Ecological considerations

Drainage Works Tuggerah Pde Long Jetty

Prepared for:

Wyong Shire Council

by:

Beyond Environmental Consulting

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Table of Contents

Appendices

1 Introduction

1.1 Background

Wyong Shire Council (WSC) proposes to upgrade and redesign stormwater outlets along the Tuggerah Lakes foreshore at Long Jetty. Currently, there are about 34 stormwater outlets that take stormwater from Long Jetty centre and urban areas and discharge this water into Tuggerah Lakes through narrow channels that bisect the foreshore parkland.

WSC engaged Storm Consulting to redesign the current outlets and include water sensitive urban design (WSUD) treatments to improve the quality of stormwater entering Tuggerah Lakes. An area that includes six stormwater channels, between Lake Street and Gladstan Avenue would be undertaken initially. This design would then be replicated along the 2km length of the foreshore of Tuggerah Lakes at Long Jetty.

The design would include landscaping treatments to improve the visual amenity and facilitate recreational enjoyment of the parkland for the community while protecting and enhancing wildlife habitat and the ecological function.

1.2 Location

The area, which is the subject of this study, is located on the eastern foreshore of Tuggerah Lakes at Long Jetty. The foreshore in this location is zoned for public recreation and consists of mown grassed parkland with indigenous remnant trees and regrowth. The park includes toilet amenities, picnic tables and a cycleway. It is a popular recreational area for local residents for activities such as walking, running, cycling, picnics and water sports.

The location is of particular environmental sensitivity. Tuggerah Lakes is listed under the Australian Government's Directory of Important Wetlands where it has been determined as important habitat for flora and fauna, including nationally significant species, and as refuge for wildlife during drought and vulnerable stages in certain species' lifecycle. The foreshore vegetation forms part of the Stepping Stones Wildlife Corridor project, which is vegetative link between the southern section of Wyrrabalong National Park and the northern section of this conservation area.

The foreshore area has undergone considerable past disturbance through clearing and land reclamation. However, a reasonable amount of Indigenous vegetation remains within the parkland, including large remnant *Melaleuca quinquenerva* (Broad-leaved Paperbark) and *Casuarina glauca* (Swamp Oak). Indigenous regrowth has formed a riparian edge along the stormwater channels and patches of Coastal Saltmarsh are present along the intertidal area. This vegetation is representative of the vegetation that would have been present prior to development of the foreshore and forms part of vegetation communities which are listed as threatened under state legislation.

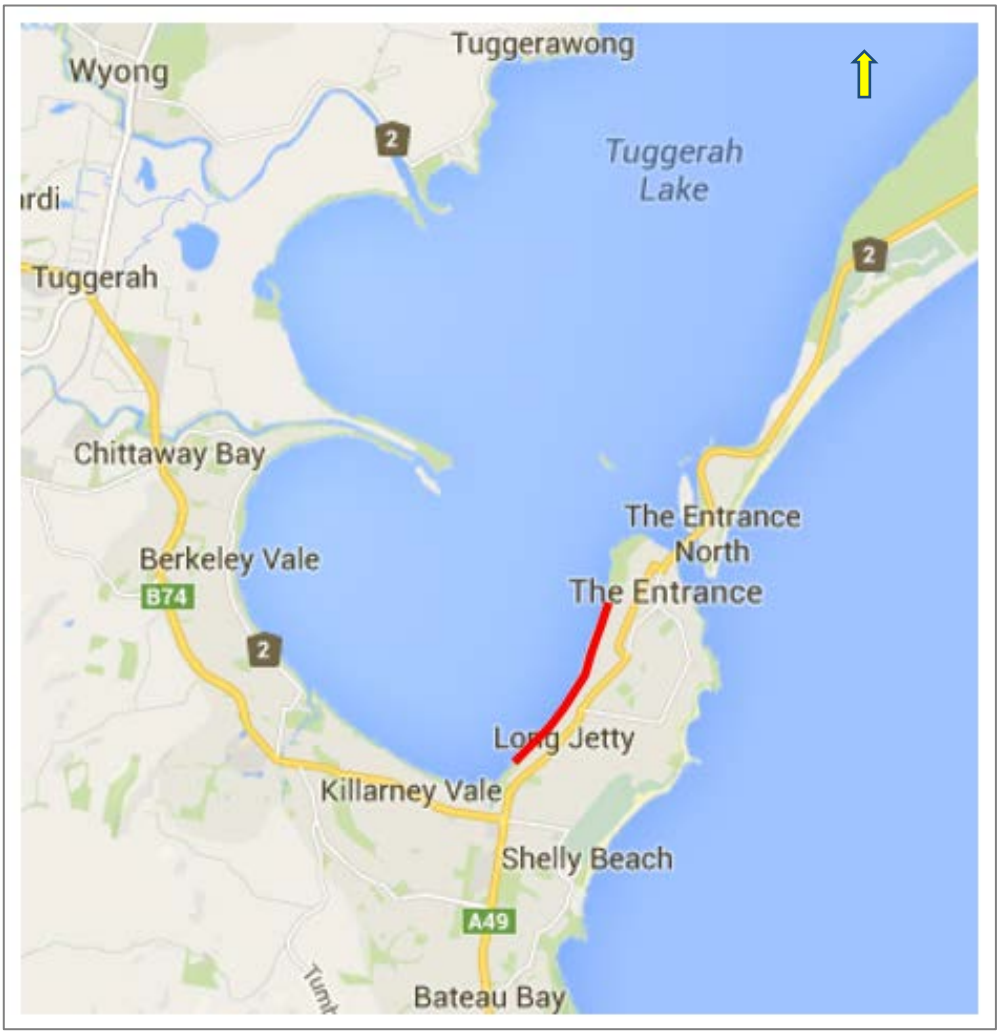


Figure 1: Location
Source: Google Maps

1.3 Issues

The main issues relevant to the stormwater upgrade and landscaping treatments are:

- The stormwater pipes leading to the channels, that carry water across the parkland to the lake, are situated lower than the level of the lake. Water from the lake enters the channels and stormwater becomes trapped leading to stagnation and associated amenity and water quality issues. This poor quality stormwater currently flows untreated into Tuggerah Lakes.

- The current channelled flow regime of the stormwater outlets creates turbidity in the lake during discharge. This can affect the growth of seagrasses close to shore. The seagrasses are also susceptible to algal growth which is increased through the release of untreated, nutrient rich stormwater.

- The Coastal Saltmarsh community is listed under both the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This community is fragile and easily impacted through weed incursion, foot traffic and channelled release of stormwater. This vegetation community is currently under considerable pressure from these issues.

- The main natural vegetation community on the foreshore is Swamp Oak Floodplain Forest, a community listed under the NSW *Threatened Species Conservation Act 1995*). This community is dominated by *C. glauca*. Where reclamation of the foreshore has occurred and mowing is not regularly undertaken, *C. glauca* regrowth forms thick groves. These groves provide little habitat value but create a visual barrier, reducing visual connectivity and resulting in a series of discreet areas between stormwater outlets. *C. glauca* has also encroached into the intertidal zone community in some areas, where it is outcompeting Coastal Saltmarsh.

- There are many mature indigenous trees along the foreshore, mostly adjacent to Tuggerah Parade, outside of the area affected by past reclamation. These trees provide forage, refuge and nesting opportunities for local fauna, including threat listed and migratory species. These trees form an important component of the wildlife corridor.

1.4 Purpose of the report

Beyond Environmental Consulting has been engaged by Wyong Shire Council to investigate the potential ecological impacts on foreshore ecology and habitat from the proposed stormwater upgrade and associated landscaping and to provide advice on how these impacts can be avoided and mitigated through the design.

Advice presented in this study is applicable to the 2km length of foreshore and will be considered when preparing the concept design for the stormwater infrastructure upgrade and associated landscaping. The concept design will cover a small section of the foreshore, referred to as the Proposal Site (refer to Section 2). Environmental assessment under Part 5 of the *Environmental Planning and Assessment Act 1979* will be undertaken once the detailed design for the proposal site has been developed. The design will eventually be replicated to cover the remainder of the 2km stretch of foreshore and further environmental assessment undertaken as funding become available.

2 Scope & Methodology

2.1 Scope

Two areas are defined in this report:

Study Area

Study area is the total foreshore area adjacent to Tuggerah Parade. WSC intend to eventually upgrade the stormwater infrastructure along this entire section. The area is indicated in red in Figure 2.

Proposal site

The Proposal Site refers to the section of the foreshore adjacent Tuggerah Parade between Lake Street and Gladstan Avenue, Long Jetty. The Proposal Site defines the area covered by the stormwater design and initial environmental assessment. This area is indicated in blue in Figure 2.

Source: Google Maps

Figure 2: Proposal and study area

2.2 Methodology

- Undertake a review of all applicable statutory and instruments that govern management of the foreshore area

- Investigate ecological values of the foreshore and any natural constraints on the proposal. This involved:
    - Database searches
    - Site visit of the study area and adjacent bushland
    - Aquatic and terrestrial flora and fauna surveys (covering the proposal site)
    - Literature review

- Compile a list of objectives based on:
    - Statutory provisions relevant to the management of the foreshore
    - Results of literature review
    - Results of database searches
    - Results and recommendations from ecological field investigations

- Compile a list of recommendations

2.3 Limitations

Aquatic and terrestrial surveys covered only the proposal site and not the entire study area. Suitable habitat for a wider range of species may be available in areas of the study area outside of the proposal site.

Although a considerable amount of environmental assessment was undertaken in order to provide the recommendations outlined in this report, it would not fulfil the requirements of S11 of the *Environmental Planning and Assessment Act 1979*. A Review of Environmental Factors will be developed to address all relevant legislation requirements under a separate report.

3 Proposal Objectives

Aim:

To facilitate access and enjoyment of the foreshore by the public while maintaining and improving the natural hydrological and ecological functions.

