of landfill rubbish and garden refuse, polluted runoff from urban and agricultural areas, construction of roads and other utilities, and grazing by domestic livestock. The principal weed species affecting Swamp Oak Floodplain Forest include *Araujia sericiflora* (moth plant), *Asparagus asparagoides* (bridal creeper), *Baccharis halimifolia* (groundsel bush), *Cyperus eragrostis* (umbrella sedge), *Cinnamomum camphora* (camphor laurel), *Conyza* spp. (fleabanes), *Hydrocotyle bonariensis* (American pennywort), *Ipomoea cairica*, *I. purpurea* and *I. indica* (morning glories), *Lantana camara*, *Paspalum dilatatum* (paspalum), *Pennisetum clandestinum* (kikuyu), *Rubus fruticosus* agg. (blackberries), *Solanum pseudocapsicum* (Madeira winter cherry), *S. nigrum* (black-berry nightshade), *Tradescantia fluminensis* (wandering jew) and *Verbena bonariensis* (purpletop), (Tozer 2003, Keith and Scott 2005). In general, remaining examples of Swamp Oak Floodplain Forest from the most saline environments are in better condition, while those from less saline habitats are generally more degraded.

14. Small areas of Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions are contained within existing conservation reserves, including Stotts Island, Ukerebagh, Tuckean, Pambalong, Wamberal, Towra Point and Cullendulla Creek Nature Reserves and Bongil Bongil, Myall Lakes and Conjola National Parks. These occurrences are unevenly distributed throughout the range and unlikely to represent the full diversity of the community. In addition, wetlands within protected areas are exposed to hydrological changes that were, and continue to be initiated outside their boundaries. Some areas of Swamp Oak Floodplain Forest are protected by State Environmental Planning Policy 14, although this has not always precluded impacts on wetlands from the development of major infrastructure.

15. Given the dynamic hydrological relationship between Swamp Oak Floodplain Forest, Coastal Saltmarsh and other endangered ecological communities on coastal floodplains, future management of water and tidal flows may result in the expansion of some communities at the expense of others. Proposals for the restoration of natural hydrological regimes and for the rehabilitation of acid sulfate soils may also result in changes to the distribution and composition of floodplain communities. Co-ordinated planning and management approaches across whole catchments will be required to address and resolve priorities between different management objectives.

16. In view of the above the Scientific Committee is of the opinion that Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions is likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate.



Wetland Management Plan

Associate Professor Paul Adam

Chairperson

Scientific Committee

Proposed Gazettal date: 17/12/04

Exhibition period: 17/12/04 - 28/01/05

References

Benson DH (1992) The natural vegetation of the Penrith 1:100 000 map sheet. *Cunninghamia* **2**, 541-596.

Benson DH, Howell, J (1990) 'Taken for granted: the bushland of Sydney and its suburbs.' (Kangaroo Press, Sydney.)

Benson DH, Howell J, McDougall L (1996) 'Mountain devil to mangrove.' (Royal Botanic Gardens, Sydney.)

Boulton AJ, Brock MA (1999). 'Australian freshwater wetlands: processes and management.' (Gleneagles Publishing, Glen Osmond.)

Goodrick GN (1970) A survey of wetlands of coastal New South Wales. Technical Memorandum No. 5. CSIRO, Canberra.

Hughes L (2003) Climate change and Australia: trends, projections and impacts. *Austral Ecology* **28**, 423-443.

IPCC (2001) Climate change 2001: Impacts, adaptation and vulnerability. Report from Working Group II. Intergovernmental Panel on Climate Change, Geneva.

Johnston SG, Slavich PG, Hirst P (2003) Alteration of groundwater and sediment geochemistry in a sulfidic backswamp due to *Melaleuca quinquenervia* encroachment. *Australian Journal of Soil Research* **41**, 1343-1367.

Keith DA (2002) 'A compilation map of native vegetation for New South Wales. NSW Biodiversity Strategy.' (NSW National Parks and Wildlife Service, Sydney.)

Keith DA (2004) 'Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT.' (NSW Department of Environment and Conservation, Sydney.)

Keith, DA Bedward, M (1999) Vegetation of the South East Forests region, Eden, New South Wales. *Cunninghamia* **6**, 1-218.

Keith DA, Scott, J (2005) Native vegetation of coastal floodplains- a broad framework for definition of communities in NSW. *Pacific Conservation Biology* **11**, in press.

Marchant S and Higgins PJ (1990) Handbook of Australian, New Zealand and Antarctic Birds Volume 3. Oxford University Press, Melbourne.

NPWS (1999) Forest ecosystem classification and mapping for the upper and lower north east Comprehensive Regional Assessment. NSW National Parks and Wildlife Service, Coffs Harbour.

NPWS (2000) Vegetation Survey, Classification and Mapping: Lower Hunter and Central Coast Region. Version 1.2. NSW National Parks and Wildlife Service, Sydney.



Wetland Management Plan

NPWS (2002) Native vegetation of the Wollongong escarpment and coastal plain. NSW National Parks and Wildlife Service, Sydney.

Pressey RL (1989a) Wetlands of the lower Clarence floodplain, northern coastal New South Wales. *Proceedings of the Linnean Society of NSW* 111, 143-155.

Pressey RL (1989a) Wetlands of the lower Macleay floodplain, northern coastal New South Wales. *Proceedings of the Linnean Society of NSW* 111, 157-168.

