14. Sea Level Rise

14.1. The Science

Even a small rise in sea level might be sufficient to cause flooding of low-lying areas around many Australian coastal communities. Similarly, changes in the intensity of droughts and storm events may increase existing climatic and weather hazards or create new ones.

The best available information on sea level rise comes from the work of the Intergovernmental Panel on Climate Change (IPCC), which was established by the World Meteorological Organisation and the United Nations Environment Programme in 1988. The IPCC work has been reviewed and analysed by CSIRO for Australia.

The main objective of the IPCC was to 'assess scientific, technical and socio-economic information relevant to the understanding of human-induced climate change, potential impacts of climate change and options for mitigation and adaptation'. Sea-level rise is one of the likely outcomes of climate change documented in the three IPCC reports over the last decade.

The IPCC's Third Assessment Report - "Climate Change 2001: The Scientific Basis" - was prepared by more than one hundred scientific authors assessing the published scientific literature, with many more contributing to and reviewing the report.

The average global surface temperature has increased by about 0.6^0C over the past 100 years. In Australia, the average temperature has increased by about 0.7^0C since records began in 1910. The warmest decade of last century was the 1990s, with 1998 being the warmest year on record (CSIRO, 2004).

As the planet warms, ice melts and water expands, causing the level of the oceans to rise. During last century, global average sea levels rose between 10 and 20cm. In Australia, the rate of global averaged sea-level rise over the last century is estimated to be 1-2mm a year, an order of magnitude larger than the average rate over the previous several thousand years (CSIRO, 2004).

However, the surface temperatures of parts of the southern hemisphere oceans and Antarctica, do not appear to have warmed in the past 100 years. From the limited data available, the frequency of tropical storms, tornadoes and thunderstorms appears not to have changed either.

14.2. Projections for the 21st Century

The Third IPCC Report stated that changes in sea-level will be felt through:

- Increases in intensity and frequency of storm surges
- Increased erosion
- Loss of important wetlands and mangroves.
- Impact on coastal ecosystems such as coral reefs
- Impact on human settlements
- A reduction in crop yields around tropical and sub-tropical regions
- Decreased water availability in areas already short of water
- An increase in the spread of diseases such as malaria and dengue fever; and
- Increased instances of flooding as intensity of rainfall increases and sea levels increase.

The positive aspects of a small amount of global warming include:

- Increases in crop yields in some mid-latitude regions with temperature increases up to two to three degrees Celsius;
- Potential increase in timber supplies from managed forests;

The IPCC projections are for a sea-level rise of between 9 and 88 cm between 1990 and 2100, and a global average surface temperature rise of between 1.4 and 5.8°C. Beyond the 21st century, sea level rise will depend strongly on what global greenhouse gas emissions control strategies are adopted (IPCC, 2001).

The rate and magnitude of sea-level change in the next century is also likely to vary from region to region around the globe, however there is little agreement on the pattern of sea-level rise. The results vary because there is a range of possibilities for future greenhouse gas concentrations, environmental responses, population, trade, technology and energy use.

14.3. Impacts on the Boyters Lane Wetlands

The impacts on the Boyters Lane site will be substantial, even in the next two decades, if the higher IPCC sea level projections of some 88cm total rise up until the year 2100 eventuate. Sea level may rise at up to 8mm per year from some point in the future. At the lower projected rate of rise, a little less than 1mm per year, changes will still occur, but less rapidly.

In the high sea level rise scenario, the estuarine areas are likely to increase in area, with the open water estuary advancing as mangroves move up-slope into the saltmarsh. Saltmarsh in turn will colonise the upper zones of the higher ground presently occupied by Kikuyu grass and Casuarinas (Swamp Oak). Casuarinas will be lost from the site in this case - there is no higher ground on the site except for the playing fields.

This process could accelerate over the next two decades. In this scenario, orthodox rainforest plantings would be lost well before they mature, and risk assessment would indicate that a smaller area of rainforest plantings of appropriate species is a prudent approach.

The lower rate of rise scenario is basically a continuance of the present pattern of a long term rise of about 1mm per year. The trend of mangrove colonisation of saltmarsh will continue. The impacts of a lower range sea level rise will be more significant on the lower slope zones such as saltmarsh, as seeds colonise upward into higher elevations.

Mangroves will probably maintain their deepwater boundary for several decades. Casuarinas will similarly survive for several more decades. In this scenario, there is a good argument for rainforest plantings since they may survive for 50 years or more. However, it is highly likely on present projections that within a century most of the Boyters Lane site will be predominantly saline.

15. Community Consultation

Several meetings with the community, Aboriginal people, Agencies and Council staff were held during the development of this Draft Management Plan. Meetings were held with residents Ken Shingleton and Bob Ford on site on 8th July and Ken Shingleton 9th July on site. This meeting was in conjunction with meeting Ron Kemsley from Council on the 8th July. The history of, and future plans for, the site were discussed.

Thirteen people from the local community and Council attended a meeting on site on the15th September to discuss the management options available for the property. The community consensus was general approval and support for the vision of playing fields in concert with managing and rehabilitating the wetland. However, there were concerns regarding the potential impacts on the wetland system from the use of pesticides and/or fertilisers on the playing fields. Discussions of specific sports the fields would cater for introduced the possibility of Little Athletics players using part of the site for throwing sports such as Javelin and Discus.

The management of Teal Lagoon is difficult, with no real consensus among the community present. To remove the berm would accord with the Fisheries Management Act (1994) by removing a structure that currently limits fish passage, however this is balanced by the Threatened Species Conservation Act (1995) by allowing mangroves to establish and reduce habitat area for threatened birds that frequent the site. The issue of future spring high tides possibly overtopping Boyters Lane and entering adjoining land was discussed as an effect of removing the berm.

Access paths through the wetland were discussed, with a general consensus that the original route proposal, through the wetland along the Main Berm, would produce more impacts than benefits, through the higher risk of bird disturbance and rubbish accumulation. Routes that traversed around the wetland (along Spencers Creek and Boyters Lane) were preferred. As such, the removal of the Main berm was supported.

A proposal for providing picnic facilities in concert with the proposed regeneration of the south east corner of the site and the potential for a walkway through the area was put forward. This action would provide a more accessible fishing area to Spencers Creek for both locals and visitors, which could in turn provide tourist dollars to South West Rocks. Ideas for educational signage throughout the site were discussed, as well as potential research opportunities for students.

A discussion was held with Aboriginal representatives Gary Morris and Val March at Booroongen Djugun College, Kempsey, on the 25th October regarding the Boyters Lane Wetland Management Plan. The main goals, issues and options for the site were explored, with particular emphasis on aspects of most interest to Aboriginal people. These include the return of natural conditions to the site wherever possible, the potential involvement of Aboriginal people (especially the College) in the Project such as participation in the site planning, interpretive signage, and the planting of bush tucker plants as part of revegetation efforts.

The College supports the initiative of Kempsey Council in the proposed management of the site, and is keen to partner with Council. The College teaches a relevant course unit

"Conservation and Land Management", which would be an appropriate way of including students and Aboriginal people in planning and management of the wetlands. The detailed management options for the site will be assessed and a submission would be lodged.

Gary Morris stated that his family (the Drews) had a history of use of the Boyters Lane land. The creek was also known as a productive area for fish and crabs. Support was expressed for the idea of a picnic area on the bank of Spencers Creek near the bridge, with the proviso that the potential for littering was addressed. Val March also stated as a resident of Boyters Lane that the bridge corner is a serious traffic safety hazard, and supports the installation of a turning lane as part of the road access upgrade for the playing fields.

Plate 12: Community consultation, September 15, 2004

16. The Strategy

16.1. Management Areas

Management Unit	Options			
	One	Two	Three	Four
1. Playing fields Issue: High-powered lights for training and playing at night to be installed	*Do nothing* **Positives:** No cost **Negatives:** Lights from fields impact on wetland wildlife	*Plant buffer vegetation between fields and wetland* **Positives:** Reduction in light pollution from fields. **Negatives:** Establishment cost, possible interference from trees with shorebird line-of-sight **Indicative Costs:** $10,000		
2. East edge of playing fields **Issue:** Quality and quantity of runoff from playing fields, existing Kikuyu grass	*Do nothing.* **Positives:** low cost. **Negatives:** ongoing grass management problems, nutrients and increased runoff from fields enter Teal Lagoon.	*Create stormwater wetland with buffer plantings* **Positives:** biodiversity gain, manage nutrients and peak flows from fields, maintain sight distance for waterbirds, provide a buffer between wetlands and playing fields. **Negatives:** establishment and maintenance costs, potential ASS impacts. **Indicative Costs:** $15-25,000	*Revegetate* **Positives:** some filtering of nutrients, reduces ongoing management costs, biodiversity gain. **Negatives:** reduces sight distance for waterbirds, impacts on threatened species. **Indicative Costs:** $12,500	*Encourage saltmarsh expansion* **Positives:** increased extent of endangered ecological community, biodiversity gain, improved fish habitat, low management cost. **Negatives:** establishment and short-term maintenance cost, potential ASS impacts, possible loss of saltmarsh in long-term if Teal Lagoon berm is removed or eroded, or with sea level rise. **Indicative Costs:** $3,000

Management Unit	Options			
	One	**Two**	**Three**	**Four**
3. North edge of playing fields **Issue:** Quality and quantity of runoff from playing fields, existing Kikuyu grass	*Do nothing* **Positives:** no establishment cost. **Negatives:** ongoing management cost, low biodiversity value, no biodiversity gain.	*Encourage expansion of saltmarsh* **Positives:** increased extent of endangered ecological community, biodiversity gain, improved fish habitat, low management cost. **Negatives:** establishment and short-term maintenance cost, potential ASS impacts. **Indicative Costs:** $8,000	*Create stormwater wetland* **Positives:** biodiversity gain, reduce nutrients entering estuary, maintain sight distance for waterbirds. **Negatives:** establishment costs, potential ASS impacts. **Indicative Costs:** $50,000	*Revegetate* **Positives:** some filtering of nutrients, reduces ongoing management costs, biodiversity gain. **Negatives:** Impacts on line-of-sight **Indicative Costs:** $9,000
4. Teal Lagoon **Issue:** Constructed berm is becoming degraded, reduced tidal exchange	*Do nothing* **Positives:** low cost, expansion of mangroves (medium term), improved fish habitat. **Negatives:** loss of waterbird habitat (medium term), altered biodiversity, berm failure, loss of brackish water habitat (long term), reduced educational values, impacts on threatened species habitat, uncertainty.	*Repair berm replace pipes with drop board structure - manage as brackish lagoon for waterbirds, control mangroves.* **Positives:** improved waterbird habitat, improved fish passage, reduced nutrient accumulation, educational values, no impact on threatened species. **Negatives:** cost of ongoing management, uncertainty regarding ability to exclude mangrove seedlings, cost of maintenance, risk of future berm and pipe or weir failure, lower fish passage than if berm removed. **Indicative Costs:** $40-$60,000	*Remove berm and restore fully estuarine habitat* **Positives:** low establishment cost, minimal maintenance cost, increased fish passage and fish habitat, educational values. **Negatives:** altered biodiversity, reduced waterbird values, reduced wetland diversity, impacts on threatened species habitat. **Indicative Costs:** $20,000	*Repair and Maintain Berm – stop tidal inflows to create freshwater habitat.* **Positives:** Potential increase in a wide range of habitat values, e.g. wetland plants for food and nest material **Negatives:** Reduced fish passage, altered biodiversity values, impacts on threatened species, potential weed issues (e.g. hyacinth), possible nutrient enrichment from birds. **Indicative Costs:** $30,000