Objectives:

	Flora and Fauna
1	Protect and restore indigenous vegetation where possible, in particular endangered ecological communities
2	Identify existing fauna habitats (both terrestrial and aquatic) and restore and enhance these where possible
3	Water sensitive urban design (WSUD) to protect and enhance existing indigenous vegetation communities and fauna habitats
4	Identify opportunities for increasing the value of the area as a wildlife corridor for resident wildlife and incorporate plantings to meet this aim in the design
	Water Quality
5	WSUD to, as much as possible, remove pollutants from stormwater
6	WSUD to reduce 'channelled flow' effect and provide for increased dissipation of flow to mimic natural overland flow paths
	Soils
7	Minimise disturbance to soils
8	Minimise depth of excavation to avoid ASS and aluminium toxicity
9	WSUD to reduce erosion and turbidity where stormwater discharges to the lake
	Community access and recreation
10	Improve existing community access and recreation opportunities while minimising impact on the natural environment
11	Promote community understanding of the local natural environment
	Visual amenity
12	Retain existing mature indigenous trees adjacent to Tuggerah Parade and scattered through the park
13	Tree removal and plantings to consider overall visual impact on the area
14	WSUD to be visually appealing and fit in with the natural foreshore environment
	Maintenance
15	WSUD and landscaping design to minimise Council maintenance requirements

4 Statutory and planning Objectives

A review of legislation and planning instruments governing the management of the land, water, foreshore environment and its flora and fauna was undertaken. The table below provides a summary of relevant objects outlined in those planning instruments. This provides an indication of the general intent of the planning framework and has informed the advice on the design of stormwater infrastructure and modifications along the Tuggerah Lakes foreshore.

The table does not indicate hierarchical considerations of statutory instruments and does not outline environmental assessment requirements or permits required. Although these aspects have been considered in advice provided in this report, they will be outlined and further considered as part of the Review of Environmental Factors for the works.

Each Act and planning instrument is listed with an outline of the aspects relevant to the proposal at Appendix I.

Aspect	**Relevant provisions under legislation and planning documents**
Flora and Fauna	• Protect, prevent extinction and promote recovery of threatened species, communities & populations (EP&A Act, TSC Act, FM Act) • Properly assess impact on above (TSC Act) • Assess impacts on Commonwealth matters of environmental significance (EPBC Act) • Eliminate or manage threatening processes (TSC Act) • Conserve key fish habitat (FM Act) • Maintain fish passage (FM Act) • Protect and conserve native coastal vegetation (SEPP 71) • Protect and conserve native plants and animals (EP&A Act) • Protect and restore important fisheries habitats, such as seagrasses and mangroves (Coastal Policy) • No net loss of seagrasses within coastal and estuarine waters (FHP 2) • Protect important wetland habitat (DCP 30) • Weed control shall be by both preventative measures and active control measures (PoM). • Landscape design will be in accordance with any design guidelines adopted by the Council (PoM). • Gardens may be constructed and maintained on the land (PoM). • Ensure that proper consideration is given to trees and native vegetation in planning, designing and constructing development (DCP 14). • Minimise unnecessary injury to or destruction of trees and native vegetation (DCP 14). • Facilitate the removal of undesirable exotics, noxious weeds, dangerous trees and any other inappropriate plantings and to replace these with suitable local indigenous species which will positively contribute to visual and environmental amenity and ecological sustainability (DCP 14). • Retain viable representative samples of native vegetation, which have an intact structure and complete floristics, wherever practicable (DCP 14). • Protect, maintain and restore freshwater wetland vegetation (EMS) • Protect, maintain and restore aquatic and semi-aquatic estuarine vegetation (EMS) • Protect, maintain and restore floodplain vegetation (EMS) • Protect, maintain and restore aquatic and riparian vegetation (EMS) • To maintain and protect environmentally significant areas and threatened species/communities (EMS)
Water Quality	• Protect, enhance and restore water sources and water quality (WM Act) • Recognise and foster significant social and economic benefits to the state that result from sustainable and efficient use of water including benefits to the environment, culture

Aspect	Relevant provisions under legislation and planning documents
	and heritage (Aboriginal and non-aboriginal), etc (WM Act) • Integrate management of water resources with the management of other aspects of the environment including land, its soil, native vegetation and native fauna (WM Act). • Encourage best practice use of water (WM Act) • Protect and restore floodplains and dependent ecosystems (WM Act) • Maintain water quality in coastal waters and improve where it is currently inadequate (Coastal Policy) • Control discharges (to stormwater) from both point and non-point sources (Coastal Policy) • Maintain functions of low lying lands for the purpose of improving downstream water quality for the benefit of Tuggerah Lakes and Lake Macquarie systems (DCP 30) • Council are to minimise flow of nutrients to watercourses (PoM) • Provide space for waterway protection (LEP). • Provide space for integrated stormwater treatment devices for flow and water quality management (LEP). • Provide adequate environmental flow to sustain estuarine and riverine ecology (EMS). • Maintain water quality to protect healthy ecosystem function in the estuary and rivers. • Provide water quality in rivers and the estuary safe for primary human contact. • Maintain flow patterns while minimising flooding threat to life and property. • Minimise changes to groundwater flow/stores. • To ensure community is pro-actively involved in estuarine health and management.
Land Management & Soils	• Floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation and salinity (WM Act). • Where possible, land must be rehabilitated (WM Act) • Provide a healthy environment on the land (PoM) • Acid sulfate soils should preferably be left undisturbed (PoM) • To protect and restore soil landscapes and improve understanding of land capability and suitability in the catchment (EMS)
Visual Amenity	• Protect and improve natural scenic quality (SEPP 71) • Protect visual amenity (SEPP 71) • Proper management of landscaping measures, trees and vegetation is important to provide a high degree of amenity on the land (PoM) • Any proposed development is to take into account impacts on the natural scenic quality and amenity of the foreshore (LEP). • Retain healthy individual trees of local amenity and aesthetic value (DCP 14).
Ecological processes	• Conserve biodiversity (SEPP 71, CP Act) • Promote biodiversity (FM Act, EPBC Act) • Protect native species and ecosystems (EPBC Act) • Protect and preserve the marine environment (SEPP 71) • Protect, enhance and restore water resources, their associated ecosystems, ecological processes and biological diversity (WM Act, CP Act) • Hydrological processes are to be maintained where possible, including natural vegetation and the flow regimes to maintain creek line stability and health of terrestrial and aquatic plant communities (FM Act, FHP 1) • Encourage land use practices and environmental design measures that enhance the sustainability of wetlands functions and values (DCP 30) • Provide linked open space for ecosystem continuity (LEP). • To maintain the biodiversity and ecological function of the catchment in a manner that protects the estuary (EMS) • To minimise human disturbances that effect ecological function (EMS)
Community access	• Protect and improve existing public access to the extent that is compatible with natural attributes (SEPP 71)

Aspect	Relevant provisions under legislation and planning documents
	• Provide public access to community land (PoM) • To provide for public access and amenity at designated recreation areas (EMS)
Recreation	• Protect and manage recreational and economic attributes (SEPP 71) • Provide a broad spectrum of safe, high quality recreational and commercial opportunities (PoM). • Enable land to be used for public open space or recreational purposes (LEP). • Provide a range of recreational settings and activities and compatible land uses (LEP). • Protect and enhance the natural environment for recreational purposes (LEP). • Provide linked open space for local community recreation (LEP)
Maintenance	• Provide high quality open space and facilities requiring a minimum of maintenance (PoM).
Ecologically Sustainable Development (see Appendix I for definition)	• Promote and manage in accordance with ESD (EP&A Act, SEPP 71, TSC Act, FM Act, WM Act, EPBC Act, CP Act, PoM) • To provide for economically and socially justified levels of development whilst containing adverse ecological impacts (EMS)

Key:

EMS	Tuggerah Lakes Estuary Management Study
EPBC Act	Environment Protection and Biodiversity Conservation Act
CP Act	Coastal Protection Act 1979
TSC Act	Threatened Species Conservation Act 1995
PoM	Draft Plan of Management No.16 Council Owned Foreshore Land at The Entrance North, The Entrance, Long Jetty, Blue Bay, Toowoon Bay, Shelly Beach and Bateau Bay
SEPP 71	State Environment Planning Policy No. 71: Coastal Protection
WM Act	Water Management Act 2000
FM Act	Fisheries Management Act 1994
LEP	WSC Local Environment Plan 2013
DCP 14	Development Control Plan No. 14:
DCP 30	Development Control Plan No. 30: Wetlands
FHP 1	Fish Habitat Protection Plan No.1
FHP 2	Fish Habitat Protection Plan No.2 Seagrasses

5 Past Disturbances

The Tuggerah Lakes has been a holiday destination since the late the 1800s. Over the past 100 years the area has undergone a substantial change in land use from a mostly rural and forested catchment to the mostly urban and business centre that it is today.

The rapid development in the catchment led to considerable impacts on the lakes and surrounding environment. Surrounding wetlands have been reclaimed for rural and urban development. There was a substantial loss of native vegetation, particularly riparian vegetation for housing developments. High levels of nutrients entered the lakes from septic systems during the 1960s, 1970s and early 1980s. Urban stormwater runoff carried nutrients, sediment and other pollutants to the lakes during rain events. These activities lead to a great decline in the health of the lakes which resulted in eutrophication, with macroalgae blooms being a common occurrence in the near shore habitats (Scott 1999).

In the late 1980s, the government responded to the excessive macroalgal growth in the lakes by undertaking the Tuggerah Lakes Restoration Project. This project involved removal of seagrass racks and macroalgal growth from the lakes through mechanical means, dredging of the channels and creeks and reclamation of the lake foreshore. It was believed at the time that improving tidal exchange was an important measure for addressing water quality in the lakes. Although reducing nutrient and sediment input into the lakes from the catchment was recognised as a measure to improve the water quality of the lakes, the emphasis of these works was on mechanical solutions. The works resulted in further environmental degradation and impacts on habitat (Scott 1999). The foreshore area where the proposed works would take place, underwent substantial disturbance through beach restoration works that involved mechanical removal of 'weed' and reclamation of the foreshore.

It is now acknowledged that the quality of the water in Tuggerah Lakes is mostly dependent on the quality of the water that flows into it in the creeks, rivers and stormwater drains than on flushing of seawater through the Entrance channel. The importance of maintaining and enhancing the native vegetation in the catchment is also recognised (Dickenson *et al* 2006).