Pressey RL, Griffith SJ (1992) Vegetation of the coastal lowlands of Tweed shire, northern New South Wales, species and conservation. *Proceedings of the Linnean Society of NSW* 113, 203-243.

Speight JG (1990) Landform. In: 'Australian soil and land survey. Field handbook' Second edition (Eds. RC McDonald, RF Isbell, JG Speight, J, Walker, MS Hopkins), pp9-57. Inkata Press, Melbourne.

Stevenson, M (2003) Remote sensing and historical investigation of environmental change and *Melaleuca* encroachment in Tuckean Swamp, north-eastern NSW. Unpublished report. School of Environmental Science and Management, Southern Cross University, Lismore.

Thackway R, Creswell ID (1995) (eds) 'An interim biogeographic regionalisation of Australia: a framework for establishing the national system of reserves.' (Australian Nature Conservation Agency: Canberra).

Tindall D, Pennay C, Tozer MG, Turner K, Keith, DA (2004) Native vegetation map report series. No. 4. Araluen, Batemans Bay, Braidwood, Burragorang, Goulburn, Jervis Bay, Katoomba, Kiama, Moss Vale, Penrith, Port Hacking, Sydney, Taralga, Ulladulla, Wollongong. NSW Department of Environment and Conservation and NSW Department of Infrastructure, Planning and Natural Resources, Sydney.

Thomas V, Gellie N, Harrison T (2000) 'Forest ecosystem classification and mapping for the southern Comprehensive Regional Assessment.' (NSW National Parks and Wildlife Service, Queanbeyan.)

Tozer MG (2003) The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities. *Cunninghamia* 8, 1-75.



APPENDIX 2

Personnel required carrying out work within Wetland Management Plan

The qualifications required by personnel engaged to carry out specific duties within this VMP are outlined below:

(1) Weeding and Plantings

Primary and the secondary weed control will be completed by a qualified Bush Regenerator or Regeneration Team. The contracted Bush Regenerator will hold a s132 Scientific Licence issued by the Department of Environment and Climate Change (DECC) to work in an Endangered Ecological Community (EEC).

All bush regeneration workers will hold a TAFE Accredited Certificate in Bushland Conservation & Management, or equivalent, and will be experienced in up-to-date techniques for Vegetation Rehabilitation and Management.

All chemical users will be experienced and licensed in accordance with the relevant legislation.

(2) Fencing

Fencing will be carried out by a licensed Fencing Contractor.

(3) Monitoring

An overall monitoring plan will be developed and implemented by an appropriately qualified Ecologist. This person will be independent of the Bush Regeneration Team.

Bush regeneration monitoring will be undertaken by the Bush Regeneration Team Leader.



APPENDIX 3

Approximate timeline for rehabilitation works

GANTT chart showing timing of all works

	Year 1	Year 2	Year 3	Year 4	Year 5
Wetland Construction	→				
Construction of Tidal Flap	→				
MA1 (to be commenced after completion of constructed wetland)					
Fencing to protect SEPP 14 Wetland	→				
Weed Control	→				
Planting	→				
Signage	→				
Maintenance					→
Monitoring					→
Adaptive Management					→
MA2 (To be commenced as soon as possible after acceptance of this plan)					
Weed Control	→				
Encouragement of Natural Regeneration					→
Planting (adaptive management)	→				
Maintenance					→
Monitoring					→
Adaptive Management					→
Work in MAs 3 to 6 to be undertaken in a staged approach after work is completed in MA1 and MA2					
MA3					
Weed Control	→				
Encouragement of Natural Regeneration					→



Wetland Management Plan

Planting (adaptive management)	↑								
Maintenance									↑
Monitoring									↑
Adaptive Management									↑
MA4									
Weed Control	↑								
Encouragement of Natural Regeneration									↑
Planting (adaptive management)	↑								
Maintenance									↑
Monitoring									↑
Adaptive Management									↑
MA5									
Weed Control	↑								
Encouragement of Natural Regeneration									↑
Planting (adaptive management)	↑								
Maintenance									↑
Monitoring									↑
Adaptive Management									↑
MA6									
Weed Control	↑								
Encouragement of Natural Regeneration									↑
Planting (adaptive management)	↑								
Maintenance									↑
Monitoring									↑
Adaptive Management									↑



APPENDIX 4

WEED CONTROL METHODS

COMMON WEED CONTROL METHODS

Species	Control Methods
Asparagus fern	Rhizomes: crown out and remove or gouge and paint. Stems: windup and spray, or spray whole plant (G200mL/10L + surfactant)
Balloon Cotton Bush (<i>Gomphocarpus physocarpus</i>)	Hand-pull; spray (G 1:100 + surfactant).
Billygoat Weed (<i>Ageratum houstonianum</i>)	Spray or hand-pull and spray regrowth (G 1:100 + surfactant).
Broad-leaved Paspalum (<i>Paspalum dilatatum</i>)	Spray (G 1:100 + surfactant).
Camphor Laurel (<i>Cinnamomum camphora</i>)	Trees: diameters greater than 10 cm and taller than 1.3m will be stem injected with Glyphosate. The poisoned weed tree will be left standing to provide a perch for birds. Seedlings: hand-pull/spray (G 1:100 + MM [1-2g/10L] + surfactant). Stems: <100mm CSP (G 1:1) >100mm frill or inject @ <250mm (G 1:1 2ml/cut) >250mm diameter (G neat 2ml/cut).
Carpet Grass (<i>Axonopus affinis</i>)	Spray (G 1:100 + surfactant).
Coastal morning glory (<i>Ipomoea cairica</i>)	Vines and runners: hand pull, roll up and hand to dry, CS&P (G1:1.5) on the larger stem, roots and nodes. Spray (G100mL/10L + mm1.5 g/10L + Li700)
Grasses including Paspalum, Pigeon grass and Molasses grass	Spot spray Glyphosate (1:100 + LI700).
Groundsel	CS & P: (1:1.5); well before flowering: spray: (1:50).