Management Unit	Options			
	One	**Two**	**Three**	**Four**
5. Western elevated land	*Do nothing*	*Revegetation - mix of swamp forest and rainforest depending on elevation.*	*Construct freshwater wetland*	*Revegetate with native grasses or sedges*
Issue: Kikuyu	**Positives:** no establishment cost, maintain threatened species habitat (Grass Owl only). **Negatives:** ongoing maintenance costs, fire risk, low biodiversity, low educational value.	**Positives:** reduced fire risk, low ongoing maintenance cost, increased educational value, increased biodiversity, increased conservation value, threatened species habitat. **Negatives:** establishment costs, intensive management required initially, loss of grass owl habitat, reduced line-of-sight distance for waterbirds, potential ASS impacts. **Indicative Costs:** $50,000	**Positives:** Increased biodiversity value, maintain line-of-sight distance for waterbirds, educational value, creates threatened species habitat, complement other wetland types. **Negatives:** establishment and maintenance cost, possible ongoing weed management, removal of grass owl habitat, potential ASS impacts. **Indicative Costs:** $20,000	**Positives:** biodiversity gains, educational value, maintain line-of-sight distance for waterbirds, maintains grass owl habitat, creates threatened species habitat. **Negatives:** establishment and maintenance costs, ongoing weed management (includes *Casuarina* colonisation), potential ASS impacts. **Indicative Costs:** $10,000
6. Estuary **Issue:** Pipe on edge of site to Spencers Creek	*Do nothing* **Positives:** allow estuarine system, including mangroves to re-establish post grazing, no establishment and maintenance cost. **Negatives:** None	*Remove concrete pipe on eastern inlet.* **Positives:** restoring natural processes. **Negatives:** short term low level erosion, small cost. **Indicative Costs:** $200		

Management Unit	Options			
	One	**Two**	**Three**	**Four**
7. Central Inlet **Issue:** Main Berm is eroding, berm restricts natural tidal flows, *Juncus* has established extensively south-east of berm	*Do nothing* **Positives:** low cost, slow expansion of mangroves, increased fish passage. **Negatives:** erosion of berm (long term), difficult to predict impacts on extant saltmarsh	*Repair berm and manage tidal flows* **Positives:** maintain existing habitat, educational benefits, and maintenance of site access. **Negatives:** maintenance cost, reduced fish passage, ongoing management, possible change in habitat upstream of berm, potential ASS disturbance. **Indicative Costs:** $1,000	*Remove berm and increase tidal flows* **Positives:** improved fish passage, low cost, expansion of mangroves, possible expansion of saltmarsh, educational value. **Negatives:** possible reduction in *Juncus*, uncertainty, altered biodiversity, impacts on grass owl. **Indicative Costs:** $2,000	*Repair and Maintain Berm – stop tidal inflows to create freshwater habitat.* **Positives:** Potential increase in a wide range of habitat values, e.g. wetland plants for food and nest material **Negatives:** Reduced fish passage, altered biodiversity values, impacts on threatened species, loss of saltmarsh. **Indicative Costs:** $1,000
8. *Central elevated land* **Issue:** Kikuyu grass, fire risk	*Do nothing* **Positives:** no establishment cost, maintain Grass Owl habitat. **Negatives:** ongoing maintenance costs, fire risk, low biodiversity, low educational value.	*Revegetation - mix of swamp forest, sedges and rainforest depending on elevation.* **Positives:** solves issue of fire and ongoing maintenance, increased educational value, increased biodiversity, and increased conservation value. **Negatives:** establishment costs, intensive management required initially, impacts on grass owl habitat. **Indicative Costs:** $57,500		

Management Unit	Options			
	One	**Two**	**Three**	**Four**
9. Eastern Inlet **Issue:** Freshwater influences, Main Berm restricts saltwater flows, one existing 150mm PVC pipe in berm	*Do nothing* **Positives:** no establishment cost, increased fish passage should berm fail (long-term). **Negatives:** possible berm/pipe failure (long term), reduction of waterbird habitat, reduced wetland diversity, uncertainty.	*Repair berm and maintain existing tidal exchange* **Positives:** ensures that existing management regime is maintained, educational value of another wetland type. **Negatives:** restricting extent of saltmarsh and mangroves, ongoing maintenance of berm, restricted fish passage, potential ASS impacts from berm disturbance. **Indicative Costs:** $1,000	*Remove berm - increase tidal exchange.* **Positives:** low establishment cost, increased fish passage, possible expansion of mangroves, possible expansion of saltmarsh. **Negatives:** reduction of waterbird habitat, reduced wetland diversity, reduced educational value, uncertainty, potential ASS impacts from berm soil disturbance, threatened species impacts. **Indicative Costs:** $2,000	*Repair berm and stop tidal inundation – create freshwater habitat* **Positives:** increased wetland diversity, educational values, returns to previous management regime as freshwater wetland (although not the natural condition). **Negatives:** establishment cost, altered biodiversity, loss of fish habitat, loss of saltmarsh, potential ASS impacts from berm soil disturbance. **Indicative Costs:** $1,000
10. East elevated land **Issue:** Kikuyu grass, fire risk, remnant swamp forest	*Do nothing* **Positives:** no establishment cost, maintain Grass Owl habitat. **Negatives:** ongoing maintenance costs, fire risk, low biodiversity, low educational value.	*Revegetation - mix of swamp forest and rainforest depending on elevation.* **Positives:** solves issue of fire and ongoing maintenance, increased educational value, increased biodiversity, increased conservation value. **Negatives:** higher establishment costs, intensive management required initially, impacts on grass owl habitat. **Indicative Costs:** $77,500		

Management Unit	Options			
	One	**Two**	**Three**	**Four**
11. Roadside vegetation **Issue:** Existing grass and sedges are slashed, thin screen of trees at end of Teal Lagoon	*Do –nothing* **Positives:** low cost. **Negatives:** potential disturbance impacts on wetlands from passing traffic, reduced bird habitat, possible increase in road strike.	*Maintain thick vegetation and plant screen between pedestrian access and wetlands/vegetation.* **Positives:** reduces disturbance impacts, maintains biodiversity values. **Negatives:** establishment costs. **Indicative Costs:** $1,000	*Regular slashing and maintenance.* **Positives:** improved visibility for pedestrians and motorists. **Negatives:** loss of bird habitat, possible increase in road strike, no buffer to wetland, increased disturbance impacts. **Indicative Costs:** $100/month	*Maintain, but alter roadside vegetation, by removing mangroves, planting screen & encouraging native rushes* **Positives:** reduced management cost associated with Teal Lagoon (reduction in mangrove propagules to the lagoon), maintain dense screen for waterbirds, reduced disturbance impacts, maintain buffer to wetland. **Negatives:** removal of mangroves, increased level of Environmental Impact Assessment **Indicative Costs:** $1,100

16.2. Facilities

Type of Facility	Options			
	One	Two	Three	Four
1. Playing fields lights **Issue:** High-powered lights for training and playing at night to be installed	*Do nothing* **Positives:** No cost **Negatives:** Intense lights from fields impact on wetland wildlife	*Ensure lights are 'environmental' Type D* **Positives:** Reduction in light pollution from fields. **Negatives:** Cost		
2. Pedestrian access **Issue:** Need for public access to playing fields as well as wetlands	*Do nothing* ***Positives:** no cost, no impacts on biodiversity values.* **Negatives:** under-utilising an important community asset, reduced community awareness and education.	*Central access track with bridge over Spencers Creek* **Positives:** encourages people to move through the wetland, education and community awareness. **Negatives:** impacts on wetland biodiversity, litter disposal, access by pest species (dogs, cats), high establishment cost, high level of disturbance, potential ASS impacts from bridge and consolidating Main Berm. **Indicative Costs:** $363,400	*Eastern access track with bridge over Spencers Creek. Track traverses revegetated land and edges of wetlands.* **Positives:** encourages people to move through the wetland without impacts on wetland values, education and community awareness. **Negatives:** high cost of bridge and path construction and maintenance, encourages use by people not interested in the wetland, potential ASS impacts from bridge, access by pest species, disturbance of birds. **Indicative Costs:** $304,420	*Road-side access track across the existing road bridge and along the edge of Boyters Lane, with loop track/s through revegetated habitat and wetlands.* **Positives:** lower bridge cost, ensures that wetland walkway is used more for educational purposes than for playing field access, lower impacts on wetland biodiversity, improved educational value. **Negatives:** higher cost associated with path construction, pest species. **Indicative Costs:** $54,500-$84,705

Type of Facility	Options			
	One	**Two**	**Three**	**Four**
3. Bird Hides **Issue:** Potential for community enjoyment and education in environmental values	*Do nothing* **Positives:** low cost. **Negatives:** lower educational values, encourage people to move closer to birds possibly increasing disturbance.	*Construct one bird hide near Teal Lagoon.* **Positives:** increased educational value, allows for ongoing use of the wetland by bird watchers. **Negatives:** establishment and maintenance costs, potential vandalism. **Indicative Costs:** $5-10,000	*Construct two or more bird hides* **Positives:** provides additional viewing opportunities. **Negatives:** additional construction and maintenance expense, potential vandalism. **Indicative Costs:** $10-20,000	
4. Interpretive signage **Issue:** Potential for explanation of the environment increases enjoyment and understanding	*Do nothing* **Positives:** no expenditure required. **Negatives:** does not satisfy educational aims, under-utilises an important community resource.	*Provide interpretive signage at key locations along the walking track and at viewing platform/s, bird hide/s etc.* **Positives:** Assists with the education of students and the community, ensures that unguided groups gain knowledge about wetlands, potential to involve Aboriginal people. **Negatives:** establishment and maintenance costs. **Indicative Costs:** $3,000		

Type of Facility	Options			
	One	**Two**	**Three**	**Four**
5. Viewing Platform **Issue:** Opportunity for better observations of wetlands	*Do nothing* **Positives:** no cost, no risk of ongoing disturbance impacts. **Negatives:** reduced educational experience, under-utilised resource.	*Construct one viewing platform near the southern end of the central inlet and the constructed wetland.* **Positives:** Enhanced educational experience. **Negatives:** establishment and maintenance costs, risk of disturbance to waterfowl, potential vandalism. **Indicative Costs:** $2,500-$3,000	*Construct two or more platforms.* **Positives:** Enhanced educational experience. **Negatives:** establishment and maintenance costs, risk of disturbance to waterfowl, potential vandalism. **Indicative Costs:** $5-10,000	
6. Vehicle control **Issue:** Increased vehicle presence along Boyters Lane	*Do nothing* **Positives:** no additional costs. **Negatives:** ongoing impact of vehicle strike on birds crossing Boyters Lane.	*Integrate traffic calming devices into road design.* **Positives:** reduced road strike. **Negatives:** increased cost, risk of injury to drivers.	*Enforce a 40km/hr speed zone and install signage.* **Positives:** reduced risk of road strike, lower costs, lower risk of injury to public. **Negatives:** establishment cost	
7. Picnic facilities **Issue:** Opportunity for community to enjoy creek-side environment	*Do nothing* **Positives:** no establishment or maintenance cost. **Negatives:** reduced community use, reduced educational experience, impacts from informal use.	*Provide picnic facilities near the southeastern corner of the site* **Positives:** enables management of recreational use, reduced impacts, enhanced wetland and creek experience **Negatives:** establishment and maintenance cost, possible disturbance impacts unless facilities are appropriately designed, increased need for other facilities such as toilets. **Indicative Costs:** $2,000 each		

17. Research Opportunities

The provision of funds for research students can often be limited as allocation for studies is not normally a component of Council budgets. However, if Council is prepared to allocate modest funding in future, as well as seek funding from other sources (see Section 18 Funding Opportunities), a greater understanding of the Boyters Lane wetland, and coastal wetlands in general, would ensue.

Prior student research projects such as the Environmental Audit by Walker *et. al.* (2004) should be followed up. Councils staff could write to appropriate universities (e.g. University of New England, Southern Cross University, Newcastle University) with a description of the site and project, and the potential research opportunities, along with a statement of the matching services or resources Council could supply such as transport, GIS data, and survey.

There are various one-off and ongoing research subjects possible on the Boyters Lane site. For example, the ongoing monitoring of habitat change within the Central Inlet following the removal of a section of the Main Berm; studies on the Grass Owl and the species' use of the site; techniques for revegetation in low-lying landscapes; fish passage, and water quality, in Teal Lagoon; and monitoring runoff from the playing fields, are just some of the research opportunities available on this project.