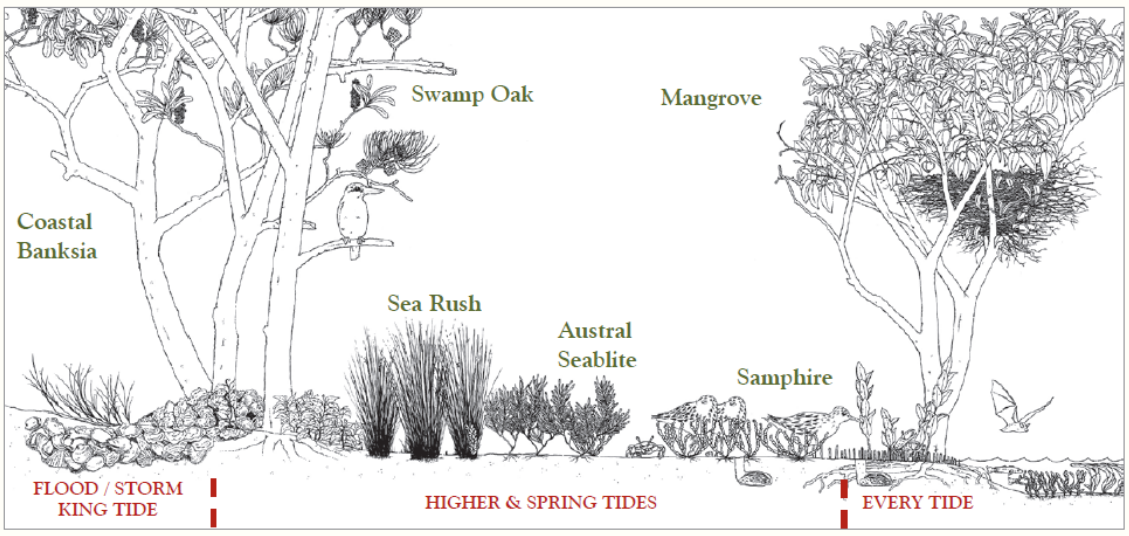
6 Vegetation

The vegetation at the site displays the profile of the complex of coastal and estuarine communities that would have been present prior to clearing and reclamation. Below the lakes edge the remnants of seagrass beds are evident. Landward of the lake, in the intertidal area, the Coastal Saltmarsh community exists in patches where it is under considerable pressure from encroaching exotic grasses and other weeds. This community abuts disturbed Swamp Oak Floodplain Forest which intergrades with Swamp Sclerophyll forest on the higher slopes as the saline influence in the soil is reduced. This is evident where indigenous vegetation remains towards the northern end of the study area. Figure 3 provides a depiction of the vegetation profile similar to that which is likely to have naturally occurred.

The foreshore itself has been subjected to considerable disturbance through excavation and reclamation in the 1990s which would have destroyed all existing vegetation along the length of the foreshore in the study for a width of about 20m from the waters' edge.

Scattered individual remnant trees remain adjacent to Tuggerah Parade. These are mostly mature *C. glauca* and *M. quinquenerva*, many of which are habitat trees as they provide forage and nesting opportunities for fauna such as microbats, birds and possums.

After foreshore reclamation, *C. glauca* was replanted along the drainage channels. It is now regenerating vigorously on the foreshore where mowing does not take place and there is little competition from other plants. Small groves have formed adjacent to the drainage channels that intersect the foreshore reserve. The understorey adjacent to the drainage lines is mostly *Phragmites australis*, a species that is frequently present in Swamp Oak Floodplain Forest where there is a moderate to high saline influence. A number of other flora species present would naturally be associated with Swamp Oak Floodplain Forest, including *Cupaniopsis anacardioides* (Tuckeroo), *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca quinquenerva* (Broad-leaved Paperbark), *Glochidian ferdinandi var ferdinandi* (Cheese Trees) and *Alphitonia excels* (Red Ash).



A typical profile of the Coastal Saltmarsh Endangered Ecological Community between Mangroves and Swamp Oak Floodplain Forest. Examples of both the flora and fauna of the ecological community can be seen, including bats, birds and crustaceans.

Figure 3: Typical foreshore vegetation community profile

6.1 Coastal Saltmarsh

Coastal Saltmarsh is a salt tolerant vegetation community that is found on the upper limits of the inter-tidal zone of estuaries and intermittently opened coastal lagoons. It is mostly a treeless assemblage of unique salt tolerant plants that include succulent herbs, salt tolerant grasses and sedges. It is often found between mangrove forests and Swamp Oak Floodplain forest. At the proposal site, the Coastal Saltmarsh occupies a narrow band of 5 – 10m from the lakes edge, indicating the small tidal area of the lakes. Saltmarsh species present include *Sarcicornia quinqueflora* (Samphire), *Selliera radicans* (Swamp Weed) and *Juncus krausii* (Sea Rush).

6.1.1 Ecology

Wetland communities, including Coastal Saltmarsh, are the most productive of all ecosystems due to the many ecosystem services that they provide, including filtering stormwater, sequestering carbon, providing refuge and feeding grounds for juvenile fish as well as providing habitat and forage for a range of other aquatic and terrestrial fauna (Daley 2013).

At high tides, fish and crabs take refuge in this vegetation. Studies have found over 40 species of fish inhabiting Coastal Saltmarsh communities, including many commercially important species such as Mullet, Yellowfin Bream and Sand Whiting. It is particularly important as a refuge for smaller and juvenile fish as it provides refuge from predators (Daley 2013 p.2).

At low tides, many species of fauna feed on the vegetation itself or the insects that live there. Fauna that feed on Coastal Saltmarsh include swamp wallabies, microbats, kangaroos and a range of birds. Migratory birds, such as Sandpipers use this vegetation as roosting habitat (Daley 2013).

Coastal Saltmarsh also plays a role in filtering surface water prior to it entering the lake (or sea). It is also among the most efficient ecosystems when it comes to sequestering carbon. This is because of the ability of tidal wetlands to retain carbon for a long time and because salt environments greatly reduce the ability of bacteria to emit of methane (one of the most potent greenhouse gases) (Daley 2013).

6.1.2 Site issues

Studies undertaken by Dickinson *et al* (2006) found that the Coastal Saltmarsh community on the foreshore of Tuggerah Lakes has been reduced by 80% of its original extent (Dickinson *et al* 2006 p.2). The coastal saltmarsh that remains on the foreshore is under pressure from a number of disturbances, including intrusion from exotic weeds, mowing, foot traffic and altered hydrological flows. The difficulty in managing this issue is that turfed areas of the park land abut the coastal saltmarsh community and there is currently no barrier to prevent foot traffic, weeds and lawn mowing from impacting directly on the vegetation. Also, the current stormwater outlets result in channelled delivery of fresh water across the intertidal area, preventing establishment of most of the wetland species that would normally grow there and facilitating the spread of *P.australis* and introduced weeds such as *Hydrocotyle bonariensis* (OEH 2014c). In many locations, *C. glauca* is growing within the intertidal zone and is outcompeting the Coastal Saltmarsh.

Figure 4: Coastal Saltmarsh Tuggerah Lakes Foreshore (Photo: Carolyn Donnelly)

6.1.3 Recommendations

- Leave a band of up to 10m from the lakes edge to allow for natural and assisted regeneration of Coastal Saltmarsh, taking into account sea level rise through climate change.
- Remove *C.glauca* regrowth and other weeds that are competing vigorously with the Coastal Saltmarsh species in the intertidal zone (refer Figure 5). This should occur as part of ongoing restoration activities.
- Provide a protective planted buffer between the Coastal Saltmarsh and mown lawn areas. The vegetated stormwater swale could serve this purpose.
- Provide delineated access points to the foreshore to prevent adhoc foot traffic.
- Consider interpretive signage which explains the ecological and economic importance of the Coastal Saltmarsh.

6.2 Seagrass

Seagrasses are marine plants that occupy the intertidal and subtidal zones of estuaries. They play a crucial role in coastal ecosystems as they stabilise marine sediments, filter water and provide food and shelter to aquatic biota, including crustaceans, molluscs, echinoderms and fish. Seagrasses have been described as 'the nurseries of the sea' due to their importance to juvenile marine fish and crustaceans. Hence, they are particularly important to the fishing industry (Smith, Holliday & Pollard 1997).

The aquatic survey undertaken for this study found that seagrass beds occur adjacent to the stormwater channels approximately 56 – 111 m from the drainage outlets at a depth of between 0.4m and 1.1m (McQueen 2014 p.8). Adjacent to the study area, the seagrass beds consist of one species, *Zostera capricornia* (Eelgrass). This is consistent with seagrass mapping undertaken by NSW Fisheries. To the north of the study site, within the proposal site, further species of seagrass, *Halophila* spp. and *Ruppia* spp. are present (McQueen 2014).

6.2.1 Issues

Seagrasses are fragile habitats that are easily damaged. A number of human activities and management practices have a deleterious effect on seagrasses. These include dredging, reclamation, harvesting, bait digging, trawling and netting, anchoring of boats and swing moorings and artificial opening of coastal lagoons to the sea (Smith, Holliday & Pollard 1997). Seagrass beds are also impacted by the increased turbidity and discharge of nutrient high water that can occur through discharge of stormwater directly into the estuary or wetland. Turbidity reduces the amount of light that reaches the plants. Nutrients discharged in the marine environment increase algal growth. The algae increases turbidity levels. Some algae grow directly on the seagrasses, reducing their ability to photosynthesise. Loss of seagrass creates a cycle whereby further loss of seagrass occurs as sediments become suspended in the water column, reducing light penetration to the plants (EPA 1998).

The seagrass beds adjacent to the stormwater drains in the study area were found to be patchy and not a continuous healthy mat. The likely reason given by McQueen (2014) for this is a combination of winter dieback and human activity such as stormwater input, boating, swimming and wrack harvesting.

Macroalgae was found by McQueen (2014) to occur in varying amounts with larger amounts of algae closer to the shoreline. This is possibly due to the higher nutrient levels closer to shore.

6.2.2 Recommendations:

- Allow (and assist if possible) regeneration of seagrasses in the inshore area.
- WSUD to dissipate stormwater to the lake over a wider area to reduce the 'channelled flow' effect.