Wetland Management Plan

Species	Control Methods
Inkweed (<i>Phytolacca octandra</i>)	Manual removal with mattock or Spray: (G 1:100 + surfactant).
Lantana	The most appropriate control method is to remove the Lantana using the cut and paint method. Lantana can be cut as low on the main stem as possible then painted with Glyphosate at a ration of one (1) part Glyphosate to (1.5) parts water. Spot spaying of Glyphosate can also be undertaken. Areas of dense Lantana could be slashed in selected areas prior to planting as there is very limited presence of native trees and shrubs. NB: Slashing to be overseen by suitably qualified bush regenerator. Native trees and shrubs to be flagged in this instance.
Morning Glory (<i>Ipomoea purpurea</i>)	Roll up long runners and hang up to dry; scrape & paint (G 1:1.5); spray (G 1:100 + surfactant).
Paddy's Lucerne (<i>Sida rhombifolia</i>)	Spray: (G 1:100 + surfactant).
Paspalum (<i>Paspalum</i> sp.)	Spray (G 1:100 + surfactant).
Pigeon Grass (<i>Setaria</i> sp.)	Spray: (G 1:100 + surfactant).
Rhodes Grass (<i>Chloris gayana</i>)	Spray: (G 1:100 + surfactant).
Scotch Thistle (<i>Onopordum acanthium</i>)	Spray: (G 1:100 + surfactant).
Umbrella Tree (<i>Schefflera actinophylla</i>)	Seedlings: hand-pull/spray (G 1:50 + surfactant or G 1:50 + MM 1-2gms/10L + Ag 2ml/10L) Stem: <100mm CSP >100mm frill or inject (G 1:1.5). Best treatment in late spring.
Whiskey Grass (<i>Andropogon virginicus</i>)	Spray: (G 1:100 + surfactant).



Wetland Management Plan

Species	Control Methods
White Passion-fruit (<i>Passiflora subpeltata</i>)	Handpulling, Cut Scrape and Paint with 1:1 glyphosate. Spraying of seedlings with 1:100 glyphosate + surfactant (note: spraying is not the most effective control as waxy leaves prevent herbicide uptake).
Wild aster (<i>Aster subulatus</i>)	Hand-pull; spray (G 1:100 + surfactant).
Wild Tobacco (<i>Solanum mauritianum</i>)	Spray: Hand pull/spray (G 1:100 + surfactant). Stem: CSP (G 1:1).
Winter Senna (<i>Senna pendula</i> var. <i>glabrata</i>)	Seedlings: hand-pull/spray (G 1:100 + surfactant) Stem: <100mm CSP >100mm frill or inject (G 1:1.5). Best time for treatment early summer or when actively growing.

*Key: CS & P - Cut, scrape and paint; S & P- Scrape and paint; F/I - Frill/inject/spear; (1:?) - Numbers in brackets are Glyphosate dilution ratios; LI 700 - denotes use of penetrant recommended.



APPENDIX 6

SUGGESTED SPECIES FOR THE REVEGETATION OF THE WETLAND FOCUS AREA

SUGGESTED SPECIES FOR THE REVEGETATION OF THE WMFA

SPECIES NAME	COMMON NAME	Suitable for Landscaping	Suitable for constructed wetland	Suitable for Saltmarsh Regeneration
Macrophytes (emergent and aquatic)				
<i>Alisma plantago-aquatica</i>			✓	
<i>Najas marina</i>			✓	
<i>Najas tenuifolia</i>			✓	
<i>Nymphaea gigantea</i>			✓	
<i>Nymphoides geminata</i>			✓	
<i>Nymphoides indica</i>			✓	
<i>Ottelia ovalifolia</i>			✓	
<i>Persicaria attenuata</i>			✓	
<i>Persicaria decipiens</i>			✓	
<i>Persicaria decipiens</i>	Slender knotweed		✓	
<i>Potamogeton crispus</i>			✓	
<i>Potamogeton ochreatus</i>			✓	
<i>Potamogeton perfoliatus</i>			✓	
<i>Potamogeton tricarlinatus</i>			✓	
<i>Utricularia australis</i>			✓	
<i>Vallisneria spp.</i>			✓	
<i>Wolffia spp.</i>			✓	
Ground Covers				
<i>Atriplex semibaccata</i>	Creeping saltbush			✓
<i>Blechnum indicum</i>	Swamp Water Fern		✓	
<i>Bolboschoenus caldwellii</i>	Club-rush		✓	