The Booroongen Djugun College in Kempsey conducts a Conservation and Land Management course. This would provide a good opportunity for teaching students about natural resource management issues, with biological, hydrological and social aspects.

18. Funding Opportunities

Funding can be made or sought more easily once a management plan is in place, allowing clearly-defined actions or on-ground works to be presented to a funding body for consideration.

There are various Federal and State programs available to both community and local government groups. For example, **Envirofund** is the community component of the $3 billion Natural Heritage Trust. Through Envirofund, community groups and individuals can apply for grants of a few hundred dollars up to $30,000 to tackle local environmental and natural resource management problems. Typical Envirofund projects include tree planting, fencing, weeding and seed collecting. They also include training and education activities to help community groups improve their knowledge about the environment and sustainable agriculture. The Australian Government invests $20 million in two Envirofund rounds each year, which are held approximately six months apart.

The **Fisheries Action Program** develops awareness among all resource users and the wider community of fisheries issues, the sources of fisheries habitat problems and the actions required to remedy them. It also develops a sense of ownership in fisheries resources by all user groups, and responsibility for their sustainable use. Participation in fish habitat rehabilitation and aquatic pest identification by direct users of the resource is encouraged, as well as the enhancement of sustainable resource use by fishers and 'upstream' groups through ensuring that impacts on fish resources and habitats are considered in their processes, plans and actions.

The **National Landcare Program** supports projects that contribute to an integrated program of sustainable management of land, water, vegetation and biological diversity. The Program supports collective action by communities to manage natural resources sustainably, in partnership with government. Achieving sustainable agriculture is a major environmental goal for Australia. The Program encourages on-ground action that will result in integrated and sustainable natural resource management at the farm, catchment and regional level. Support will be provided for the development of locally initiated and managed projects addressing critical issues on public and private land for the public benefit.

Implementation of the Northern Rivers Catchment Management Authority's **Catchment Blueprint** is also likely to deliver significant funding over the next decade as investment in natural resource management.

A recreational fishing licence is required to fish in NSW, and revenue raised from licence sales is used in community programs to promote sustainable fishing and research under the **Saltwater and Freshwater Recreational Fishing Trusts**. Habitat restoration can also be funded by the Fishing Trusts.

Section 94 plans, pursuant to c.94 of the *EP&A Act 1979*, allows for collections of funds for the provision, augmentation and embellishment of regional structured and casual open space. Within Kempsey Shire, Section 94 contributions are sourced from facilities such as roads and trunk stormwater drains within new development areas. There is scope to expand to include the upgrading required as a result of the new development in the existing infrastructures. Council may also consider the introduction of a Section 94 Plan for community facilities, which would raise funds for appropriate works (KSC, undated).

Conservation Volunteers carry out projects such as tree planting, seed collection, protection of endangered species, flora and fauna surveys, walking trail construction and maintenance, fencing and environmental monitoring. Projects must be designed to preserve, protect and restore Australia's natural environment, indigenous or historical cultural heritage, and to encourage a sense of ownership of projects.

Green Corps provides young people aged between 17 and 20 years of age with the opportunity to demonstrate their commitment to preserve and restore Australia's environment and heritage. It is a voluntary, transitional youth development scheme designed to provide participants with personal and skill development and improved connections with their community.

Green Reserve involves Australian's between the ages of 40 and 65 who receive the full rate of Newstart allowance in local conservation projects. Working in small teams, Green Reserve volunteers contribute 2 days a week for 26 weeks to the project.

There is also the potential to use the services of day-release prisoners from the new gaol, proposed to be situated near Kempsey, for some maintenance tasks such as mangrove seedling removal, and planting maintenance.

19. Further Investigations

- A comprehensive assessment of the presence of acid sulfate soils where any works are to be carried out (e.g. Playing Fields, stormwater wetland, Central freshwater wetland, walkway, sewer lines) should be conducted before any works start on the site. A management plan for ASS should result from this assessment.

- A vegetation management plan, with a projected cost of about $5000 would be commissioned from contractors. Contractors who are familiar with the area and can demonstrate local experience should be sought.

- Monitoring of physico-chemical parameters in Teal Lagoon.

- More detailed survey of areas the site proposed for management actions, to 100mm contours.

- Liaise with regional universities to encourage research into fish and invertebrate communities on the site. Research could also consider how alterations to tidal exchange would influence fish passage.

20. Conclusions and Recommendations

- The Boyters Lane site can be successfully rehabilitated and managed over time as productive and biologically diverse wetlands, alongside the construction and use of playing fields on the 6ha of land allocated in the southwestern portion.

- Council's responsibilities in relation to the site are defined as: compliance with relevant legislation and policy; and management of the site according to Ecologically Sustainable Development principles with particular focus on protecting and enhancing the biodiversity values of the site.

- The rehabilitation and restoration of the site will be best undertaken by staging the adopted works program, and by following an adaptive management approach, that is, adjust the works program over time in the light of the new information that should flow from each stage implemented.

- To minimise impacts on the wildlife, the playing fields should be designed to (i) allow minimal flood-light illumination of the rest of the site by installing the correct light type, and a screen of trees, and (ii) allow efficient but site-sensitive drainage ideally through a constructed stormwater wetland.

- The original concept proposal of a footbridge across Spencers Creek linking with access across the Main Berm that traverses the three estuarine embayments incurs several severe constraints. We recommend elimination of this proposal, with alternative access routes to be installed.

- Environmental education can be integrated into the project through provision of access paths, viewing platforms and a bird hide, and interpretive signage, along with site tours by ecologists and Council staff.

- Much of the lower-lying area of the site appears to be unsuitable for most rainforest species. Revegetation of the site is likely to be most effective as a mix of strategies including natural revegetation of the swamp forest association that was probably native to the lower elevations of the site; planting of selected rainforest species in trials on higher ground and around the playing fields; sedges and native grasses on specific zones near sensitive bird habitats; and saltmarsh extension where practical.

- The three inlets or embayments on the site have been severely modified by changed hydrology and the resultant vegetation responses. The berm used to control their hydrology is now deteriorating, and berm repair introduces high costs and potential site damage. Following assessment of each berm and inlet, it is recommended (i) to remove the Central Inlet berm and allow full estuarine conditions to develop, and (ii) to retain the Eastern Inlet berm structure in place whilst observing the impacts of removing the Central Berm.

- The complex problem of deciding whether and how to manage Teal Lagoon in the short to medium term as a continuing site of high waterbird value, or to remove the berm in the interests of a rapid return to natural conditions, is a philosophical issue more than scientific. The issue must be resolved by community and government together considering and deciding based on the balance of benefits and losses associated with

each option, in particular the almost certain loss of the substantial waterbird values by removing the berm.

- Impacts on grass owls would be minimised by staging the revegetation works, restoring one area of degraded grassland to sedgeland and retaining extant saltmarsh habitat.

21. References

ASGAP (The Association of Societies for Growing Australian Plants) (2004) (http://farrer.csu.edu.au/ASGAP/).

Atkinson, G. (1999) *Soil Landscapes of the Kempsey-Korogoro Point 1:100 000 Sheet*, NSW Department of Land and Water Conservation.

Australian Greenhouse Office (2004) Fact Sheet, *Global Warming in the 20th Century*. Department of Environment and Heritage (http://www.greenhouse.gov.au/index.html)

CSIRO (2004) *Global sea-level rise*. CSIRO Marine Research, Australia. (http://www.marine.csiro.au/LeafletsFolder/45slevel/45.html)

DEH (2004) "Mangroves and Saltmarshes – Muddy Management" in *Wetlands Australia* newsletter, Department of Environment and Heritage, Canberra.

DIPNR (2004) Macleay River http://www.dlwc.nsw.gov.au/care/water/estuaries/Inventory/macleay.html)

Dwyer, P. (2002) *Floodgate Design Workshop - Proceedings*. Workshop, Ballina, Northern NSW, August 14th 2002.

Eddie, M.W., (2000) *Soil Landscapes of the Macksville-Nambucca 1:100 000 Sheet*, NSW Department of Land and Water Conservation.

Floyd, A.G. 1990. *Australian Rainforests in New South Wales, Volumes 1 and 2.* NSW National Parks and Wildlife Service. Surrey Beatty and Sons, Chipping Norton.

Greening Australia (1999) Management Principles To Guide The Restoration And Rehabilitation Of Indigenous Vegetation. Report prepared by the Technical Sub-committee, Greening Australia (NSW) Board.

IPCC (2001) *Climate Change 2001: The Scientific Basis*. Third Assessment Report, Intergovernmental Panel on Climate Change. World Meteorological Organization and United Nations Environment Programme.

Kempsey Shire Council (1987) *Kempsey Local Environment Plan 1987 as amended*, Kempsey Shire Council, Kempsey, NSW.

KSC (undated) *Future Infrastructure Planning for South West Rocks*, Kempsey Shire Council.

Low, T (1988); Wild Food Plants of Australia, Angus and Robertson, Sydney.

Macleay Water (2004) *Review of Environmental Factors: Proposed Development of Vacuum Sewer System and Pump Station for Jerseyville Area*, Prepared for Kempsey Shire Council.

MacDonald, T. (2003) Protection and Management of Saltmarsh in NSW – a NSW Fisheries perspective. In Straw, P. (ed) *Status and Management of Migratory Shorebirds in Sydney*, Sydney Olympic Park Authority.

MNCCMB (2002) *Integrated Catchment Management Plan for the Mid North Coast Catchment*, Mid North Coast Catchment Management Board, NSW Department of Land and Water Conservation.

Nambucca Valley Landcare (Undated) Riverbank Restoration for the Nambucca River Estuary. A Decision Making Guide. Phone 02 65647838.

NSW Government (1992) *Estuary Management Manual*. NSW Government, Sydney.

NSW Government (1996) *The NSW Wetlands Management Policy*. NSW Department of Land and Water Conservation, Sydney.

NSW Government (1997) *NSW Coastal Policy 1997*. NSW Government, Sydney.

Pierson, W.L., Bishop, K., Van Senden, D., Horton, P.R. and Adamantidis, C.A. (2002) *Environmental Water requirements to Maintain Estuarine Processes*. Environmental Flows Initiative Technical Report, No. 3. Environment Australia, Canberra.

Raine, A. and Gardner, J. (1997). *Revegetating Streams in the Macleay Catchment. A Guide to Species and Planting Methods*. NSW Dept of Land and Water Conservation, Landcare Australia, Land and Water Resources Research and Development Corporation.

RFS (2001) *Planning for Bushfire Protection: A Guide for Councils, Planners, Fire Authorities, Developers and Home Owners*. NSW Rural Fire Service and Planning NSW, Sydney.

Roy, P. S., Williams, R. J., Jones, A. R., Yassini, I., Gibbs, P. J., Coates, B., West, R. J., Scanes, P. R., Hudson, J. P. and Nichol, S. (2001) Structure and Function of South-east Australian Estuaries. *Estuarine, Coastal and Shelf Science*; **53**, 351-384.

Saenger, P.E. (1994) Mangroves and saltmarshes, *In* Hammond, L.S and Synnot, R.N. (eds) *Marine Biology*, Longman Cheshire, Melbourne.

Saintilan, N. and Rogers, K. (2002) The Declining Saltmarsh Resource, In *Coast to Coast 2002 Conference Proceedings*, Coastal CRC, Australia. Held Tweed Heads, NSW

Tulau, M.J. (2002) *Agricultural Drainage in Acid Sulfate Soil Backswamps in New South Wales, Australia - Technical, Regulatory and Policy Responses.* Department of Land and Water Conservation, Sydney.

Tulau, M.J. and Naylor, S.D. (1999) *Acid Sulfate Soil Management Priority Areas in the Lower Macleay Floodplain*. Report. Department of Land and Water Conservation, Sydney.

Walker, G., Bromhead, B. and Kinsela, A. (2004) *Boyters Lane Wetland Audit*, Prepared for Kempsey Shire Council.