6.3 Swamp Oak Floodplain Forest

The main vegetation community at the proposal site is Swamp Oak Floodplain Forest. The vegetation community is found on coastal floodplains on humic clay and sandy loam soils in areas that are periodically inundated or waterlogged. The canopy layer is usually dominated by *C. glauca*. However, a number of other trees species are also often present in much lower numbers, including *G. ferdinandi* var. ferdinandi, *C. anacardioides* and Melaleuca species. Vines such as *Parsonsia straminea* (Common Silkpod), *Geitoplesium cymosum* (Scrambling Lily) and *Stephania japonica* (Snake Vine) are characteristically present, The shrub and groundcover layer is usually sparse and contains moisture loving herbs, grasses and sedges such as *Commelina cyanea* (Commelina), *Carex appressa* (Tussock Sedge), *Gahnia clarkei* (Tall Saw Sedge) and, in more saline conditions, *P. australis, J. krausii* and salt marsh species (DECC 2007). This plant assemblage is evidenced at the proposal site.

As the vegetation on the foreshore meets the criteria for the endangered ecological community *Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* (DECC 2007), a test of significance will be required as part of the environmental assessment process to assess the significance of clearing, thinning or disturbance to the community that would result from the stormwater infrastructure and landscaping works.

The NSW Scientific Committee, in their final determination to list this vegetation community as an endangered ecological community under the TSC Ac, found, amongst other things, that the Swamp Oak Floodplain Forest community does not provide significant habitat for water birds but it does sometimes provide a food resource for Glossy Black Cockatoos (*Calyptorhynchus lathami lathami*) and Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*). The fauna in this community may also include the Squirrel Glider (*Petaurus norfolcensis*) and several species of frogs (OEH 2004b). The Glossy Black Cockatoo and the Squirrel Glider are both listed as threatened under the TSC Act and both species have been recorded within 10km of the proposal site.

The Glossy Black Cockatoo feeds almost exclusively on *Allocasuarina* species such as *Allocasuarina littoralis* and *Allocasuarina torulosa* (BirdLife Australia 2012). These species are not present within the study area.

Also, studies have found that Squirrel Gliders prefer a habitat which has an overstorey of winter-flowering eucalypts, such as *Eucalyptus robusta* and *E. tereticornis,* and an understorey of winter-flowering banksias and acacias (Smith and Murray 2003). Indigenous species of this type occur within the study area, mostly towards the northern end of the foreshore. This is relevant to other threatened species, such as the Swift Parrot, that has been identified within the wildlife corridor further to the south at Bateau Bay. Proposed actions outlined in this report include recommendations to incorporate plantings of these winter flowering species as part of the landscaping design.

6.3.1 Issues

The dominant canopy species in Swamp Oak Forest, *C. glauca,* is a fast growing tree that grows to 20m and has a longevity of 100-200 years (Benson and McDougall 1999). *Casuarinas* are nitrogen fixing plants, in that they have a nitrogen fixation association with a bacteria that enables them to take nitrogen from the atmosphere and convert it to a form that plants can use for growth (Benson & McDougall 1999). Nitrogen fixing plants are commonly pioneer species that initially colonise disturbed areas. They increase the value of the soil and enable the establishment of other species. Plants that have nitrogen fixation associations are beneficial for the environment play an important part of the nitrogen cycle. *C. glauca* has

the ability to regenerate quickly and vigorously from root suckers and has fast initial growth rates. Its ability to tolerate soil waterlogging, high salinity, extremes in pH and salt laden winds makes it well suited to the lake foreshore environment (Florabank nd). This species often forms pure stands adjacent to salt marsh or mangroves (Benson and McDougall 1999).

C. glauca's tendency to grow quickly and form thick groves limits floral diversity. This is a natural tendency of the species. In many locations within the study area, *C. glauca* is growing thickly within the intertidal zone, where it is outcompeting Coastal Saltmarsh and thwarting efforts to retain this ecologically important community. The NSW Scientific Committee found that, due to the dynamic hydrological relationship between endangered ecological communities on coastal floodplains, management of water and tidal flows may result in the expansion of some communities at the expense of others (OEH 2004). This is evidenced on the Tuggerah Lakes foreshore in the interaction between the Coastal Saltmarsh and the Swamp Oak Floodplain Forest.

Whereas the *C. glauca* stands represent an important vegetation community on the foreshore, the groves exist as small pockets of vegetation that are only capable of providing minimal habitat benefits. As the foreshore is zoned as public recreation and regeneration of the vegetation must compete with the conflicting land uses under this zoning, this is likely to continue to be the case. Active management, therefore, is required to ensure the best ecological outcome can be achieved.

Also relevant are the community use objectives that have been established for the foreshore parkland and are supported under SEPP 71, which provide for community access and recreation.

One endeavour of this study is to find where the balance of these competing objectives lies so that management of the vegetation communities on the foreshore can be undertaken in a way that results in the best possible environmental outcome and community use objectives can be realised in a way that does not compromise the ecological objectives of the area.

Figure 5: *C.glauca* in intertidal area (Photo: Carolyn Donnelly)

6.3.2 Recommendations

- Where clearing is required to take place in order to construct stormwater infrastructure and for community access requirements, selectively remove C. glauca regrowth (trees that have a dbh of ≤ 100mm), wherever possible, keeping the larger trees (trees with a dbh >100mm).
- Removal of *C. glauca* regrowth should allow for touching canopies to remain wherever possible.
- Where clearing is required to construct stormwater infrastructure and larger trees must be removed in order to undertake this work, replant with a range of trees indigenous to the location such *as G. ferdinandi var ferdinandi, B. integrifolia, M. quinquenerva* and *E. robusta*.
- Landscaping should include a dense understorey planting of sedges and grasses indigenous to the location to exclude *C. glauca* regrowth and weeds.

(Further relevant recommendations are found in section 7 and 11 of this report.)

Figure 6: Foreground of photo shows that dense understorey planting is reducing *C.glauca* regrowth (Photo: Carolyn Donnelly)

7 Fauna

7.1 Aquatic fauna

The aquatic survey undertaken for this study focussed on habitat assessment and did not include a fauna survey. However, opportunistic sightings were recorded during the site visit by the aquatic ecologist. Bream and Mullet were observed swimming around Mr Parry's Jetty in the lake and schools of juvenile fish, mostly mullet, were observed in the upper reaches of the drainage channels. Within the lake, Shells of *Anadara trapezia* (Sydney Cockle) and *Velacumantus australis* Sydney mud whelks were common amongst the seagrass. No live molluscs were identified in the lake or channels (McQueen 2014).

Although juvenile fish were seen in the channels, the seagrass wrack at the entrance of the drainage channels would limit fish passage. The poor water quality and dense growth of *C. glauca* and *P. australis* would limit habitat opportunities for estuarine benthos within drainage channels (McQueen 2014).

No threatened species were considered likely to occur within the area studied. However, the broader study area does contain habitat for seagrass and syngnathids (seadragons, pipefish and seahorses) (McQueen 2014). Further investigation of these areas would be required as part of the environmental assessment process to determine the likelihood of threatened species occurring in those areas prior to any development.

7.2 Terrestrial Fauna

Database searches indicate a number of protected fauna could potentially occur in the proposal area. These included 80 threat listed species and migratory birds within a 10km radius of the proposal site.

Fauna surveys were conducted within the proposal site to provide an indication of species that could be present. One threat listed species was recorded at the site, the Grey Headed Flying Foxes (*Pteropus poliocephalus*). The Grey Headed Flying Fox is listed as vulnerable under both the NSW TSC Act and the Commonwealth EPBC Act. Significance tests will be required under both pieces of legislation for this species as part of the environmental assessment process.

One migratory bird was also observed, Caspian Tern (*Hydroprogne caspia*). Migratory birds are matters of national environmental significance under the EPBC Act and, therefore, a test of significance would need to be undertaken for the Caspian Tern under this legislation.

A total of 33 species of terrestrial fauna were recorded during the fauna survey. Thirty birds were recorded. Two of these, the Striated Heron and Pied Butcherbird, were nesting in larger trees on the foreshore.

Three mammals were recorded, Grey-headed Flying and two microbats, White-striped Freetail Bat (*Austronomus australis*) and Gould's Wattled Bat (*Chalinolobus gouldii*).

Surveys only provide a snapshot of the fauna present in the area at a particular moment/s in time. The surveys undertaken for this study only covered the proposal area, which is just a small section of the entire study area. There is potential for the area to be providing habitat for other species of fauna, including threat listed species and migratory birds. A full

assessment of the likelihood of all threat listed species that could potentially use the area will be undertaken as part of the environmental assessment process.

7.2.1 Grey Headed Flying Fox

Grey Headed Flying Foxes occur in subtropical and temperate rainforests, tall sclerophyll forests, woodlands, wetlands and heaths. They also visit urban gardens and fruit farms. They normally feed within 20km of their roosting camp but will travel up to 50km to find food. There is a Grey Headed Flying Fox camp at Avoca Beach, which is less than 20km direct flying from Long Jetty. They feed on the nectar and pollen of indigenous trees such as Eucalyptus, Melaleuca, Banksia and rainforest trees and vines (OEH 2014a). These foraging characteristics makes flying foxes vital to maintaining ecosystems. They are major pollinators and seed disperses of these flora species and play a substantial role in ensuring the ongoing survival of rainforests (Department of Environment 2014a). Landscaping for the proposed works should include nectar and pollen producing plants that are indigenous to the location to maintain and enhance the habitat of the Grey Headed Flying Fox.

7.2.2 Caspian Tern

The Caspian Tern is a migratory bird found through Australasia, North America, Eurasia and Africa. It is found in both inland and coastal habitat, at large lakes and ocean coastline. In NSW, they are mainly found in coastal regions. They feed on fish, foraging mostly in open wetlands and preferring shallow water near the margins. They nest in a range of sites in the open or among low or sparse vegetation including tussocks and saltmarsh. They roost mainly on bare sand, banks, shell spits and shores of coast, lakes and estuaries (Department of Environment 2014b).