Wetland Management Plan

SPECIES NAME	COMMON NAME	Suitable for Landscaping	Suitable for constructed wetland	Suitable for Saltmarsh Regeneration
<i>Centella asiatica</i>	Indian Pennywort		✓	
<i>Einadia trignos</i>	Fishweed		✓	
<i>Enydra fluctuans</i>			✓	
<i>Suaeda australis</i>				✓
<i>Baumea articulata</i>			✓	
<i>Baumea rubiginosa</i>			✓	
<i>Blechnum indicum</i>	Swamp Water Fern		✓	
<i>Bolboschoenus caldwellii</i>			✓	
<i>Bolboschoenus fluviatilis</i>			✓	
<i>Brasenia schreiberi</i>			✓	
<i>Carex appressa</i>	Tall Sedge		✓	
<i>Centipeda minima</i>			✓	
<i>Ceratophyllum demersum</i>			✓	
<i>Eclipta platyglossa</i>			✓	
<i>Eclipta prostrata</i>			✓	
<i>Eleocharis acuta</i>			✓	
<i>Eleocharis equisetina</i>	Common spike-rush		✓	
<i>Eleocharis minuta</i>			✓	
<i>Eleocharis sphacelata</i>			✓	
<i>Gratiola pedunculata</i>			✓	
<i>Hemarthria uncinata</i>			✓	
<i>Hydrilla verticillata</i>			✓	
<i>Hydrocharis dubia</i>			✓	
<i>Persicaria decipiens</i>	Slender knotweed		✓	
<i>Persicaria hydropiper</i>			✓	
<i>Persicaria lapathifolia</i>			✓	
<i>Persicaria strigosa</i>			✓	



Wetland Management Plan

SPECIES NAME	COMMON NAME	Suitable for Landscaping	Suitable for constructed wetland	Suitable for Saltmarsh Regeneration
<i>Philydrum lanuginosum</i>			✓	
<i>Philydrum lanuginosum</i>	Frogsmouth		✓	
<i>Pseudoraphis spinescens</i>			✓	
<i>Ranunculus inundatus</i>	River buttercup		✓	
<i>Schoenoplectus litoralis</i>			✓	
<i>Schoenoplectus mucronatus</i>			✓	
<i>Schoenoplectus validus</i>			✓	
<i>Spirodella</i> spp.			✓	
<i>Triglochin procera sensu lato</i>			✓	
<i>Baumea juncea</i>		✓		✓
<i>Juncus kraussii</i>	Salt Rush	✓		✓
<i>Cordyline stricta</i>	Narrow-leaved Palm Lily	✓		
<i>Isolepis nodosa</i>	Knobby Club-rush			
<i>Schoenus brevifolius</i>			✓	
<i>Pomax umbellata</i>	Pomax			✓
<i>Fimbristylis ferruginea</i>	Fringe-rush		✓	
<i>Hardenbergia violacea</i>	False Sarsaparilla	✓		
<i>Juncus kraussii</i>	Salt Rush		✓	
<i>Tetragonia tetragonioides</i>	New Zealand Spinach		✓	
<i>Cyperus lucidus</i>			✓	
<i>Fimbristylis dichotoma</i>			✓	
<i>Juncus polyanthemos</i>			✓	
<i>Juncus usitatus</i>			✓	
<i>Lepironia articulata</i>			✓	
<i>Fimbristylis ferruginea</i>	Fringe-rush	✓	✓	✓
<i>Leersia hexandra</i>			✓	
<i>Samolus repens</i>	Creeping brookweed			✓



Wetland Management Plan

SPECIES NAME	COMMON NAME	Suitable for Landscaping	Suitable for constructed wetland	Suitable for Saltmarsh Regeneration
<i>Sarcocornia quinqueflora</i>	Samphire			✓
<i>Selliera radicans</i>				✓
<i>Spergularia marina</i>	Lesser Sea-spurrey			✓
<i>Sporobolus virginicus</i>	Salt couch	✓		✓
<i>Suaeda australis</i>				✓
<i>Tetragonia tetragonioides</i>	Native Spinach			✓
<i>Triglochin striata</i>				✓
<i>Triglochin striatum</i>				✓
<i>Zoysia macrantha</i>				✓
<i>Lomatia silaifolia</i>	Crinkle Bush	✓	✓	
<i>Glycine clandestina</i>	Twining glycine	✓		
<i>Isolepis cernua</i>	Nodding club-rush			
<i>Lomandra longifolia</i>	Spiny-headed Mat-rush	✓		
<i>Ludwigia peploides</i>	Water primrose	✓	✓	
<i>Dichondra repens</i>	Kidney Weed			
<i>Dianella caerulea</i>	Blue Flax-lily	✓		
<i>Dianella caerulea</i>	Blue Flax-lily	✓		
Shrubs /Small trees				
<i>Breynia oblongifolia</i>	Coffee Bush			
<i>Dodonaea triquetra</i>	Large-leaf Hop-bush	✓		
<i>Einadia hastata</i>	Berry Saltbush			
<i>Persoonia linearis</i>	Narrow-leaved Geebung	✓		
<i>Zieria southwellii</i>		✓		
<i>Dodonaea triquetra</i>	Large-leaf Hop-bush	✓		
<i>Einadia hastata</i>	Berry Saltbush			
<i>Persoonia linearis</i>	Narrow-leaved Geebung	✓		