Wood, M. (2002) *Floodgate Design Workshop - Proceedings*. Workshop, Ballina, Northern NSW, August 14th 2002.

Appendix 1

Complete bird list of sightings at or near the Boyters Lane site. Sightings by Mr Ken Shingleton, June 1991 to April 2004.

Species Name	Common Name	Species Name	Common Name
Coturnix pectoralis	Stubble Qual	*Lopholaimus antarcticus*	Topknot Pigeon
Coturnix ypsilophora	Brown Quail	*Calyptorhynchus lathami*	Glossy Black-Cockatoo
Dendrocygna eytoni	Plumed Whistling-Duck	*Cacatua roseicapilla*	Galah
Oxyura australis	Blue-billed Duck	*Cacatua tenuirostris*	Long-billed Corella
Cygnus atratus	Black Swan	*Cacatua sanguinea*	Little Corella
Chenonetta jubata	Australian Wood Duck	*Cacatua galerita*	Sulphur Crested Cockatoo
Anas superciliosa	Pacific Black Duck	*Trichoglossus haematodus*	Rainbow Lorikeet
Anas rhynchotis	Australasian Shoveler	*Trichoglossus chlorolepidotus*	Scaly-Breasted Lorikeet
Anas gracilis	Grey Teal	*Platycercus eximius*	Eastern Rosella
Anas castanea	Chestnut Teal	*Cuculus pallidus*	Pallid Cuckoo
Malacorhynchus membranaceus	Pink-eared Duck	*Cacomantis variolosus*	Brush Cuckoo
Aythya australis	Hardhead	*Cacomantis flabelliformis*	Fan-Tailed Cuckoo
Tachybaptus novaehollandiae	Australasian Grebe	*Chrysococcyx basalis*	Horsefields Bronze Cuckoo
Poliocephalus urinatrix	Hoary-headed Grebe	*Chrysococcyx lucidus*	Shinning Bronze Cuckoo
Anhinger melanogaster	Darter	*Eudynamys scolopacea*	Common Koel
Phalacrocorax melanoleucos	Little Pied Cormorant	*Scythrops novaehollandiae*	Channel Billed Cuckoo
Phalacrocorax sulcirostris	Little Black Cormorant	*Centropus phasianinus*	Pheasant Coucal
Phalacrocorax carbo	Great Cormorant	*Hirundapus caudacutus*	White-Throated Needletail
Pelecanus conspicillatus	Australian Pelican	*Dacelo novaeguineae*	Laughing Kookaburra
Egretta novaehollandiae	White-faced Heron	*Todiramphus pyrrhopygia*	Red-backed Kingfisher
Egretta garzetta	Little Egret	*Todiramphus sanctus*	Sacred Kingfisher
Ardea pacifica	White-necked Heron	*Merops ornatus*	Rainbow Bee-eater
Ardea alba	Great Egret	*Eurystomus orientalis*	Dollarbird
Ardea intermedia	Intermediate Egret	*Malurus cyaneus*	Superb Fairy Wren
Ardea ibis	Cattle Egret	*Malurus lamberti*	Varigated Fairy Wren
Nycticorax caledonicus	Nankeen Night Heron	*Malurus melanoc ephalus*	Red-Backed Fairy Wren
Botaurus poicilopilus	Ausralasian Bittern	*Pardalotus striatus*	Striated Pardalote
Plegadis falcinellus	Glossy Ibis	*Gerygone mouki*	Brown Gerygone
Threskiornis molucca	Australian White Ibis	*Gerygone levigaster*	Mangrove Gerygone
Threskiornis spinicollis	Straw-necked Ibis	*Acanthiza pusila*	Brown Thornbill
Platalea regia	Royal Spoonbill	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill
Platalea flavipes	Yellow-billed Spoonbill	*Acanthiza nana*	Yellow Thornbill
Ephippiorhynchus asiaticus	Black-necked Stork	*Anthochaera carunculata*	Red Wattlebird
Pandion haliaetus	Osprey	*Anthochaera chrysoptera*	Little Wattlebird
Aviceda subcristata	Pacific Baza	*Acanthagenys rufogularis*	Spiney-cheecked Honeyeater
Elanus axillaris	Black-Shouldered Kite	*Plectorhyncha lanceolata*	Striped Honeyeater
Lophoictinia isura	Square-tailed Kite	*Philemon corniculatus*	Noisy Friarbird
Haliaster sphenurus	Whistling Kite	*Philemon citreogularis*	Little Friarbird
Haliaster indus	Brahminy Kite	*Manorina melanocephala*	Noisy Miner
Haliaeetus leucogaster	White-Bellied Sea Eagle	*Meliphaga lewinii*	Lewins Honeyeater
Circus approximans	Swamp Harrier	*Lichenostomus chrysops*	Yellow-faced Honeyeater

Species Name	Common Name	Species Name	Common Name
Accipiter fasciatus	Brown Goshawk	*Lichmera indistincta*	Brown Honeyeater
Accipiter cirrhocephallus	Collared Sparrowhawk	*Phylidonyris nigra*	White-Cheecked Honeyeater
Aquila audax	Wedge-tailed Eagle	*Acanthorhynchus tenuirostris*	Eastern Spinebill
Hieraaetus morphnoides	Little Eagle	*Myzomela sanguinolenta*	Scarlet Honeyeater
Falco longipennis	Australian Hobby	*Pachycephala pectoralis*	Golden Whistler
Falco peregrinus	Peregrine Falcon	*Pachycephala rufiventris*	Rufous Whistler
Falco cenchroides	Nankeen Kestrel	*Colluricincla harmonica*	Grey Shrike Thrush
Grus rubicunda	Brolga	*Myiagra rubecula*	Leaden Flycatcher
Gallirallus philippensis	Buff-Banded Rail	*Myiagra cyanoleuca*	Satin Flycatcher
Rallus pectoralis	Lewins Rail	*Grallina cyanoleuca*	Magpie-lark
Porzana fluminea	Australian Spotted Crake	*Rhipidura rufifrons*	Rufous Fantail
Porzana tubuensis	Spotless Crake	*Rhipidura fuliginosa*	Grey Fantail
Porphyrio porphyrio	Purple Swamphen	*Rhipidura leucophrys*	Willie Wagtail
Gallinula tenebrosa	Dusky Moorhen	*Dicrurus bracteatus*	Spangled Drongo
Fulica atra	Eurasian Coot	*Coracina novaehollandiae*	Black-Faced Cuckoo Shrike
Gallinago hardwickii	Latham's Snipe	*Lalage suerii*	White-winged Triller
Limosa limosa	Black-tailed Godwit	*Oriolus sagittatus*	Olive Backed Oriole
Limosa lapponica	Bar-tailed Godwit	*Sphecotheres viridis*	Figbird
Numenius minutus	Little Curlew	*Artamus leucorynchus*	White-Breasted Woodswallow
Numenius phaeopus	Whimbrel	*Cracticus torquatus*	Grey Butcherbird
Numenius madagascariensis	Eastern Curlew	*Cracticus nigrogularis*	Pied Butcherbird
Tringa stagnatilis	Marsh Sandpiper	*Gymnorhina tibicen*	Australian Magpie
Tringa nebularia	Common Greenshank	*Strepera grucelena*	Pied Currawong
Tringa glareola	Wood Sandpiper	*Corvus tasmanicus*	Forest Raven
Actitis hypoleucos	Common Sandpiper	*Corvus orru*	Torresian Crow
Calidris canutus	Red Knot	*Sericulus chrysocephalus*	Regent Bowerbird
Calidris ruficollis	Red-necked Stint	*Anthus novaeseelandiae*	Richard's Pipit
Calidris acuminata	Sharp-tailed Sandpiper	*Neochima temporalis*	Red-Browed Finch
Calidris ferruginea	Curlew Sandpiper	*Lonchura castaneothorax*	Chestnut-Breasted Mannikin
Irediparra gallinacea	Comb-crested Jacana	*Dicaeum hirundinaceum*	Mistletoebird
Mimantopus himantopus	Black-winged Stilt	*Hirundo neoxena*	Welcome Swallow
Pluvialis fulva	Pacific Golden Plover	*Hirundo nigicans*	Tree Martin
Elseyornis melanops	Black-fronted Dotterel	*Hirundo ariel*	Fairy Martin
Erythrogonys cinctus	Red-kneed Dotterel	*Acrocephalus stentoreus*	Clamorous Reed-Warbler
Vanellus miles	Masked Lapwing	*Megalurus timoriensis*	Tawny Grassbird
Larus novaehollandiae	Silver Gull	*Megalurus gramineus*	Little Grassbird
Streptopelia chinensis	Spotted Turtle Dove	*Cristicola exilis*	Golden-Headed Cisticola
Columba leucomela	White-Headed Pigeon	*Zosterops lateralis*	Silvereye
Ocyphaps lophotes	Crested Pigeon	*Sturnus vulgaris*	Common Starling
Geopelia striata	Peaceful Dove	*Acridotheres tristis*	Common Myna
Geopelia humeralis	Bar Shouldered Dove		

Appendix 2

1. Acid Sulphate Soils Report
2. Water Quality Report
3. Sediment Size and Texture Analysis

RESULTS OF ACID SULPHATE SOIL ANALYSIS (Page 1 of 1)

1 sample supplied by Australian Wetlands on 27th October, 2004 - Lab. Job No. E2867
Analysis requested by David Pont.

Sample Site	Texture (note 9)	Reduced Inorganic Sulphur (% chromium reducible S) (%Scr) (note 2)	TAA pH	Total Actual Acidity (TAA) mole / Kg	Lab. Bulk Density tonne DW/m^3	Potential Acidity Neutralising Calculation Kg Lime/m^3 (based on %Scr)	Actual Acidity Neutralising Calculation Kg Lime/m^3 (based on TAA)	Neutralising of Actua and Potential ASS Kg Lime/m^3 (see note 10)	COMMENTS RE: Classification as actual or potential acid sulphate soil (ASS) (based on %Scr results)
Boyters Soil	Medium	0.002	4.58	0.025	1.34	0.1 Refer Note 6 & 7	1.6 Refer Note 6 & 7	1.7 Refer Note 6, 7 & 10	**NOT** Actual or Potential ASS

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2 - Samples analysed by **POCAS method** (ie Peroxide Oxidation - Combined Acidity and Sulphate - Version 3 updated published method) and **'Chromium Reducible Sulphur' technique** (Scr - Method 22B)

3 - Methods from Stone, Y. Ahern CR, and Blunden B (1998). **Acid Sulphate Soil Manual 1998.** ASSMAC, Wollongbar, NSW.

4 - Total carbon and total sulphur determined using a LECO CNS 2000 analyser

5 - Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)

6 - Neutralising Requirement (based on NAGP, chromium reducible sulphur **or** total sulphur) = Kg H_2SO_4/tonne x bulk

7 - The neutralising requirement does not include a safety margin for complete neutralisation (a factor of 1.5 is often recommended)

8 - Conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm

9 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays

10 - Neutralisation Calculation for neutralisation of actual and potential acidity (ie. sum of calculation based on Crs and TAA)

11 - ANC= Acid Neutralising Capacity of the Soil (Detection limit of 0.05% $CaCO_3$ Equivalent)- (this procedure is currently NOT NATA registe

12 - NAGP= Net Acid Generating Potential= (31.3*%S_{ox})-(10*%ANC) (From Mulvey, 1993)

Laboratory Accreditation No.: 14960

(Classification of potential acid sulphate material if: coarse Scr=0.03%S; medium Scr=0.06%S; fine Scr=0.1%S)

(equivalent conversions - 0.03%S = 0.019 mole/ Kg; 0.06%S = 0.037 mole/ Kg; 0.1%S = 0.062 mole/ Kg)

* Projects that disturb >1000 tonnes of ASS soils with =0.03% S, a detailed management plan may be required.

checked: .....

RESULTS OF WATER ANALYSIS (Page 1 of 1)

1 sample supplied by Australian Wetlands on the 27th October, 2004 - Lab. Job No. E2866

Analysis requested by David Pont.