7.2.3 Recommendations

- Protect mature indigenous trees.
- Plant a diverse range of indigenous shrubs that include mid and lower stratum species, around and between existing mature and retained trees to form a continuous garden that runs in a north / south direction with access points to the reserve at convenient locations. (Species selection to ensure objectives for community access and connectivity are maintained.)
- Planting to include nectar producing keystone species (as identified by WSC DCP 14) such as *Melaleuca quinquenerva, Eucalyptus robusta, Banksia integrifolia* and *Acacia longifolia*.
- Where possible, upgraded drainage lines to be designed so as to provide small inlets that continue to provide refuge and habitat for juvenile fish. These inlets would mimic the situation that currently exists in the stormwater channel opposite Venice Street.

8 Hydrology and Water

8.1 Hydrology

Together with Lake Munmorah and Budgewoi Lake, Tuggerah Lakes makes up a series of three interconnecting coastal lagoons which cover an area of 80 km^2. Tuggerah is the largest of the three lakes with an area of 54 km^2. The average depth of the lakes is 1.9m. Limited water exchange occurs between the ocean and the lakes through the narrow channel at the Entrance. This results in a very small tidal influence within the lakes (Scott 1999 p.4).

Freshwater is delivered to the lakes via five major tributaries: Spring Creek, Wallarah Creek, Wyong River, Ourimbah Creek, Tumbi Creek and Saltwater Creek. Tumbi and Saltwater Creeks deliver freshwater to the southern section of Tuggerah Lakes and the area where the proposal site is located (Scott 1999).

Stormwater runoff from the roads and urban areas in Long Jetty is directed into a number of stormwater channels that intersect the lake foreshore before being discharged into Tuggerah Lakes. This has created an unnatural flow regime into the lakes which results in impacts on vegetation, scouring of the foreshore, turbidity and untreated discharge of pollutants into the lake.

8.2 Water Quality

A number of water quality parameters can be used to measure the physical and chemical stressors occurring in aquatic ecosystems. ANZECC guidelines provide thresholds for these measurements that can be applied to particular ecosystem types and conditions. To assess the quality of the water within the channels, selected parameters were tested against thresholds for slightly disturbed marine aquatic ecosystems. Parameters included turbidity, pH, dissolved oxygen, water temperature and salinity. These parameters can have a direct impact on species composition and abundance (ANZECC & ARMCANZ 2000).

Water quality parameters tested for this study and from previous testing undertaken by Waterwatch volunteers indicates that turbidity levels in the stormwater channels can be high, often exceeding ANZECC guideline thresholds during periods of strong winds.

Dissolved oxygen was low in all channels tested for this study (McQueen 2014). This is consistent with Waterwatch results, where dissolved oxygen has been consistently low across all channels. Dissolved oxygen levels tend to fluctuate with water temperature, aeration and usage and creation of oxygen by organisms living in the water. Colder water holds more oxygen, as does aerated water. 'Stagnant' water is usually low in dissolved oxygen. Therefore, it is not surprising that the water within the stormwater channels is consistently low in dissolved oxygen.

The pH was around 7.0 for each channel, which is neutral and at the lower end of the threshold for the ecosystem type. This result is in keeping with results consistently obtained from Waterwatch testing (McQueen 2014).

Salinity readings varied between each channel. Waterwatch results show (through the measure of electrical conductivity) a great variation in salinity over time in particular channels subject to the amount of rainfall. This is understandable, as channels holding the higher saline lake water would be flushed with the lower salinity stormwater during these

times. Generally, the water quality results show that the water in the channels is fairly poor. However, the aquatic survey undertaken for this study found that juvenile fish are still able to use the channels.

Figure 7: Stagnant water trapped in drainage channel (Photo: Carolyn Donnelly)

8.2.1 Recommendations

- Plant invert of swales with indigenous macrophytes (sedges and rushes that are effective at pollutant uptake).
- Direct stormwater through a broad shallow swale that runs parallel with the lakes edge between the Coastal Saltmarsh and mown lawn. Extend the flow path as much as room will permit by meandering the swale. Provide high flow outlets at various points along the swale or a broad outlet that allows for considerable dissipation of flow.
- Ensure that any tree clearing undertaken in order to carry out the stormwater infrastructure works retains trees that provide shade for channels that may hold water.

9 Soils

The proposal site lies within the Wyong soil landscape. This is a landscape of broad poorly drained deltaic floodplains and alluvial flats of the Quaternary. The area is associated with wetlands, meander scrolls and oxbows. Low lying, slightly elevated terraces are present in some locations within this landscape (Murphy and Tille 1992, Murphy 1992)).

The dominant soil types consist of brownish black pedal loam in the A horizon. This is a black loam to silty clay loam which is usually friable and can be hardsetting when dry. The pH of this topsoil ranges from strongly acid to slightly acid. This topsoil layer has a depth of about 10-40cm (Murphy 1992).

The B horizon consists of mottled brownish grey plastic clay for a depth of 200cm or more. This is a silty to heavy clay with a massive structure when wet. This material is often permanently water logged and ranges from strongly acid (pH 4.0) to slightly acid (pH 6.0) (Murphy 1992 p. 82).

Landscape limitations include flooding, waterlogging, high water tables and high run on. There is acid sulfate soil (ASS) potential (Murphy 1992). WSC ASS mapping indicates this potential to be high. This very strongly acid soil also has a high potential for aluminium toxicity (Murphy 1992).

In addition to these characteristics, the soil has moderate erodibility and low fertility. The topsoil is often sodic and has a hardsetting surface. The B horizon also has low permeability, high plasticity and low wet bearing strength (Murphy 1992).

The soils on the lake foreshore, where the works would take place, have been through a considerable amount of disturbance which has included scraping of the topsoil layer to remove weed build up and pushing marine sediments from mud flats onto the foreshore in order to reclaim land. This work resulted in release of sulphuric acid in some locations of the lake at the time that this work was undertaken (Scott 1999).

These soil conditions will need to be taken into account when considering the design of stormwater treatments to ensure that exposure of acid sulfate soils is avoided if possible and, where this is not possible, managed correctly and does not create an environmental problem. Also, plant species selected for landscaping/revegetation will also need to be well adjusted to site conditions.

9.1.1 Recommendations

- Design to involve minimal excavation.
- Keep any new swales as shallow as possible to avoid disturbing ASS.
- Geotechnical investigations should test for ASS.
- Plants selected for use in WSUD and landscaping should be indigenous to the location and well adapted to the site conditions.

10 Wildlife Connectivity

The proposal area displays the complex of natural areas, urban areas and towns that is typical of the Australian coastal landscape. Pockets of wildlife habitat have become isolated through development. This has disrupted the connectivity of ecosystems and reduced the environment's capacity to function naturally. It has now been well established that, in order to rebuild functioning landscapes and maximise the benefits of protected areas, it is necessary to link protected areas with other areas of ecological value (DSEWPaC 2012).

The proposal area forms part of the Stepping Stones Wildlife Corridor, which aims to form a vegetated link between the southern and northern sections of Wyrrabalong National Park. This project is a partnership between the Community Environment Network, Wyong Shire Council, Hunter Rivers Catchment Management Authority with support from the NSW Environmental Trust. The corridor has been a focus of planting and bush regeneration by WSC and bushcare groups since the early 1980s. The mature trees and other vegetation along the foreshore in the proposal area provides stepping stone connectivity between parcels of bushland to the north and south (CEN 2008).

Figure ..: Stepping Stones Wildlife Corridor

Maintaining, and improving where possible, the existing wildlife links through the proposal site is captured in Objective No.4 and is considered to be an important aspect of addressing ecological function. Thinning *C. glauca* may impact on the connectivity potential of the foreshore. However, there is an opportunity to mitigate this impact by incorporating plantings that provide cover and food for wildlife, while addressing aesthetics of the foreshore and increasing the enjoyment potential of the area for the community. See Section 11 and previous sections on Flora and Fauna for relevant recommendations.

11 Summary of Recommendations

Objective	Recommended Actions
Flora and Fauna	
Protect and restore indigenous vegetation where possible, in particular endangered ecological communities Identify existing fauna habitats (both terrestrial and aquatic) and restore and enhance these where possible Identify opportunities for increasing the value of the area as a wildlife corridor for resident wildlife and incorporate plantings to meet this aim in the design	• Provide a strip of intertidal area between the lakes edge and vegetated swale for Coastal Saltmarsh restoration and regeneration. The width of the strip should cover the existing conditions suitable for this community and additional space for the effects of climate change. 10m is recommended. • Remove C. glauca regrowth and introduced weeds from areas where it is competing with Coastal Saltmarsh as part of an ongoing restoration effort. • Allow (and assist if possible) regeneration of seagrasses in the inshore area. • Protect mature indigenous trees. • Plant a diverse range of indigenous shrubs that include mid and lower stratum species, around and between existing mature and retained trees to form a continuous garden that runs in a north / sound direction with access points to the reserve at convenient locations. (Species selection to ensure objectives for community access and connectivity are maintained.) • Planting to include nectar producing keystone species (as identified by WSC DCP 14) such as Melaleuca quinquenerva, Eucalyptus robusta, Banksia integrifolia and Acacia longifolia. • Where possible, upgraded drainage lines to be designed so as to continue to provide fish refuge / habitat.
Water sensitive urban design (WSUD) to protect and enhance existing indigenous vegetation communities and fauna habitats	• Vegetate swale inverts (and wetlands) with indigenous sedges and rushes such as *Juncus krausii* and *Baumea juncea*.
Water Quality	
WSUD to, as much as possible, remove pollutants from stormwater	• Plant invert of swales with indigenous macrophytes (sedges and rushes that are effective at pollutant uptake).
WSUD to reduce 'channelled flow' effect and provide for increased dissipation of flow to mimic natural overland flow paths.	• Direct stormwater through a broad shallow swale that runs parallel with the lakes edge between the Coastal Saltmarsh and mown lawn. Extend the flow path as much as room will permit by meandering the swale. Provide high flow outlets at various points along the swale where possible to disperse stormwater over a great area.
Soils	
Minimise disturbance to soils	• Design to involve minimal excavation.
Minimise depth of excavation to avoid ASS and aluminium toxicity	• Keep any new swales as shallow as possible to avoid disturbing ASS.