Wetland Management Plan

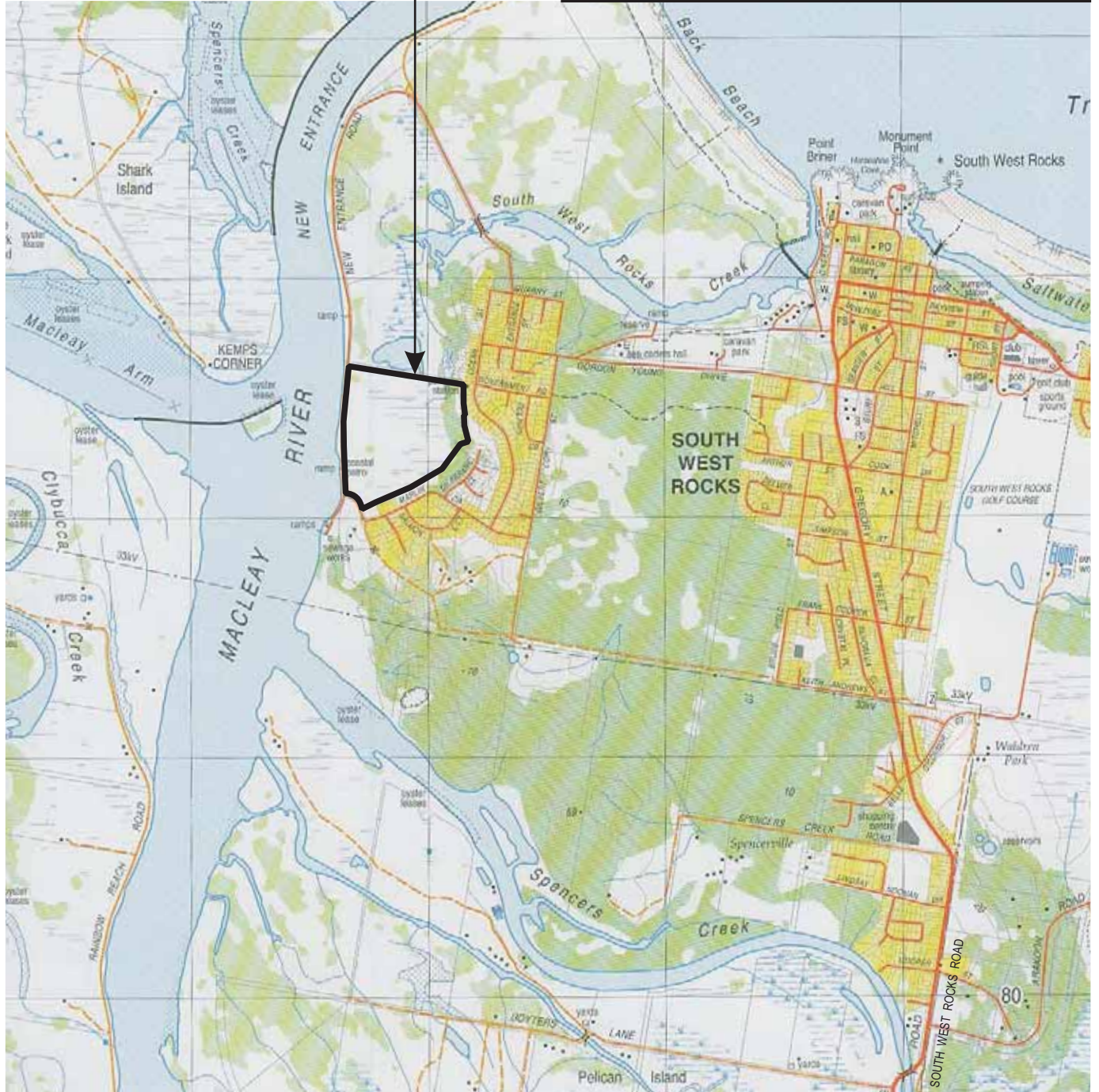
SPECIES NAME	COMMON NAME	Suitable for Landscaping	Suitable for constructed wetland	Suitable for Saltmarsh Regeneration
Trees				
<i>Acacia longifolia</i>		✓		
<i>Acmena smithii</i>	Lilly Pilly	✓		
<i>Acronychia imperforata</i>	Beach Acronychia	✓		
<i>Acronychia imperforata</i>	Beach Acronychia	✓		
<i>Alectryon subdentatus</i>	Hard alectryon	✓		
<i>Alectryon subdentatus</i>	Hard alectryon	✓		
<i>Alphitonia excelsa</i>	Red Ash	✓		
<i>Cupaniopsis anacardioides</i>	Tuckeroo	✓		
<i>Duboisia myoporoides</i>	Corkwood	✓		
<i>Elaeocarpus reticulatus</i>	Blueberry Ash	✓		
<i>Ficus coronata</i>	Creek Sandpaper Fig	✓		
<i>Ficus watkinsiana</i>	Strangling Fig	✓		
<i>Glochidion ferdinandi</i>	Cheese Tree	✓		
<i>Guioa semiglauc</i>	Guioa	✓		
<i>Melaleuca quinquenervia</i>	Broad-leaved paperbark	✓	✓	✓
<i>Melaleuca styphelioides</i>	Prickly-leaved Tea Tree	✓		
<i>Melaleuca styphelioides</i>	Prickly-leaved Tea Tree	✓	✓	
<i>Tristaniopsis laurina</i>	Kanooka	✓		