PARAMETER	METHODS REFERENCE	Sample 1 Boyters Water
	Job No.	*E2866/1*
pH	APHA 4500-H^+-B	7.64
CONDUCTIVITY (EC) (dS/m)	APHA 2510-B	20.60
TOTAL DISSOLVED SALTS (mg/L)	calculation using EC x 680	14,008
CHLOROPHYLL 'a' (mg/L)	** APHA 10200-H	0.131
SALINITY (ppt)	SALINITY METER	12.8

Notes:

1. Total Available metals - samples acidified with nitric acid and then filtered through 0.45µm cellulose acetate
2. 1 mg/L (milligram per litre) = 1 ppm (part per million) = 1000 µg/L (micrograms per litre)= 1000 ppb (part per billion)
3. For conductivity - 1 dS/m = 1 mS/cm = 1000 µS/cm
4. Analysis performed according to APHA, 1998, "Standard Methods for the Examination of Water & Wastewater", 20th Edition, except where stated otherwise.
5. Analysis conducted between sample arrival date and Report provision date
6. ** denotes these test procedures are as yet not NATA registered but quality control data is available

checked: .....

Head Office:
16 Greenway Drive, Tweed Heads South
Telephone: (07) 5570 3799
Fax: (07) 5574 3523
ALL CORRESPONDENCE:
PO Box 6146
Tweed Heads South NSW 2486
Email: info@bordertech.com.au
Web Site: www.bordertech.com.au

QLD BRANCH:
1/39 Old Pacific Highway Yatala Qld
Telephone: (07) 3804 6044
Fax: (07) 3804 6866
ALL CORRESPONDENCE:
PO Box 6146
Tweed Heads South NSW 2486
Email: QLDmail@bordertech.com.au
Web Site: www.bordertech.com.au

BORDER-TECH

GEOTECHNICAL ENGINEERING SERVICES

ABN 22 379 074 308

SOIL TESTING LABORATORIES • COMPACTION CONTROL • FOUNDATION DRILLING & ENGINEERING DESIGN

DB:db:BT 13677

12 August 2004

Australian Wetlands
70 Butler Street
Byron Bay NSW 2482

Attention: David Pont

Dear Sir,

Re: Indicative Permeability of Supplied Sample

As requested we have assessed the sample supplied on 27 July to provide an indicative measure of permeability.

Testing of the sample included;

1. Textural classification in accordance with AS/NZS 1547:2000 Table 4.1D1.
2. Particle size distribution analysis in accordance with 1289 3.6.1.

Textural classification indicated that the material is a Fine Sandy Clay LOAM with a massive to weak structure. Clay content of this material is typically 20 – 30%, and AS/NZS 1547:2000 suggests an indicative permeability of 0.06 – 0.5 metres per day.

Particle size distribution analysis confirmed the results of the textural classification. The attached test results indicate that the sample is comprised of fine sand, silt and clay.

Should you require any further information or clarification please do not hesitate to contact this office.

Yours faithfully
For and on behalf of
BORDER - TECH

David Bayel
Environmental Scientist

Head Office & Engineering:
Unit 13 Corporate House
Corporation Circuit Tweed Heads South
Telephone: (07) 5524 8199
Fax: (07) 5524 8533

Postal: PO Box 6340
Tweed Heads South NSW 2486
Email: info@bordertech.com.au
Web Site: www.bordertech.com.au

BORDER-TECH

GEOTECHNICAL ENGINEERING SERVICES

ABN 22 375 074 338

4/ 2 Greenway Drive Tweed Heads South
Telephone: (07) 5524 8149
Fax: (07) 5523 1465
Email: lab@bordertech.com.au
Beenleigh Laboratory:
1/3a Old Pacific Highway Yatala
Telephone: (07) 3804 6844
Fax: (07) 3804 6866
Email: qlb@bordertech.com.au

SOIL TESTING LABORATORIES • FOUNDATION DRILLING • ENGINEERING DESIGN • ENVIRONMENTAL SERVICES

PARTICLE SIZE DISTRIBUTION

CLIENT :	AUSTRALIAN WETLANDS				
CLIENT ADDRESS:	70 BUTLER STREET BYRON BAY NSW 2482				
PROJECT :	SAMPLE AS DELIVERED				
REPORT No:	22730	DATE ISSUED:	6/8/04	JOB No:	BT 13677

TEST DATA

Sample Number	57121			
Date Sampled	29/7/04			
Date Tested	4/8/04			
Test Location and Level	As Per Delivered Sample			
Test Site Selected By	Client			

PARTICLE SIZE DISTRIBUTION RESULTS

		% Passing	% Passing	% Passing	% Passing
Sieve Size -	53.0 mm				
	37.5 mm				
	26.5 mm				
	19.0 mm				
	13.2 mm				
	9.5 mm				
	4.75 mm				
	2.36 mm				
	1.18 mm				
	600 micron	100			
	425 micron	99			
	300 micron	99			
	150 micron	83			
	75 micron	75			

Test Methods: AS1289 3.6.1

Note: The tests reported have been carried out by our Tweed Heads Laboratory.

T. Dick
Quality Assurance Manager

Authorised Signatory

Appendix 3

Boyters Lane Wetlands and Playing Fields Management Plan – Fauna Component

Report by Sandpiper Environmental

BOYTERS LANE PLAYING FIELDS AND WETLANDS MANAGEMENT PLAN.

FAUNA COMPONENT

PREPARED BY SANDPIPER ENVIRONMENTAL FOR AUSTRALIAN WETLANDS

15 APRIL 2005

Sandpiper Environmental

ABN: 47 327 438 027
Ref No: A040507

Boyters Lane Playing Fields and Wetlands Management Plan. Fauna Component

15 APRIL 2005

PO Box 401
ALSTONVILLE NSW 2477

Approved by:_____
Project Manager

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 BACKGROUND

Sandpiper Environmental was subcontracted by Australian Wetlands to assess the fauna issues associated with the preparation of the Boyters Lane Wetland and Playing Fields Plan of Management. The Plan of Management (POM) is being prepared for Kempsey Shire Council. The primary purpose of the plan is to "identify Councils responsibilities and define appropriate management strategies for both the wetland/estuary and playing field areas and proposed walkway" (Kempsey Shire Council 2004).

The aim of this report is to identify and discuss the vertebrate fauna issues associated with the management of the Boyters Lane Wetland for inclusion into the POM. The report is divided into six sections, Introduction, review of Background Information, Field Assessment, Review and Analysis of Issues, Management Options and Objectives and Preferred Management Options and Recommendations.

The objectives of the report include:

- Undertake a field survey to assess the type and distribution of fauna habitats, define important habitat features, important habitats and the long-term viability of habitat for fauna.
- Describe the current fauna values of the Boyters Lane Wetland.
- Review and analyse the issues identified by the Boyters Lane Wetland Working Group and the Coastal and Estuary Management Committee that relate to fauna.
- Prioritise issues concerning fauna, in accordance with the level of risk that they pose to management of fauna and fauna habitat.
- Review the fauna component of the Environmental Audit of the subject site (Walker *et al.* undated) to determine if the audit provides an appropriate level of detail to prepare management strategies for fauna.
- Map the distribution of fauna habitats based on the results of the site analysis, air photo interpretation and review and analyse supporting documents that pertain to fauna.
- Identify and evaluate options for wetland management and assess the positive and negative benefits of the various options for fauna.
- Prepare management objectives that address the range of fauna issues identified by the Boyters Lane Wetland Working Group and the Coastal and Estuary Management Committee.
- Prepare a list of management options and provide information on costs, benefits, limitations and impacts associated with each option.

1.2 STUDY AREA

1.2.1 Subject site

The subject site is situated on the floodplain of the Macleay River, near the town of South West Rocks on the mid-north coast of NSW. The site covers a total area of 25.8ha and includes an area of estuarine wetland known as the Boyters Lane Wetland. The site is bordered to the south by Boyters Lane, to the north and east by Spencers Creek and to the west by agricultural land (grazing). Freshwater wetlands occur on the southern side of Boyters Lane. The site is comprised of two lots DP 754396 and DP 832777.

To assist with the discussion of wetland values and management descriptive names have been developed for various areas within the subject site (Figure 1.1). These names have been developed for this report only and it is suggested that Council may wish to seek community input in developing descriptive names should the Plan of Management be adopted.

1.2.2 Ecological context

Boyters Lane wetland is tidally influenced, with a direct connection to Spencers Creek, which inturn is linked to the Macleay River. The wetland is characterised by several parallel tidal inlets, which were most likely historical creek channels. 'Fingers' of elevated land separate each tidal inlet. A bund wall extends from near the northern edge of the site across each of the inlets (Figure 1.1). Tidal movement through the bund walls is restricted by 15cm diameter PVC pipes, although the wall across Juncus Inlet has been eroded to create a narrow tidal channel. Full inundation of all inlets occurs during spring high tides.

Grassland vegetation dominates the elevated land and covers the southwestern third of the site and the southeastern corner (Figure 1.1). Areas of grassland may become waterlogged after prolonged rainfall. The Boyters Lane Wetland has not been mapped under State Environmental Planning Policy (SEPP) No. 14. The nearest SEPP 14 wetland (wetland No.443) is situated on the northern side of Spencers Creek.

Definitive information on the management of the subject site is unavailable, although some information was obtained from discussion with long-term residents. The wetland has a long history of modification. Bund walls were initially constructed in the 1960's, and shortly after construction tidal flow was halted. This resulted in a change from an estuarine system to a predominantly fresh or brackish system with limited or no tidal exchange through the bund walls. It was during this period that mangrove dieback occurred in Teal Lagoon.

PVC pipes were installed in the mid 1990's to restore some tidal exchange. This system has operated until the present time, although deterioration of pipes and the bund wall has resulted in increased tidal exchange in Teal lagoon and Juncus Inlet. The site has been grazed by cattle for an extended period. Grazing has influenced the distribution and extent of wetland vegetation.

Figure 1.1: The study area, with habitat types and site names included.

1.3 DESCRIPTION OF THE PROPOSAL

Kempsey Shire Council proposes to construct sports fields on the area of grassland in the southwestern third of the subject site (Figure 1.1). The proposed sports fields will cover 6ha and include lights for night training. Vehicle access to the sports fields would be via Boyters Lane. Council has a preliminary proposal to construct a pedestrian walkway across the wetland to link South West Rocks directly with the sports fields (Appendix 1).

The pedestrian access way would also be used for the purpose of environmental education, with viewing platforms and interpretive material integrated into the access way design. It is proposed to revegetate elevated land between the inlets and in the southeastern corner of the site. A pumping station is also proposed in the southeastern corner of the site.

2 REVIEW OF BACKGROUND INFORMATION

2.1 AUDIT REPORT

The purpose of reviewing the audit report was to assess the adequacy of information contained within the report for use in preparing management strategies for fauna. Whilst the audit report is appropriate for the purpose for which it was prepared it contains limited information to assist with the preparation of management strategies for fauna. Apart from some general information on invertebrates the report does not contain any new fauna records or information on the value of the subject site for fauna. The authors readily acknowledge the limitations of the report with respect to fauna (refer to sections 3.2, 6.2 and 6.3.1 of the audit report). One of the recommendations of the audit report (section 6.3.1) was to prepare a comprehensive fauna audit before assessing any development proposals.

2.2 ATLAS OF NSW WILDLIFE

A search was undertaken of the Atlas of NSW Wildlife to obtain historical and recent fauna species records for the locality (5km radius surrounding the subject site). The Atlas search encompassed an area of 100km^2 surrounding the subject site. The search was dated 27 July 2004. The search revealed records for 30 threatened fauna species (Table 2.1). Many of the threatened species recorded in the locality are unlikely to utilise the subject site at present. The list of threatened species is indicative of threatened species that may utilise the site if appropriate habitat is provided. For example, revegetation of elevated land with locally endemic fruiting trees would provide habitat for fruit-doves and flying foxes, whilst forested habitat in general would provide a food resource for insectivorous bats and square-tailed kites. Revegetation and rehabilitation of grassland is likely to benefit a wide range of species.