Objective	Recommended Actions
	• Geotechnical investigations should test for ASS.
WSUD to reduce erosion and turbidity where stormwater discharges to the lake	• Broaden the mouth of high flow channels to disperse flow over as broad an area as possible or disperse over a number of small outlets.
Community access and recreation	
Improve existing community access and recreation opportunities while minimising impact on the natural environment	• Thin Casuarina glauca regrowth (< 100mm dbh), keeping larger trees (>100mm dbh) to maintain touching canopies and to maintain shade over stormwater outlets. • Keep other indigenous trees where possible. • Provide small timber bridges or boardwalks over swales to provide community connectivity across stormwater outlets. • Strategically plant understorey vegetation to give the impression of openness, to provide visual connectivity and to suppress regrowth of C. glauca and exotic weeds.
Promote community understanding of natural environment	Provide interpretation signage at key locations such as at the end of boardwalks that provide access to lake viewing areas. Possible examples include: • Explanation of the lake processes. • Information about Coastal Saltmarsh and Seagrass community, associated fauna and economic benefits to the community.
Visual amenity	
Retain existing mature indigenous trees adjacent to Tuggerah Parade and scattered through the park	As per objective
Tree removal and plantings to consider overall visual impact on the area	• Landscape design to include a diverse variety of indigenous species and be visually appealing.
WSUD to be visually appealing and fit in with the natural foreshore environment	• Meander swales slightly to provide a more ‘natural’ look. • Plant swales with a variety of sedges and rushes that are indigenous to the location.
Maintenance	
WSUD and landscaping design to minimise Council maintenance requirements	• Provide sediment bays at pipe outlets for easy access for council staff. • Provide dense plantings of indigenous species in swales and other landscaped areas to exclude regenerating C. glauca and exotic weeds. • Line swales with jute to exclude weeds and casuarinas while sedges are maturing. • Provide a thick layer of mulch to new plantings in other landscaped areas to provide weed exclusion while plants are growing. • Consider ongoing bush regeneration of the area to maintain weeds and C. glauca regrowth.

12 Conclusion

WSC engaged Beyond Environmental Consulting to provide ecological recommendations for the design of the stormwater infrastructure and associated landscaping that is proposed for the Tuggerah Lakes foreshore, adjacent to Tuggerah Parade at Long Jetty.

The brief for this study was to investigate the potential ecological impacts on foreshore ecology and habitat from the proposed stormwater upgrade and associated landscaping and provide advice on how these impacts can be avoided and mitigated through the design. This was achieved through undertaking field investigations and desktop research, liaising with design engineers, Storm Consulting, and reviewing relevant the statutory requirements.

Site specific issues include poor quality stormwater stagnating in channels and entering the lake untreated, impacts to coastal saltmarsh through management and recreational activities, potential impacts to threatened vegetation communities and protected fauna from the proposed stormwater infrastructure works, vigorous regrowth of *C. glauca* competing with Coastal Saltmarsh and reducing community access.

Fifteen objectives have been developed based on statutory and planning objectives for the area, the results of field investigations and research and consultation with WSC. Twenty seven recommendations have been compiled to meet the objectives. Recommendations endeavour to address the current site specific issues and potential impacts that could occur from the proposed works.

In meeting the fifteen objectives, compromises would be required. Some removal of *C. glauca* regrowth and immature trees would be required to protect the Coastal Saltmarsh, construction of the WSUD treatments and to achieve community access. Flexibility exists in how this compromise can be achieved in order to reduce ecological impacts.

On balance, it is considered that any reduction in ecological value that occurs through thinning of *C. glauca* could be adequately offset by replanting with a diversity of indigenous species that provide ecological benefit to a range of protected fauna and, in particular, threatened species and migratory species. This would be achieved through restoration of Coastal Saltmarsh and strategic replanting with a high diversity of indigenous species to increase species and structural diversity and increase habitat and connectivity opportunities.

13 References

Benson, D. and McDougall, L. 1999, Ecology of Sydney Plant Species Part 3: Dicotyledon families Cabombaceae to Eupomatiaceae, Cunninghamia 6(2): 217-431.

BirdLife Australia 2012, *Glossy Black-Cockatoo* (*Calyptorhynchus lathami*) *Cacatuidae*, viewed 13 November 2014 <http://www.birdlife.org.au/bird-profile/glossy-black-cockatoo>

Australian Government Bureau of Meteorology (BOM*), Climate statistics for Australian locations*, viewed 28 October 2014, <http://www.bom.gov.au/climate/averages/tables/cw_061366.shtml>.

Coastal Protection Act 1979

Community Environment Network 2008, *Stepping Stones Corridor – Entrance to Bateau Bay*, viewed 7 November 2014 http://www.cen.org.au/CEN-Projects/Stepping-Stones/

Daly, T. 2013, Primefact: Coastal Saltmarsh, NSW Department of Primary Industries, viewed 6 November 2014 <http://www.dpi.nsw.gov.au/__data/assets/.../Coastal-Saltmarsh-Primefact.pdf>

Department of Environment 2014a, *Flying Foxes*, Department of the Environment, Canberra, viewed 12 Nov 2014 <http://www.environment.gov.au/biodiversity/threatened/species/flying-fox-law>

Department of Environment 2014b, *Hydroprogne caspia – Caspian Tern in Species Profile and Threats Database,* Department of the Environment, Canberra, viewed 12 November 2014 <http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=808>

Department of Environment and Climate Change NSW (DECC) 2007, *Swamp Oak Floodplain Forest: Identification Guidelines for Endangered Ecological Communities*, Department of Environment and Climate Change.

Department of Primary Industries Office of Water (NOW) 2012, *Macquarie Tuggerah catchment 2012,* viewed 27 October 2014, < http://www.water.nsw.gov.au/Water-management/Basins-and-catchments/Macquarie-Tuggerah-catchment/Macquarie-Tuggerah-catchment>.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2012, *National Wildlife Corridors Plan: A framework for landscape-scale conservation*, Public Affairs, Commonwealth of Australia, Canberra.

Dickinson, T.G., Roberts, D.E., Geary, M. McPherson, R., Dye, A., Muston, R. 2006, *Tuggerah Lakes Management Plan*. Prepared for Wyong Shire Council and Department of Natural Resources. Bio-Analysis Pty Ltd: Marine, Estuarine and Freshwater Ecology, Narara.

Environmental Planning and Assessment Act 1979 (NSW)

Environmental Protection and Biodiversity Conservation Act 1999 (Cwlth)

Fisheries Management Act 1994

Florabank nd, Casuarina glauca, viewed 6 November 2014 <http://www.florabank.org.au/lucid/key/species%20navigator/media/html/Casuarina_glauca.htm>

Local Government Act 1993 (NSW)

McQueen 2014, *Aquatic Assessment Drainage Works Tuggerah Parade Long Jetty*. Prepared for Beyond Environmental Consulting, Bateau Bay.

Murphy C.L. and Tille, P.J. 1992, *Soil Landscapes of the Gosford-Lake Macquarie: 100 000 Sheet Map*, Department of Conservation and Land Management (Incorporating the Soil Conservation Services of NSW, Sydney).

Murphy C.L., 1992, *Soil Landscapes of the Gosford-Lake Macquarie: 100 000 Sheet Map*, Department of Conservation and Land Management (Incorporating the Soil Conservation Services of NSW, Sydney).

National Parks and Wildlife Act 1974 (NSW)

Office of Environment and Heritage (OEH) 2014a, *Grey-headed Flying-Fox* in Species Profile and Threats Database, Office of Environment and Heritage 2014, viewed 12 November 2014 <http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10697>

Office of Environment and Heritage (OEH) 2014b, *Swamp oak floodplain forest on the NSW North Coast, Sydney Basin and South East Corner bioregions – endangered ecological community listing*, viewed 13 November 2014 http://www.environment.nsw.gov.au/determinations/SwampSchlerophyllEndSpListing.htm

Office of Environment and Heritage (OEH) 2014c, *Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions – endangered ecological community listing*, viewed 13 November 2014 <http://www.environment.nsw.gov.au/determinations/CoastalSaltmarshEndSpListing.htm>

Scott, A. 1999, *The Ecology of the Tuggerah Lakes Historical Records*, CSIRO Land and Water, Canberra.

Smith, A.P. and Murray, M. 2003. *Habitat requirements of the squirrel glider (Petaurus norfolcensis) and associated possums and gliders on the New South Wales central coast*, Wildlife Research 30(3) 291-301, CSIRO Publishing.

State Environment Planning Policy No. 71: Coastal Protection

Threatened Species Conservation Act 1995 (NSW)

Water Management Act 2000

Wyong Shire Council 2000, *Tuggerah Lakes Estuary Process Study,* prepared by D.E. Roberts, Wyong Shire Council, Wyong.