Wetland Management Plan



SUBJECT SITE



0 1000m

SOURCE: Topographic map "South West Rocks"

SCALE: 1 : 25 000 @ A4

JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 1

PREPARED: BW
DATE: 05 May 2010
FILE: 05084_WMP_locality.cdr

TITLE

LOCALITY PLAN



0 50m

SOURCE: NSW LPI Aerial Photograph
(taken 26/08/03)

SCALE: 1 : 2000 @ A3

JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

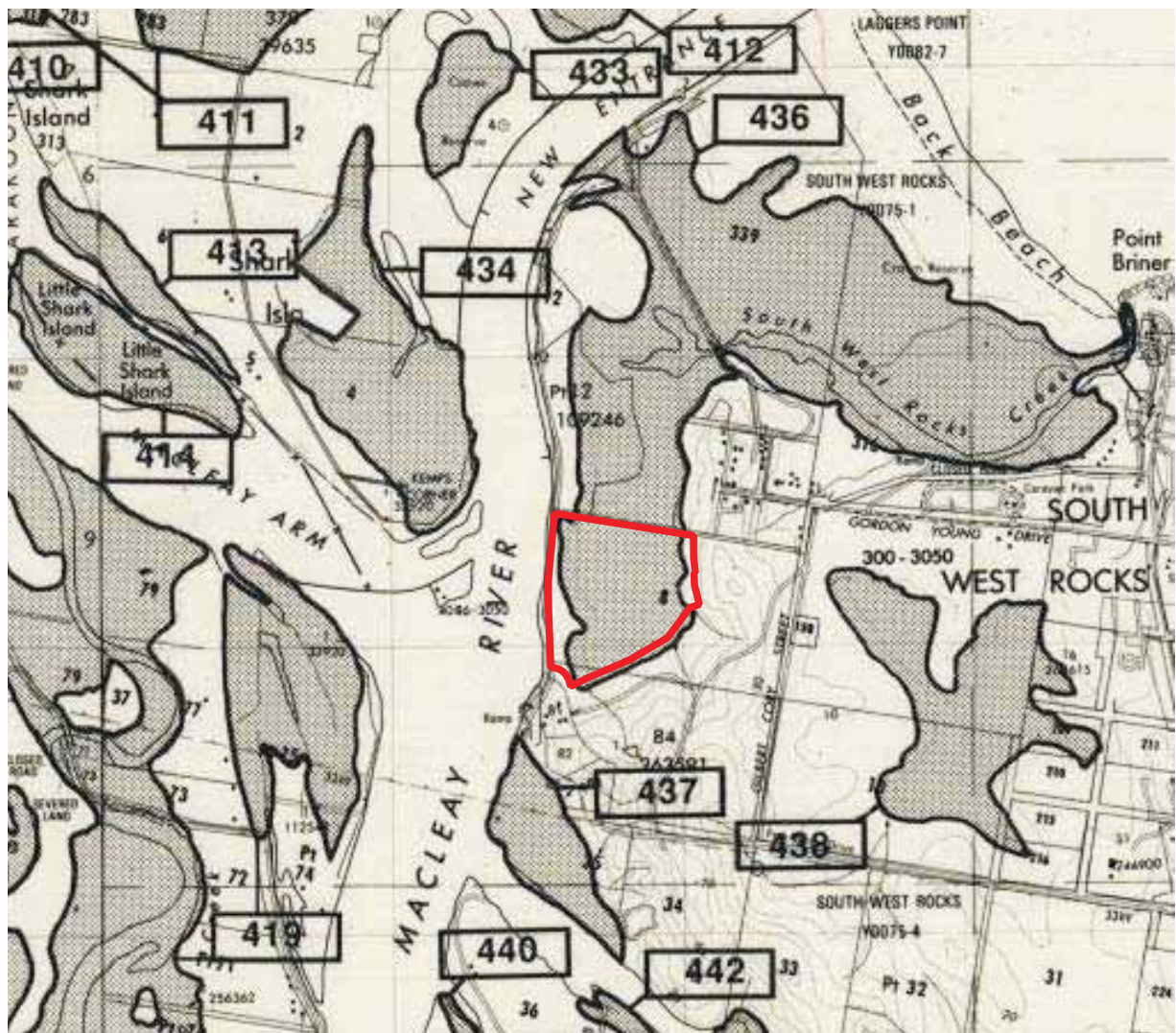
CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 2

PREPARED: BW
DATE: 05 May 2010
FILE: 05084_WMP_Aerial.cdr

TITLE

**AERIAL
PHOTOGRAPH**



Legend

-  Area subject to SEPP No. 14
(with index number)
-  Subject Site

SOURCE: State Env. Planning Policy No. 14
Map 27 Amend. 11

SCALE: 1 : 25 000 @ A4

JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 3

PREPARED: BW
DATE: 05 May 2010
FILE: 05084_WMP_Sep14.cdr

TITLE
**PROXIMITY TO
SEPP No. 14
AREAS**



M.G.A. COORDINATES

	EASTING	NORTHING
PEG 1	501756.682	6582084.301
PEG 2	501766.129	6582116.049
PEG 3	501738.538	6582157.238
PEG 4	501746.722	6582196.996
PEG 5	501706.602	6582198.102
PEG 6	501702.242	6582222.125
PEG 6A	501732.726	6582230.951
PEG 7	501752.680	6582252.877
PEG 8	501774.482	6582249.590
PEG 9	501745.795	6582336.156
PEG 10	501725.438	6582359.213
PM 74276	501633.670	6582152.296
SSM 61122	501721.549	6581960.601