Table 2.1: Threatened fauna recorded from the locality of the subject site.

Species Name	Common Name	Status TSC	Last Record	No. Records
	AMPHIBIANS			
Crinia tinnula	Wallum Froglet	V	15/3/03	11
	REPTILES			
Caretta caretta	Loggerhead Turtle	E1	1/3/97	2
Dermochelys coriacea	Leathery Turtle	V	9/12/00	1
	MAMMALS			
Phascolarctos cinereus	Koala	V	30/6/99	1
Phascogale tapoatafa	Brush-tailed Phascogale	V	15/2/03	11
Syconycteris australis	Common Blossom-bat	V	22/1/98	2
Pteropus poliocephalus	Grey-headed Flying-fox	V	5/3/03	22
Petaurus norfolcensis	Squirrel Glider	V	15/3/03	29
Vespadelus troughtoni	Eastern cave Bat	V	19/5/00	1
Mormopterus norfolcensis	Eastern Freetail Bat	V	25/2/02	1
Chalinalobus nigrogriseus	Hoary-wattled Bat	V	17/10/01	1
Scoteanax rueppellii	Greater Broad-nosed Bat	V	11/10/94	1
Miniopterus australis	Little Bentwing-bat	V	26/10/94	3
	Australian Fur Seal	V	23/7/01	1
Megaptera novaeangliae	Humpback Whale	V	13/10/99	2
	BIRDS			
Anseranas semipalmata	Magpie Goose	V	20/1/92	1
Ixobrychus flavicollis	Black Bittern	V	5/3/03	1
Ephippiorhynchus asiaticus	Black-necked Stork	E1	9/5/01	7
Lophoictinia insura	Square-tailed Kite	V	27/7/00	2
Pandion haliaetus	Osprey	V	5/3/03	35
Limosa limosa	Black-tailed Godwit	V	18/4/00	1
Irediparra gallinacea	Comb-crested Jacana	V	28/9/00	2
Haematopus longirostris	Pied Oystercatcher	V	19/7/01	6
Haematopus fuliginosus	Sooty Oystercatcher	V	5/3/03	8
Sterna albifrons	Little Tern	E1	24/10/00	1
Ptilinopus magnificus	Wompoo Fruit-Dove	V	3/9/01	4
Ptilinopus regina	Rose-crowned Fruit-Dove	V	17/11/01	2
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	15/3/03	37
Ninox strenua	Powerful Owl	V	23/10/00	1
Coracina lineata	Barred Cuckoo-shrike	V	1/12/99	1

2.3 HISTORICAL BIRD SURVEYS

A local ornithologist (Mr Ken Shingleton) has been surveying birds on the subject site on a regular basis for the past 12 years. These surveys have provided a good indication of the conservation value of the Boyters Lane Wetland for waterbirds. During the survey period 143 species of bird have been recorded on or near the subject site (Appendix 2), including nine species listed on the NSW *TSC Act* and approximately 47 migratory species listed under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*.

Threatened species recorded on-site include, blue-billed duck, black-tailed godwit, black-necked stork, osprey, square-tailed kite and brolga.

A number of regionally significant species have also been recorded on-site, including many inland species that use coastal wetlands as drought refuges. The high diversity of birds recorded at the Boyters Lane wetland indicates that the wetland represents one of a mosaic of wetland habitats on the Macleay floodplain.

2.4 SUMMARY

Information on the importance of the subject wetland for fauna varies between groups. There is a good body of information on birds, but limited information on other terrestrial vertebrate groups (mammals, reptiles & frogs), fish and invertebrates. Further information on these groups would assist in ensuring that appropriate management strategies are developed and importantly ensuring that management does not have a detrimental impact on biodiversity. Research on fish and invertebrates is regarded as essential to obtain a better understanding of the importance of the wetland for these groups. In the absence of detailed ecological research it is essential to ensure that an adaptive management approach is adopted. Such an approach is considered appropriate whilst additional information is being collected.

3 FIELD ASSESSMENT

3.1 METHODS

3.1.1 Fauna Habitat Assessment

A qualitative assessment of fauna habitat was undertaken. This assessment included a meandering traverse of all fauna habitats present on the subject site. An initial indication of the distribution of fauna habitats was obtained from a site meeting and review of aerial photographs. The habitat assessment focussed on gathering information on the distribution and extent of important fauna habitat features, such as: dominant floristics in each strata, height of strata, vegetation cover, area of open water, extent of tidal influence, tree hollows, fallen logs, nest or roost trees, water depth, intertidal habitat, tidal exchange, fauna features (scats, tracks, runways, feeding sites etc) and weed species.

3.1.2 Baseline Field Survey

To obtain a better understanding of the value and use of the subject site by fauna a baseline field survey was conducted between the 8th and 10th of July and 30 and 31 August 2004. This survey included a meandering traverse of all fauna habitats, targeted searches for grass owl and Australasian bittern and dusk and dawn bird surveys. The survey was not designed to

provide a comprehensive assessment of fauna on the site and such a survey was beyond the scope of this assessment.

3.1.3 Aerial Photograph Interpretation (API)

Aerial photography of the study area was examined to assess the broad extent of vegetation communities on site, and to generate a series of vegetation polygons to be identified through ground-truthing.

3.2 RESULTS

3.2.1 Fauna Habitat Assessment

Grassland

Grassland habitat is restricted to those (elevated) areas above the highest astronomical tide (Figure 1.1), including all of the southwestern and southeastern corners. Grassland habitat on the southern boundary is separated by about 150m of the brackish lagoon habitat. Grassland is dominated by exotic grasses, with two isolated stands of exotic trees (dominated by *Pinus* spp) within the southwestern (sports fields) section and several small stands of mature swamp oak (*Casuarina glauca*). Ground cover is dense ranging between 90 and 100% and grass height ranges from about 25cm to 60cm.

Habitat in the southwest of the site slopes gently towards the brackish and estuarine habitats to the northeast. There is a distinct change in vegetation near the spring high tide level, where grasses are replaced by more salt tolerant species (refer to descriptions below). The demarcation between grassland and other habitats in the southeast is more abrupt, with small but steep inclines (0.5 to 1m high) separating habitats. Some regrowth swamp oaks, to a height of 2m, were recorded within the Grassland habitat.

Grassland habitat has some value for fauna, as it provides foraging habitat for grass owls, small mammals, common birds, reptiles and amphibians. Some common waterbirds are also likely to forage over grassland habitat during or after periods of prolonged rainfall, when the soil may be waterlogged. Both the brolga and black-necked stork have been recorded roosting on grassland habitat (K. Shingleton pers comm.).

Small islands of grassland habitat dominated by stands of swamp oak and/or introduced grasses are distributed throughout the saltmarsh habitat. Overstorey cover within these islands is <5% and swamp oaks attain a maximum height of approximately 12m.

Several species of weed were recorded within or around the periphery of the Grassland habitat, including fireweed (*Senecio* sp), fleabane (*Conyza* sp), pink lantana (*Lantana camara*), blackberry (*Rubus ulmifolius*), Morning Glory (*Ipomea indica*), camphour laurel (*Cinnamomum camphora*), groundsel (*Baccharis halimifolia*) and purple top (*Verbanea* sp).

Brackish Lagoon – Teal Lagoon

The construction of a bund wall across the tidal channel that once extended through the middle of the subject site has created a brackish lagoon (Figure 1.1). Habitat within the lagoon and on the upstream side of the bund is substantially different to (estuarine) habitat on the downstream side of the bund. Salt water enters the lagoon via two 15cm diameter PVC pipes that are situated above the mean low water height, and during spring high tides, from inflows directly through the wall. The pipes restrict tidal exchange and ensure that the lagoon does not drain fully at low tide. Freshwater inflows mix with tidal inflows creating a brackish water habitat. The presence of mature mangrove trees and several dead stumps, presumed to be mangroves, provides evidence that the lagoon was historically part of an estuarine system.

The lagoon has a surface area of approximately 2.24ha. The exact water depth is unknown although it may range from about 0.1m to 0.75m. The majority of the lagoon is open water with a narrow strip of littoral habitat. The extant of littoral habitat expands at low tide when small areas of mudflat are exposed. The littoral zone is dominated by *Juncus* spp. to a height of 1m and salt couch (*Sporobolus* spp). Mangrove cover is sparse (<10%), with the highest cover and density of mangroves at the southern end. The sparsity of the mangrove cover is attributed to historical water management and grazing. Mangroves within the lagoon are dominated by grey mangrove (*Avicennia marina*).

Mangrove seedlings, to 1m, occur around the periphery of the lagoon, with the highest densities occurring on mudflats at the southern end. The recent exclusion of cattle has enabled an increased number of mangrove seedlings to grow and mature mangroves along the southern edge of the lagoon provide a perpetual source of seed. Mangroves reach a maximum height of 4.5m. No branch or trunk hollows were recorded in the lagoon habitat.

The lagoon contains a variety of different habitats for waterbirds, including permanent brackish water habitat for waterfowl, shallow water used for foraging by stilts, spoonbills and egrets, intertidal mudflats used by sandpipers and plovers. Dead trees provide roosting habitat for a variety of species.

Brackish Inlet – Dotteral Inlet

The eastern inlet (Dotteral Inlet; Figure 1.1) is characterised by a variable pattern of inundation. The inlet becomes inundated during spring high tides, and only partially drains during the subsequent low tide. This pattern of inundation would suggest a saltwater dominated system, however, vegetation within the inlet is characterised by a mix of estuarine and freshwater species. According to local sources Dotterel Inlet was managed as a freshwater environment for several decades (B. Ford pers comm.), which explains the occurrence of freshwater vegetation.

A 3-5m wide band of Juncus occurs along much of the periphery, with salt couch and freshwater species, including *Schoenoplectus* sp, *Maundia triglochinoides*, *Cotula coronopifolia* and *Triglochin striatum* occurring below the Juncus. Water depth varies depending on tide height and freshwater inflows. The inlet is feed by a 15cm diameter PVC pipe situated within the bund wall. Water entering the inlet initially travels through dense salt

couch and sedges before broadening into a 10-20m wide by 80m long basin that was largely devoid of vegetation.

A variety of fauna habitats are represented in the inlet, including dense sedges and grasses suitable for small mammals and birds, open water suitable for large wading birds and shallow tidal flats suitable for shorebirds. Frog habitat would be present during periods of high rainfall.

Mangroves and mudflat

Mangrove habitat is restricted to a small tidal channel linked to Spencers Creek, the southern edge of Spencers Creek that adjoins the subject site and tidal channels that feed the saltmarsh habitat (Figure 1.1). Mangroves and mudflat cover almost 4ha of the subject site. The upstream extent of mangrove habitat within the tidal channel is restricted by the bund walls, which separates mangrove and mudflat habitat from brackish habitats. Grey and river mangrove (*Aegiceras corniculatum*) are the dominant species within the Mangrove habitat.

There is direct evidence of a recent expansion in the area covered by mangroves, with dense areas of mangrove seedlings, to a height of 1m, recorded between saltmarsh and mature mangroves that line the tidal creek and in several tidal channels that occur within the saltmarsh habitat. The recent proliferation in mangroves is most likely due to the removal of grazing pressure. At low tide much of the upstream extent of the tidal creek is exposed leaving a small area of intertidal mudflat with a sparse cover of seedling mangroves.

Mature mangroves adjoining the tidal creek reach a maximum height of approximately 7.5m and have an overstorey cover of approximately 60%. A small number of old growth mangroves occur adjacent to Spencers Creek along the northern edge of the site. These mangroves provide potential roosting habitat for insectivorous bats with several small branch and trunk hollows recorded. Mangrove habitat is also used by several species of common bird for foraging and roosting. Intertidal mudflats provide foraging habitat for waterbirds, including ibis, spoonbills, egrets, sandpipers, stilts and herons.