14 Acronyms and Terms

ASS	Acid Sulfate Soil
dbh	'diameter at breast height' This is the diameter of the tree measured at the breast height of the average person (around 1.3m from the ground)
DCP	Development Control Plan
EP&A Act	*Environmental Planning and Assessment Act 1979*
LEP	Local Environmental Plan
MNES	Matter of National Environmental Significance
NSW	New South Wales
Orographic	Orographic precipitation is caused by the lifting of moist air over a mountain barrier
Podzolic	Term applied to acid soils with strong texture contrast between sandy or loamy topsoil and clay subsoils. Associated colour descriptor, i.e. yellow or red, refers to dominant colour of subsoil
PoM	Draft Plan of Management for Community Land 2011
Proposal Site	The land that would be subject to the activities.
REF	Review of Environmental Factors
Regrowth	As referred to in this report, *Casuarina glauca* trees with a dbh of $\leq$ 100mm
SEPP	State Environmental Planning Policy
Soliths	Acid soils with a strong texture contrast between pale topsoil and clay subsoil
Stepping Stones	Isolated patches of vegetation, single trees, wetlands or dams which become a wildlife corridor when the distance between them is small enough for some species to be able to move from one patch to the next.
Threat listed	A species, population or community listed as threatened under legislation
TSC Act	*Threatened Species Conservation Act 1995*
WSUD	Water Sensitive Urban Design
EMS	Tuggerah Lakes Estuary Management Study
EPBC Act	Environment Protection and Biodiversity Conservation Act
CP Act	Coastal Protection Act 1979
TSC Act	Threatened Species Conservation Act 1995
PoM	Draft Plan of Management No.16 Council Owned Foreshore Land at The Entrance North, The Entrance, Long Jetty, Blue Bay, Toowoon Bay, Shelly Beach and Bateau Bay
SEPP 71	State Environment Planning Policy No. 71: Coastal Protection
WM Act	Water Management Act 2000
FM Act	Fisheries Management Act 1994
LEP	WSC Local Environment Plan 2013
DCP 14	Development Control Plan No. 14
FHP 1	Fish Habitat Protection Plan No.1
FHP 2	Fish Habitat Protection Plan No.2 Seagrasses

Appendix I: Statutory Framework

Legislation	Relevance to the Proposal
Environmental Planning and Assessment Act 1979	The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (EP&A Reg) are the main planning instruments under which planning and development is carried out in New South Wales (NSW). Environmental assessment for the proposed upgrade of stormwater infrastructure along the Tuggerah Lakes foreshore would be undertaken under Part 5 of this Act. Section111 of Part 5 requires that a determining authority, when considering an activity, examine and take into account to the fullest extent possible all matters affecting or likely to effect the environment, notwithstanding provisions of this or any other Act. Some considerations listed under Section 111 of Part 5 of this Act include (among other things) threatened species, threatened populations and their habitats and any other protected fauna or protected native plants (within the meaning of the *National Parks and Wildlife Act 1974*).
State Environmental Planning Policy (Infrastructure) 2007	The *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP) provides for a simpler process for the provision of infrastructure by local and state government. ISEPP allows the Council to undertake development associated stormwater systems on any land without consent. However, impacts on the environment must be assessed and managed in accordance with all relevant environmental planning instruments.

Legislation	Relevance to the Proposal
State Environmental Planning Policy 71 Coastal Protection (SEPP 71)	The Tuggerah Lakes foreshore, where the proposed stormwater works would take place, is designated Sensitive Coastal Location. Therefore, the aims and provisions of this SEPP apply to the land. ISEPP, being the more recent planning instrument, overrides SEPP 71 where there is an inconsistency. Therefore, the consent provisions under SEPP 71 do not apply. However, the aims are applicable and should guide the proposal. Aims of SEPP71 that are applicable to this proposal are: • to protect and manage the natural, cultural, recreational and economic attributes of the New South Wales coast, and • to protect and improve existing public access to and along coastal foreshores to the extent that this is compatible with the natural attributes of the coastal foreshore, and • to ensure that new opportunities for public access to and along coastal foreshores are identified and realised to the extent that this is compatible with the natural attributes of the coastal foreshore, and • to protect and preserve Aboriginal cultural heritage, and Aboriginal places, values, customs, beliefs and traditional knowledge, and • to ensure that the visual amenity of the coast is protected, and • to protect and preserve beach environments and beach amenity, and • to protect and preserve native coastal vegetation, and • to protect and preserve the marine environment of New South Wales, and • to manage the coastal zone in accordance with the principles of ecologically sustainable development(ESD) (within the meaning of section 6 (2) of the *Protection of the Environment Administration Act 1991*)*, and • to ensure that the type, bulk, scale and size of development is appropriate for the location and protects and improves the natural scenic quality of the surrounding area, and • to encourage a strategic approach to coastal management.

Threatened Species Conservation Act 1995 (TSC Act)	The TSC Act provides for the conservation of threat listed species, populations and ecological communities of flora and fauna in NSW and facilitates the appropriate assessment, management and regulation of actions that may impact on threatened species, populations and ecological communities. The objects of the Act are: *(a) to conserve biological diversity and promote ecologically sustainable development, and* *(b) to prevent the extinction and promote the recovery of threatened species, populations and ecological communities, and* *(c) to protect the critical habitat of those threatened species, populations and ecological communities that are endangered, and* *(d) to eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities, and* *(e) to ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed, and* *(f) to encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.* The Act lists threatened species, populations and communities along with key threatening processes. The significance of an impact from the proposal on threatened species, populations and communities is assessed using a test of significance (seven part test) in accordance with S5A(2) of this Act. The Act also outlines requirements for critical habitat and enables the preparation of recovery plans, threat abatement plans, licensing, biodiversity certification and biodiversity banking. A number of threat listed species could potentially use the area where the proposed drainage works would occur. To achieve the objects of this Act, threatened species, populations and communities present or likely to occur firstly need to be identified. Measures to protect those species, populations and communities likely to occur at the proposal site are then determined. Measures to avoid impacting species habitat or on the species directly are investigated in the first instance, followed by measures to reduce impact and to enhance/restore habitat. Where a significant impact is likely from the works, the Act requires that a Species Impact Statement be prepared. The Act also requires public authorities to have regard to critical habitat where such a declaration exists. There is no critical habitat declared for the proposal site. The Act also provides for Biodiversity certification and Biobanking. Biodiversity certification does not apply to the land. Biobanking methodologies can be used to classify vegetation type and condition. Biobanking allows for offsetting habitat loss.

Legislation	Relevance to the Proposal
Fisheries Management Act 1991 (FM Act)	The FM Act applies to all waters in the state of NSW and aims to conserve, develop and share the fishery resources of the state for the benefit of present and future generations. In particular, this Act aims to conserve fish stocks and key fish habitats, threatened species, populations and ecological communities of fish and marine vegetation and to promote ESD and biological diversity. This Act identifies threatened aquatic species, populations and ecological communities and requires the same test of significance process to be undertaken as is required under the TSC Act. A species impact statement is also required where there could be a significant impact on a threatened species listed under this Act. **Habitat Protection Plans** To assist in the protection of key fish habitats, this Act also allows the Minister to require Habitat Protection Plans for any fish habitat. Two Habitat Protection Plans have relevance for this proposal. (These are described below.) Public authorities must have regard to any habitat protection plan that relates to the exercise of their functions and must notify Fisheries regarding any functions that it proposes to undertake that are inconsistent with a Habitat Protection Plan. **Marine Vegetation** Mangroves and other marine vegetation are protected from harvesting and/or harm under this Act. It is possible that stormwater works could impact on seagrasses and coastal saltmarsh at the outlets of the stormwater channels. Under this Act, a permit is required from Fisheries to harm marine vegetation. **Dredging/Reclamation** The Act also seeks to regulate dredging and reclamation so that these activities are undertaken in a manner that is consistent with ESD. A permit is required by a local government to carry out dredging and/or reclamation.
National Park and Wildlife Act (NPW Act)	This Act deals with the conservation of nature and cultural objects, places and features. This is to be achieved through the application of the principles of ecologically sustainable development. Aboriginal heritage provisions of this Act will apply to the proposed works. This Act also provides definitions for 'protected fauna' and 'protected native plant' as referred to in the EP&A Act, which has relevance to management requirements on the proposal site. Protected fauna and Protected native plants are clarified in Schedules 11 and 13 of this Act. Essentially, all native fauna, except the dingo, are defined as 'Protected fauna'. Schedule 13 lists plants and plant groups that are defined as 'protected native plants' for the purposes of this Act.

Legislation	Relevance to the Proposal
Water Management Act 2000 (WM Act)	The WM Act aims to provide for the sustainable and integrated management of water resources, in particular: *(a) to apply the principles of ecologically sustainable development, and* *(b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and* *(c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:* *(i) benefits to the environment, and* *(ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and* *(iii) benefits to culture and heritage, and* *(iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water,* *(d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources,* *(e) to provide for the orderly, efficient and equitable sharing of water from water sources,* *(f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna,* *(g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users,* *(h) to encourage best practice in the management and use of water.* The Act sets out a number of principles for managing water. These relate directly to the protection and restoration of floodplains and dependent ecosystems (including groundwater ecosystems), the protection of flora and fauna and their habitats that benefit from the water resource, protection of water quality, management of cumulative impacts on water and their dependent ecosystems, adaptive management that is responsive to monitoring of ecological water requirements and social and economic benefits to the community. A specific principle relating to drainage management states that *floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated*.

Legislation	Relevance to the Proposal
Environmental Protection and Biodiversity Conservation Act 1999	*The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth's key piece of environmental legislation. It provides a statutory framework for the protection and management of nationally and internationally important biodiversity and heritage, defined as matters of national environmental significance (MNES). The objectives of the Act relevant to this study also include the promotion of ESD through conservation and sustainable use of natural resources, promoting the conservation of biodiversity, protection of native species and ecosystems, identifying and addressing processes that threaten all levels of biodiversity. The EPBC Act requires that potential impacts to Commonwealth land or MNES be considered. Where there is potential for a significant impact on these matters, a referral to the Commonwealth Government is required. A number migratory and threatened species listed under this Act have potential to use the area. The coastal saltmarsh community present on the Tuggerah Lakes foreshore also corresponds to the nationally threatened community listed under this Act, *Subtropical and Temperate Coastal Saltmarsh*. As for threatened species, populations and communities listed under state legislation, measures to avoid impacting species habitat or on the species directly are investigated in the first instance, followed by measures to reduce impact and to enhance/restore habitat. Where there is potential for the proposal to significantly impact a species, populations and communities listed under this Act (or any other MNES), the proposal is referred to the Commonwealth Environment Minister. The Commonwealth Government then makes an assessment as to whether the proposal is declared a 'controlled action'. Where the proposal is deemed to be a controlled action, approval from the Minister is required.
Coastal Protection Act 1979 (CP Act)	This Act aims to provide for the protection of the coastal environment for the benefit of present and future generations through a number of objectives. Of relevance to this study is the objective: • to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality, and • to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development, and • to promote public pedestrian access to the coastal region and recognise the public's right to access, and

Management Plans	Relevance
Local Environmental Plan	Wyong Shire Council Local Environmental Plan 2013 (LEP) provides the framework for land use in the WSC local government area (WSC LGA). The plan outlines the land use zones and provides the requirements for development in each zone. The object of the plan is to ... The land where the development would take place (proposal site) is zoned Public Recreation (RE1). The objects of this zone, as outlined in the LEP, are to: • To enable land to be used for public open space or recreational purposes. • To provide a range of recreational settings and activities and compatible land uses. • To protect and enhance the natural environment for recreational purposes. • To provide linked open space for ecosystem continuity, public access, local community recreation and waterway protection. • To provide space for integrated stormwater treatment devices for flow and water quality management. • To enable ancillary development that complements land zoned for recreational purposes. The LEP also provides a number of provisions for managing the natural environment and development within the coastal zone. Coastal zone development objectives aim to protect the coastal environment through promotion of ESD and to implement the principles of the NSW Coastal Policy. They require that any proposed development take into account impacts on the natural scenic quality and amenity of the foreshore, ensure community access, control the untreated discharge of effluent and stormwater to waterways and water bodies and will not significantly affect, impact on or increase the risk of coastal hazards. The LEP outlines objectives for preservation of trees and other vegetation for the purposes of preserving amenity and biodiversity values and refers to species, kinds of trees or other vegetation prescribed by the development control plan.
Development Control Plans	WSC has a number of DCPs. Where there is an inconsistency between the DCPs and the LEP, the LEP prevails. DCPs relevant to this study are discussed below.