0 50m

SOURCE: Amos & McDonald Surveyors
(Ref: Proposed SEPP 14.pdf)

SCALE: 1 : 2000 @ A3

JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 4

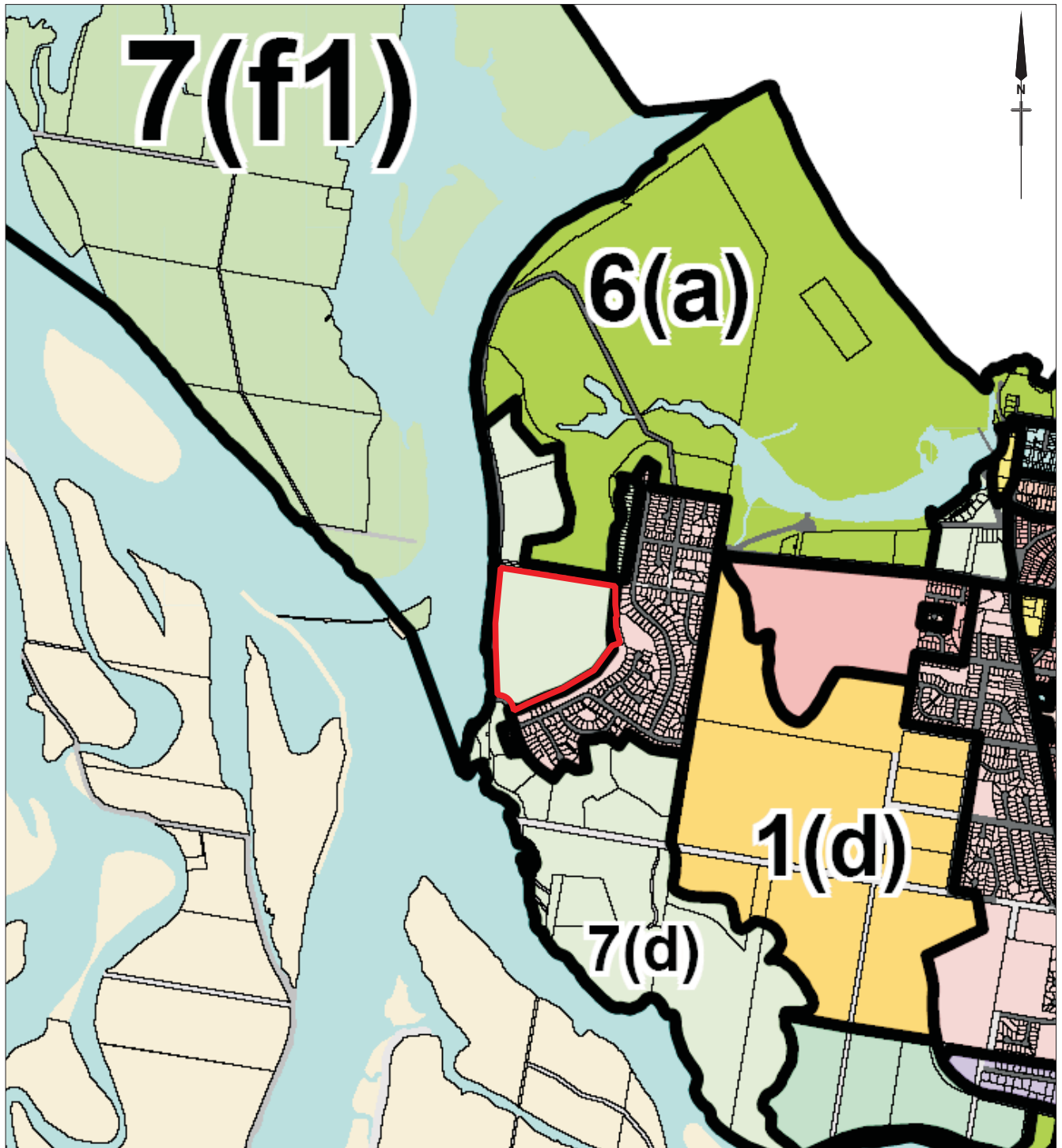
PREPARED: BW
DATE: 05 May 2010
FILE:05084_WMP_Sepp_bound.cdr

TITLE

**PROPOSED
SEPP 14
BOUNDARY**

Legend
--- Proposed SEPP 14 Boundary as
located on site (25/06/09)
□ Subject Site





Legend

- 1(a1) Rural A1
- 2(a) Residential A
- 1(d) Rural (Investigations) D
- 6(a) Open Space A
- 7(d) Scenic Protection
- 7(f1) Coastal Land Protection
- Subject Site

0 1000m

SOURCE: Kempsey Local Environmental Plan
1987 Map C Land Use Zones

SCALE: 1 : 25 000 @ A4

JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 5

PREPARED: BW
DATE: 05 May 2010
FILE: 05084_WMP_Zoning.cdr

TITLE

**LAND USE
ZONES**



Extent of Tidal Inundation

- Stage 1 0.41 m AHD (1 x 900Ø pipe with tidal floodgate)
- Stage 2 0.44 m AHD (as above plus 1 x 375Ø pipe with floodgate removed)
- Stage 3 0.48 m AHD (floodgates removed from both 900Ø and 375Ø pipes)