Saltmarsh & sedgeland

Saltmarsh habitat covers about 6.14ha in the northern third of the subject site and the inlets that are separated by grassland habitat (Figure 1.1). Dense beds of *Juncus* sp. dominate the upper tidal areas of the saltmarsh habitat, with sparse juncus and salt couch dominating the lower areas. The dense beds of juncus attain a maximum height of about 1m and have a cover of between 90 and 100%. Ground cover in the lower areas ranges from 50 to 90%, with the height of the ground stratum ranging from 10 to 50cm. The patchiness of the saltmarsh community may be due to previous grazing by cattle. A noticeable feature of the community is an undulating topography and there are a small number of shallow pools distributed throughout the juncus and salt couch community. Emergent swamp oaks were evident on the upstream side of the bund wall in Juncus Inlet suggesting that this area may not be receiving sufficient salt water to maintain saltmarsh habitat.

The dense cover and occurrence of tidal channels provide potential habitat for Australasian bittern. The dense vegetation is also used by a variety of small passerines, whilst waterbirds forage along the edge of tidal channels or throughout the salt couch community. Small

mammals occur within the saltmarsh and sedgeland and this habitat is known to be used for foraging by grass owl.

Mangrove seedlings to 1m tall occur along tidal channels that feed the saltmarsh habitat, particularly the eastern channel. The spread of mangroves into saltmarsh may be limited by competition, with dense saltmarsh vegetation, elevation and restricted tidal flow. However, if long-term sea-level predictions are correct it is likely that mangroves will expand at the expense of saltmarsh.

3.2.2 Baseline Field Survey

Birds were the most abundant fauna group recorded during the targeted field survey, with 50 species recorded (Appendix 2). Three species of threatened bird were recorded during the survey, grass owl, osprey and square-tailed kite. No Australasian bittern were recorded, although equipment failure meant that playback for this species was effective on one night only. Insectivorous bats were recorded foraging over the subject site and grey-headed flying foxes (*Pteropus poliocephalus*) were recorded traversing the site after dusk. Small ground mammals were also recorded in the saltmarsh and grassland habitats.

3.3 DISCUSSION

3.3.1 Summary of Fauna Values

The subject site, and specifically the wetlands provide a variety of habitats for fauna and in particular birds. The site includes known habitat for several birds listed as threatened under the NSW *Threatened Species Conservation (TSC) Act 1995* and several migratory species listed under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. The subject site represents a small area of modified wetland in a state and national context and despite the occurrence of migratory species it is unlikely that the subject wetland would be considered as a significant area of habitat under the EPBC Act. The known occurrence of eight species listed under the TSC Act increases the state importance of the site, although further surveys would be required to adequately assess the extent to which these species rely upon the subject wetland.

The wetland is important in the context of the Macleay Floodplain and particularly the South West Rocks area as it most likely represents one of a matrix of wetlands used by waterbirds. Given the widespread removal and degradation of floodplain wetlands previously used by waterbirds (Pressey & Harris 1988) it is essential that sites such as Boyters Lane are protected and if possible enhanced. Conservation of waterbirds relies upon maintaining a number of wetland habitats with different wetting and drying regimes (Kingsford & Norman 2000). Waterbirds that use the Boyters Lane wetland are likely to move between the estuary and other floodplain wetlands on a daily basis. The occurrence of numerous species typical of inland wetlands provides further evidence of the importance of the Boyters Lane Wetland, which may be used as a drought refuge (Kingsford & Norman 2000).

All habitats on the site have been modified by previous land management practices. Part of the value of the wetlands for waterbirds has occurred due to habitat modification resulting from the construction of bund walls and restrictions to tidal flow. Teal Lagoon provides an area of permanent habitat for waterfowl and favourable foraging habitat for a variety of waterbirds that would not have been present without the construction of the bund wall. The slow movement and warm temperatures of water in the lagoon most likely provide good breeding conditions for some invertebrates, which represent a food resource for waterbirds. Prior to the construction of the bund wall it is expected that the Teal Lagoon would have been dominated by mangroves, with only a small area of waterbird foraging habitat. Despite the favourable conditions created by the wall, increased tidal flushing would improve invertebrate productivity and reduce nutrient accumulation.

The dense grass and sedge habitat is suitable for a variety of common small mammals, which provide a food resource for grass owls and diurnal birds of prey. Grassland and sedgeland habitats would be used by a variety of common reptiles, frogs and birds. Insectivorous bats are also expected to roost within mature mangroves and forage over all habitats. Insectivorous bats may also roost in the old cow bales present on the subject site. The biodiversity values of areas currently covered by grassland habitat could be substantially improved through active management, although this habitat is currently used for foraging by at least one grass owl. The extent to which grass owls rely on the grassland habitat within the subject site is unknown, although it may form part of an individuals foraging range. It seems unlikely that grass owls roost on-site as no individuals have been flushed during 12 years of bird surveys, which have involved regular traverses of the site (K. Shingleton pers comm.).

The saltmarsh and mangrove habitats provide important roost and foraging habitat for a variety of fauna and represent an integral component of what is a modified estuarine wetland. Saltmarsh represents potential habitat for Australasian bittern and black-necked storks may occasionally forage and roost in the estuarine habitat. The recent listing of Saltmarsh as an endangered ecological community under the NSW *TSC Act* is further recognition of the high conservation value of this habitat type. Furthermore, saltmarsh communities are protected under the *Fisheries Management Act 1994*.

3.3.2 Long-term Viability of Extant Habitats

Sheltered estuarine wetlands tend to change slowly, a fact attributed to the protected nature of these systems. Modification of estuarine wetlands and in particular the alteration of tidal flows, such as has occurred on the subject site, can result in obvious changes in habitat structure and function. Changes in the type and distribution of habitats within the Boyters Lane Wetland complex have occurred since the creation of bund walls and in response to site management, which included grazing by cattle. The recent removal of cattle has resulted in further changes in habitat structure. The most obvious being the increased growth of mangroves and swamp oaks, which would have previously been browsed by cattle. In addition to the expansion of mangrove seedlings in the Mangrove habitat, seedlings are also noticeable within Teal Lagoon and Saltmarsh habitat.

The limited tidal exchange into Teal Lagoon may reduce the growth of mangroves however, given the current level of seedling development and the occurrence of mature mangrove trees within the lagoon it is anticipated that mangrove cover will increase over time. Likewise, the occurrence of seedling mangroves in the saltmarsh habitat may provide an insight into future

mangrove expansion as has occurred in other estuaries in NSW (Saintilan and Williams 1998; Saintilan 2003).

Although mangroves provide habitat for a variety of fauna, their expansion into waterbird habitat would reduce visibility, which is considered important for many species (Lawler 1996). Whilst it is too early to conclude that mangroves would dominate Teal Lagoon there is evidence to suggest that further growth and expansion is likely. The % cover of mangroves already present in the lagoon may be at a level that is unsuitable for some shorebirds (Lawler 1996).

Quantitative studies on the visual distances required by waterbirds are limited, although Lawler (1996) provides some information for shorebirds. For roosting shorebirds Lawler (1996) recommends a minimum buffer of 30m and preferably 50m to vegetation over 2m high, with a distance of 75m required for vegetation over 5m tall. Although this information is of value in must be recognised that much of Lawler's data were gathered in more open habitats and on species that demand good visibility. It is possible that shorebirds using brackish water habitats, such as sharp-tailed sandpiper, black-fronted and red-kneed dotterels, marsh sandpipers and greenshank may tolerate sites with greater vegetation cover. In considering visibility distances it is essential to recognise the limited number of studies and the fact that once vegetation is present the impacts may be irreversible. Any revegetation plans must consider the sight distances required by waterbirds using Teal Lagoon.

The presence of established mangrove seedlings in shallow depressions in the Saltmarsh Habitat could be indicative of further expansion. At present the dense saltmarsh vegetation appears to be restricting the movement of seedlings, however this could change if tidal exchange is increased or due to sea-level rise. One point obvious from the inspection of the subject site is that action is required to manage the current deterioration of bund walls. The expansion of mangroves at the expense of saltmarsh is not considered desirable.

Limiting tidal exchange, particularly into Teal Lagoon has implications for long-term water quality and ultimately the health of the brackish water habitat. Low levels of tidal inflows may result in a steady increase in nutrients, possibly to the detriment of the lagoon ecosystem. Increased tidal exchange may reduce nutrient build up and increase invertebrate productivity. The construction of an appropriately designed structure may also improve fish passage into Teal Lagoon.

4 REVIEW AND ANALYSIS OF ISSUES

4.1 REVIEW

The Boyters Lane Wetland Working Group and Coastal and Estuary Committee identified 18 issues associated with the management of the subject land. Ten of these issues are of direct relevance to fauna, including:

1. Council wishes to construct a pedestrian and educational walkway with observation stations within the eastern sector of the site.

2. Council has a long-term plan to link the Boyters Lane playing fields to the CBD and sections of the residential area with a pedestrian/cycleway.
3. The Bird Observers Club of Australia (BOCA) has identified an exceptional range of bird species on the site, including a number of species listed as threatened under the NSW *TSC Act*.
4. The Department of Environment and Conservation (DEC) has raised concerns that Councils proposal to develop sections of the site may have potential impacts on wetland values.
5. Feral and domestic animal management.
6. Sport field lighting and night activities.
7. The impact on established biodiversity as a result of any pending management changes (i.e. from grazing to non-grazing).
8. Council wishes to re-establish native riparian vegetation to supplement the educational walkway in areas determined via the Management Plan.
9. Access to playing fields.
10. Short-term fire management.

All of the above issues have direct implications for fauna and the management of fauna habitat on the subject site. The above issues can be summarised into four interrelated topics:

- Access through the wetland and to the sports field (Issues 1, 2 & 9).
- Potential habitat modification that will affect biodiversity (Issues 4, 6, 7 & 8).
- Site management (Issues 5 & 10).
- Recognition of the biodiversity values of the wetland (Issue 3).

Issues covered by the first three dot points could have positive and/or negative impacts on the biodiversity of the subject site. Dot point four differs, in that it relates to the recognition of the biodiversity values of the wetland, specifically from the perspective of birds. Recognition of the biodiversity values of the subject wetland is essential to ensure that appropriate management strategies are developed. The value of the subject wetland for vertebrate biodiversity has been addressed in Sections 2 and 3 and will not be specifically discussed in this section.

4.2 ANALYSIS

4.2.1 Access

The proposal to construct a pedestrian walkway through the centre of the wetland to link urban areas to the sports fields could have both positive and negative impacts. Use of the walkway for environmental education and the inclusion of interpretive signage and observation platforms could have a broad positive benefit for wetland conservation by

increasing public awareness of wetland values. Three major user groups are likely to utilise the walkway:

1. Groups visiting for educational purposes.
2. Local residents using the walkway for recreation and education.
3. Through traffic that use the walkway to access the sports fields.

In the absence of survey data it is impossible to conclude which user group would dominate use of the walkway. The intensity of use is likely to vary between groups and between and within days. Through traffic is likely to peak during the weekend, although intense use could be expected during school sports days. Use by local residents may be highest in the morning and afternoon and on weekends and use by educational groups is expected to be irregular occurring mainly during daylight hours on weekdays.

Although speculative, it is likely that people requiring through access and recreation would dominate use of the walkway. Although some members of this group may benefit it is likely that persons interested solely in access to the sports fields would gain minimal benefit from traversing the wetland.

Frequent visitation from persons with a low level of interest is likely to result in detrimental impacts on biodiversity and other wetland values. The main impact of site access would be disturbance, pollution (refuse) and pest species. Use of the site by education groups and interested residents would also cause disturbance, however, this disturbance would be irregular and have long-term positive benefits for wetland conservation. Active management of access by these groups would reduce impacts.

Waterbirds, which comprise a highly visible portion of the sites biodiversity, are readily disturbed by human activities (Lawler 1996; Melville 1997; Priest *et al.* 2002). Waterbirds react to irregular or short-term human disturbance in a similar manner to 'natural' forms of disturbance, such as traverses by birds of prey, with the resulting effect being initial flocking, followed by flight. The response of waterbirds will differ between species, although regular disturbance interspersed with intense bursts of activity is likely to create unfavourable conditions for many species. Some waterbirds will habituate to human activity, however, the majority of species prefer less disturbed environments and will take flight if disturbed, whilst others will concentrate activities in areas furthest from the disturbance source, or seek refuge in dense thickets of vegetation. The major impact on waterbirds would occur near Teal Lagoon.