Development Control Plan No 14 Tree Management	The purpose of this DCP is to protect and enhance the environmental amenity, special landscape characteristics, unique vegetation qualities and ecological values of the shire. Aims: • To define Council's responsibilities and requirements with respect to the protection, retention and replacement of trees and native vegetation. • To ensure that proper consideration is given to trees and native vegetation in planning, designing and constructing development. • To minimise unnecessary injury to or destruction of trees and native vegetation. • To retain healthy individual trees of local amenity and aesthetic value. • To facilitate the removal of undesirable exotics, noxious weeds, dangerous trees and any other inappropriate plantings and to replace these with suitable local indigenous species which will positively contribute to visual and environmental amenity and ecological sustainability. • To retain viable representative samples of native vegetation, which have an intact structure and complete floristics, wherever practicable. • To detail requirements for the submission of sufficient and relevant information by applicants. This DCP outlines a number of considerations that are made when WSC is assessing an application for tree removal. As the works would be assessed under Part 5 of the EP&A Act, these do not form part of the assessment process for the works. However, they do reflect the requirements of legislation and are used here as a guide to understanding the Councils general intent for tree management within the shire. The DCP also provides a list of species of local conservation and cultural significance, which should be taken into account in species selection and selective clearing on the foreshore. A number of indigenous trees that fall into the categories of Keystone or Conservation present on the foreshore, notably: • Acacia longifolia • Banksia integrifolia • Eucalyptus robusta • Melaleuca quinquenerva
Wyong Shire Wetland Development Control Plan No 30	This DCP outlines Councils requirements for management of developments near wetlands. It aims: • To protect important wetland habitat and discourage development proposals that have the potential to fragment, pollute, disturb or diminish the environmental values of such areas. • To maintain the functions of low lying lands for the purpose of improving downstream water quality for the benefit of the Tuggerah Lakes and Lake Macquarie systems. • To encourage land use practices and environmental design measures that enhance the sustainability of wetlands functions and values. • To provide clear information on Council's requirements for the submission of relevant environmental information for development proposals which are affected by Wyong's Wetland Management System. This DCP has provided specific guidance for measures outlined in this study.

NSW Coastal Policy 1997	This policy is designed to guide management and planning of the coastal zone. It addresses population growth and economic development in the coastal zone while protecting the natural, cultural, spiritual and heritage values of the coastal environment in keeping with ESD. By direction of the Minister for Planning (under S117 of EP&A Act) Councils must include provisions consistent with this policy in their LEPs. The nine goals of the Coastal Policy are: • Protecting, rehabilitating and improving the natural environment of the coastal zone. • Recognising and accommodating the natural processes of the coastal zone. • Protecting and enhancing the aesthetic qualities of the coastal zone. • Protecting and preserving the cultural heritage of the coastal zone. • Providing for ecologically sustainable development and use of resources. • Providing for ecologically sustainable human settlement in the coastal zone. • Providing for appropriate public access and use. • Providing information to enable effective management of the coastal zone. • Providing for integrated planning and management of the coastal zone. Relevant to this study are the following actions: • Water quality in coastal waters, estuaries and rivers will be maintained where it is currently adequate or improved where it is currently inadequate. This will be addressed through a number of specific actions designed to control discharges from both point and non-point sources, including development and implementation of management and monitoring programs. • Protection and restoration of important fisheries habitats, such as seagrasses and mangroves, will continue to be undertaken.

Draft Plan of Management No.16 Foreshore Land at The Entrance North to Shelly Beach	The LG Act requires councils to prepare a Draft Plan of Management for Community Land (PoM) for all land classified as community land. Community land is land owned by the council, which is kept for use by the general public. The PoM provides an overarching guideline for the appropriate use and management of land. However, it does not override the requirements of any other statutory or planning instruments. The objectives outlined in the PoM for proposal area are: • To provide high quality open space and facilities requiring a minimum of maintenance. • To provide public access to community land. • To provide a healthy environment on the land. • To provide a broad spectrum of safe, high quality recreational and commercial opportunities. • Maintain flexibility of future decision making and to allow changes in community preferences. • To allow for a range of uses (including temporary uses) for the land, provided Council is satisfied that the use does not significantly affect the land. Further aspects outlined in this plan that are relevant to this study are: • Natural hydrological processes are to be maintained where possible, including natural vegetation and the flow regimes to maintain creek line stability and health of terrestrial and aquatic plant communities. • Council are to minimise flow of nutrients to watercourses. • Acid sulfate soils should preferably be left undisturbed • Proper management of landscaping measures, trees and vegetation is important to provide a high degree of amenity on the land • Weed control shall be by both preventative measures and active control measures. • Landscape design will be in accordance with any design guidelines adopted by the Council • Gardens may be constructed and maintained on the land.
Fish Habitat Protection Plan No.1	This plan clarifies the requirements of the FM Act in regard to the protection of fish habitat and deals broadly with dredging, reclamation, fish passage requirements, protection of snags and protection of marine vegetation. Relevant to this proposal, this plan identifies the requirement for public authorities to notify Fisheries where works would result in the removal of snags from waters or potentially impede fish passage and identifies the need for Ministers consent for dredging and reclamation or to harm marine vegetation. It outlines the process to undertake, should consultation with Fisheries or a permit be required. Ecological processes are to be maintained where possible, including natural vegetation and the flow regimes to maintain creek line stability and health of terrestrial and aquatic plant communities
Fish Habitat Protection Plan No.2: Seagrasses	This plan aims to ensure that there is no net loss of seagrasses within coastal and estuarine waters of NSW by: protecting the distribution and quality of existing seagrass beds; declaring protected areas; regulating developments that damage seagrasses; restricting the issue of permits to damage or remove seagrasses; and, undertaking a regular inventory of seagrasses in NSW estuaries.

Estuary Management Study & Tuggerah Lakes Estuary Management Plan	Objectives of this study: • Provide adequate environmental flow to sustain estuarine and riverine ecology. • Maintain water quality to protect healthy ecosystem function in the estuary and rivers. • Provide water quality in rivers and the estuary safe for primary human contact. • Main flow patterns while minimising flooding threat to life and property. • Provide adequate water for community water supply. • Minimise changes to groundwater flow/stores. • Protect, maintain and restore freshwater wetland vegetation • Protect, maintain and restore aquatic and semi-aquatic estuarine vegetation • Protect, maintain and restore floodplain vegetation • Protect, maintain and restore aquatic and riparian vegetation • To maintain the biodiversity and ecological function of the catchment in a manner that protects the estuary • To minimise human disturbances that effect ecological function • To maintain and protect environmentally significant areas and threatened species/communities • To ensure fisheries is sustainable • To ensure management of the estuary and catchment protects and enhances indigenous and non-indigenous cultural heritage • To provide for economically and socially justified levels of development whilst containing adverse ecological impacts • To support forestry, agriculture and other industries in the catchment while viability of downstream ecology is maintained • To protect and restore soil landscapes and improve understanding of land capability and suitability in the catchment • To support existing industry where it is ecologically responsible • To ensure that any new commercial venture is socially and economically justified and is ecologically compatible with the estuary • To provide for public access and amenity at designated recreation areas • To identify extent of information gaps and, where appropriate, undertake studies to improve understanding • To ensure community is pro-actively involved in estuarine health and management. The Tuggerah Estuary Management plan provided a platform for managing the Tuggerah Lakes Estuary for a period of five year from completion. That time has now elapsed.

Long Jetty Village Centre Improvement Master plan	This master plan has been developed to re-establish Long Jetty as a vibrant village. It outlines a number of improvement projects in key locations that are considered to be important features of the Long Jetty area. The foreshore of Tuggerah Lakes at Long Jetty is one such important feature that has been included in this plan for improvement. The improvement plan outlines objectives and actions to undertaken at each key location. Of relevance to this study are the following actions: • Selective removal of casuarinas to provide continuous open space areas along the foreshore to assist in providing safety and visual amenity. • Existing drainage lines to be replaced with landscaped swales to assist in filtering pollutants in stormwater.
Directory of Important Wetlands in Australia	Tuggerah Lakes is listed on this directory The directory is a co-operative project between the Australian, state and territory governments. The directory identifies wetland that are important for their social, cultural and ecological importance. This directory is the primary data source for identifying potential Ramsar wetlands (which are an MNES under the EPBC Act). In order to be selected as nationally important, a wetland must meet at least one of the six nationally agreed criteria. Tuggerah Lakes has been selected because it meets criterial 3 and 4, as follows: • It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail. • The wetland supports 1% or more of the national populations of any native plant or animal taxa. The directory does not provide any statutory requirements but is intended as a management tool. Compiling an inventory of wetlands allows a better understanding of their values so that further loss of these important ecosystems can be minimised.

*For the purposes of subsection (1) (a), ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle-namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
In the application of the precautionary principle, public and private decisions should be guided by:

(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and

(ii) an assessment of the risk-weighted consequences of various options,

(b) inter-generational equity-namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations,

(c) conservation of biological diversity and ecological integrity-namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,

(d) improved valuation, pricing and incentive mechanisms-namely, that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays-that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,

(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.