0 50m

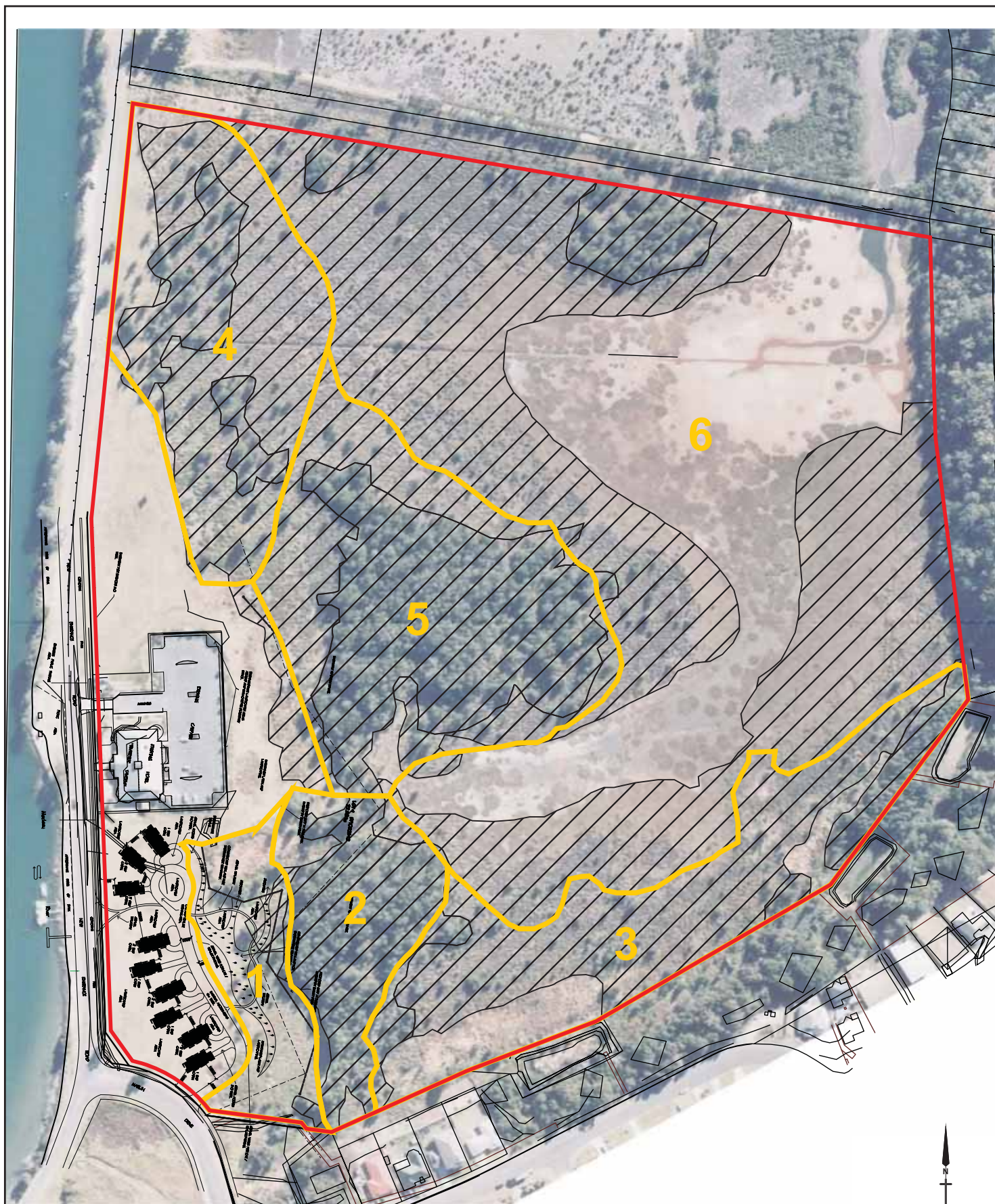
SOURCE: JWA Site Investigations; NSW LPI
Aerial Photo; Geolink (Ref: 1291562 0.2 Tidal
Inundation.pdf)
SCALE: 1 : 2000 @ A3
JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 7

PREPARED: BW
DATE: 11 November 2010
FILE: 05084_WMP_Tidal.cdr

TITLE
**PREDICTED
TIDAL FLOW
INUNDATION
LEVELS**



- Legend**
- Wetland Management Areas
 - Endangered Ecological Communities (EEC's)
 - Proposed SEPP 14 Boundary as located on site (25/06/09)
 - Subject Site

0 50m

SOURCE: JWA Site Investigations; NSW LPI
Aerial Photo (taken 26/08/03); Amos & McDonald
Surveyors (Ref: Proposed SEPP 14.pdf)
SCALE: 1 : 2000 @ A3
JAMES WARREN & ASSOCIATES PTY LIMITED
Environmental Consultants

CLIENT
Shannon Pty Ltd
PROJECT
Wetland Management Plan
Lot 4 on DP1022342
New Entrance Road, South West Rocks, NSW
Shire of Kempsey

FIGURE 8

PREPARED: BW
DATE: 01 November 2010
FILE: 05084_WMP_MgtAreas.cdr

TITLE
**WETLAND
MANAGEMENT
FOCUS AREA**