Research on the appropriate buffer distances between waterbirds and sources of disturbance is limited, although Lawler (1996) recommends a minimum buffer of 100m to areas of intense activity (i.e. high speed boats, active people, helicopters, jet skis etc) and a minimum of 50m to more sedate forms of disturbance. Pedestrian access is likely to fall within the active people category and based on Lawler (1996) would require a minimum buffer of 100m between the waterbird habitat and the disturbance source.

Nelson (1994) provides some baseline information on types of disturbance and distances at which shorebirds were disturbed by various human activities in the Richmond River Estuary.

That study identified an obvious difference in disturbance distances between large and small shorebirds.

The draft concept plan proposed by Council included the construction of a walkway that virtually crosses the centre of the wetland (Appendix 1). From the perspective of fauna conservation and particularly minimising adverse impacts the merits of such a proposal are questionable. A central walkway would divide the subject site, separating fauna habitats and pushing fauna towards the periphery of the wetland. This is an unfavourable outcome for minimising impacts on existing wetland values. Such a walkway would also provide a source of rubbish and improve access for pest species, which includes domestic dogs and cats.

4.2.2 Habitat Modification

The proposal poses a definite risk of habitat modification, which could lead to detrimental impacts on biodiversity. Any discussion of habitat modification must consider the already modified state of wetlands on the subject site. There is a strong argument to return modified wetlands to their 'natural' state however, this often has implications for species that utilise the modified system. It should be noted that all types of floodplain wetlands have been modified and the focus on one specific type of wetland causes an imbalance. Until floodplain restoration projects address all aspects of the floodplain ecosystem some groups of wetland fauna will continue to be disadvantaged as displaced habitats are not recreated elsewhere.

The long-term impact of removing cattle on wetlands has already been discussed (refer to Section 3.2.2). Other impacts could stem from lights used at the sports fields, nutrient runoff from sports fields into wetlands, reforestation of grassland habitat adjoining wetlands and restoration of tidal exchange.

Lights used for night-time sports events would illuminate a substantial area of wetland unless design constraints are imposed. Increased illumination could affect fauna in two ways. Some species may be disturbed and subsequently leave the wetland, whilst others could benefit by having the foraging substrate illuminated. Many species of waterfowl and shorebird forage irrespective of day or night (McNeil *et al.* 1992), whilst most wading birds (i.e. egrets, herons, ibis, spoonbills) forage mainly during the day and occasionally on moonlit nights (Marchant & Higgins 1990; 1993; Higgins & Davies 1996: pers obs).

Permanent artificial lighting may be beneficial to some species of shorebird by providing favourable feeding conditions, although changes in habitat use and species composition are likely (Rohweder 2000; Rohweder & Baverstock 1996; Rohweder & Lewis 2001). In this case lighting would not be permanent and would occur irregularly and for varying periods of time. Birds and other fauna are less likely to habituate to infrequent or irregular lighting events and are therefore more likely to be disturbed. Waterbirds using Teal Lagoon may be most affected as this site is closest to the light source. Specific measures will be required to reduce the incidence of light within the lagoon. The use of directional lighting and screen plantings may reduce impacts. Even with these measures some illumination of Teal Lagoon is expected, and the end result may be the creation of a full moon affect. Lighting may also affect other species. For example, insectivorous bats may forage around lights (pers obs), whilst illumination may alter the behaviour patterns of small ground mammals and grass owl.

Nutrient runoff from the sports fields into mangrove, saltmarsh and lagoon habitats is likely. Regular tidal flushing of the mangrove and saltmarsh habitats would reduce the risk of nutrient enrichment in these habitats. However, the low level of tidal flushing in Teal Lagoon could result in nutrient enrichment, which could alter the bird community, favouring those species that are tolerant of nutrient rich waters. Eutrophication of Teal Lagoon could have a detrimental impact on estuarine habitat following intense rainfall events when nutrient rich waters are flushed into the estuary.

Reforestation of grassland habitat would have both positive and negative impacts. Reforestation would substantially increase the conservation value of grassland habitat by providing additional habitat for a range of fauna. Conversely trees would reduce the sight distances required by waterbirds to detect predators. This impact would be particularly evident where trees adjoin waterbird habitat.

Patterns of tidal movement across the subject site have been highly modified for several decades and the system is currently in a slow state of modification as tidal waters erode berms. Changes to tidal inflows could have substantial impacts on vegetation communities and fauna habitat. For example, the removal of all berms would result in increased fish passage and the expansion of mangrove habitat at the expense of waterbird habitat and saltmarsh. Although small areas of grassland habitat may be colonised by saltmarsh the opportunity for saltmarsh transgression is limited by topography. Increasing tidal exchange would have both positive and negative benefits. Positive benefits include increased fish passage, expansion of mangroves and improved water quality and increased wetland productivity, whilst negative impacts include the loss of waterbird habitat, loss of saltmarsh and impacts on threatened species. There is a clear need to balance the positive benefits of increased tidal exchange with maintaining some of the existing wetland values.

4.2.3 Site Management

Issues of relevance to site management include fire, feral and domestic dogs and cats, pest species and weeds. Management of fire risk has obvious benefits for vertebrate biodiversity. The most fire prone fauna habitats on the subject site are the Grassland and Saltmarsh habitats. Although saltmarsh would normally have a low fire risk the high density of Juncus sp. and limited inundation within this habitat coupled with its close proximity to the grassland increases the level of fire risk. Under severe fire conditions i.e. low humidity, strong winds and high fuel loads in the grassland habitat it is likely that some saltmarsh habitat would be burnt. This could have a deleterious impact by displacing fauna and providing an opportunity for weed species to colonise saltmarsh habitat. A fire in the grassland habitat would temporarily displace a range of common vertebrate species. Fire risk on the subject site could be minimised by replacing grassland with a less fire prone vegetation community.

Management of feral and domestic animals would have definite benefits for vertebrate biodiversity. However, conflicts are anticipated between easy site access and feral and domestic animal management. The site access proposed by Kempsey Shire Council (2004) would provide direct access for domestic animals into the wetland resulting in additional disturbance to waterbirds and other fauna. Managing disturbance by domestic animals is likely to be very difficult when the access path bisects the subject site.

A range of introduced species are likely to utilise the subject site, however, foxes pose the greatest risk of direct impact on fauna. Fox numbers on the site could be managed via a

baiting program, although such a program would have implications for domestic dogs accessing the site from the walkway. In addition, for such a baiting program to be effective it would need to cover a broader area than just the subject site.

Weed management is also an important issue, with several weed species occurring on-site. The dense grass cover probably restricts weed growth, however, removal of this grass cover and disturbance of the soil could provide ideal conditions for weeds and weed control would need to form part of site maintenance.

4.3 ISSUE PRIORITISATION

Issues have been prioritised according to their potential risk of impact on fauna (Table 4.1). All of the issues pose either a moderate or high risk to the management of vertebrate fauna and maintenance of biodiversity values. High risks include the impact of management changes (i.e. removal of grazing, altered tidal exchange), the re-establishment of riparian vegetation over grassland habitat, and linking the sports fields to the CBD. All of these issues could potentially modify extant fauna habitat values unless specific amelioration measures are adopted. Careful planning is also required as some actions may not be reversible without additional expenditure. For example, the colonisation of saltmarsh by mangrove due to the removal of berms would be difficult to rectify without additional earthworks and assessment. Increased tidal exchange would have other benefits though asa it could increase fish passage and wetland productivity.

Playing field use, access by humans, fire and domestic animal management all pose a risk of impact on fauna. This risk is considered to be moderate as there is a high likelihood that impacts can be reduced through appropriate planning and by adopting an adaptive approach to management. Concerns by the DEC regarding impacts on threatened fauna are also warranted, however, there is a strong likelihood that impacts can be ameliorated without impacts on threatened species.

Table 4.1: Prioritisation of the risk posed to fauna from the issues identified by the Boyters Lane Wetland Working Group and Coastal and Estuary Committee.

Issue	Grouping Topic	Risk posed to management of vertebrate fauna & maintenance of biodiversity values
Construction of pedestrian and educational walkway.	Access	Moderate
Link playing fields to CBD and residential areas with walkway/cycleway.	Access	High
Access to playing fields.	Access	Moderate
DEC concerns regarding development impacts.	Modification	Moderate
Sport field lighting and night activities.	Modification	Moderate
Impact of management changes (tidal exchange etc).	Modification	High
Re-establish native riparian vegetation to supplement educational walkway.	Modification	High
Short-term fire management.	Management	Moderate
Feral and domestic animal management.	Management	Moderate
Recognition of the importance of the wetland for birds.	Biodiversity Values	Nil

5 MANAGEMENT OPTIONS AND OBJECTIVES

5.1 MANAGEMENT OPTIONS

5.1.1 Wetlands and Elevated Land

To facilitate a strategic approach to wetland management the subject site has been divided into 10 management units and management options have been developed for each unit (Table 5.1; Figure 1.1). Separate options have been developed for infrastructure (facilities) that is required to support the proposed use of the subject site (Table 5.2).

Between three and four options are proposed for each management unit, including the Do-nothing option. The positives and negatives of each option are also detailed. The options analysis (Table 5.1 & 5.2) has identified several re-occurring issues, establishment and maintenance costs, potential failure of existing structures (pipes and berm), altered biodiversity, fish passage and impacts on threatened species.

The do-nothing option has minimal establishment costs, although this option would create ongoing management costs associated with vegetation control (i.e. controlling fire hazard and weeds on elevated land) and is likely to cause a change in biodiversity values over time as pipes deteriorate and berms erode. Field inspections have shown that the berm is either highly permeable or broken in several key areas. No action in the wetland areas would result in a long-term change in the extent and type of wetlands present. This would reduce the value of the site for waterbirds and possibly the educational value of having a variety of wetland types. One positive benefit of berm failure would be increased fish passage, and possibly the expansion of mangroves, although mangrove expansion may occur at the expense of saltmarsh.

Alternative management options for the elevated (terrestrial) areas vary between locations. The central premise of management options for elevated land has been to minimise impacts on extant wetland values, whilst increasing the biodiversity value of the management unit (i.e. elevated land). Options for land either side of Teal Lagoon vary substantially, from reforestation to wetland construction. Both these options would increase the biodiversity value of the subject land, however, reforestation with trees and shrubs would most likely reduce the value of Teal Lagoon for waterbirds by reducing visibility. Conversely, there is concern over the feasibility of proposing several constructed wetlands. A suitable compromise may be to plant grasses and sedges that will provide foraging habitat for grass owls and maintain waterbird sight distances.

All of the wetlands present on the subject site have been affected by previous changes to hydrology. Apart from the Do-nothing option there are three alternatives for managing these areas, removal of berms and pipes, maintenance of controlled inflows or full closure. The removal of berms and pipes would cause a substantial change in wetland type and function. This has obvious benefits for fish passage and mangroves, although it could have negative impacts on waterbirds and saltmarsh. Ongoing control of inflows would retain the status quo and aim to manage the wetland in its current modified state, however, this option would require ongoing maintenance costs and could lead to long-term problems with water quality. It

may be that different management options are selected for each of the inlets currently affected by reduced tidal exchange.

Active management of wetlands would increase costs and the complexity of management. There is a strong case for restoring full tidal exchange and allowing the wetlands to return to a 'natural' state. However, there are positive and negative aspects to this option. For example, opening Dotterel and Bittern Inlets to full tidal inflows could result in the expansion of mangroves at the expense of saltmarsh. A better approach would be to open one inlet and monitor changes in habitat, whilst in the meantime actively managing the other inlet.

Teal Lagoon represents a unique situation and developing a management framework that creates a low maintenance (& low cost) and healthy wetland is problematic. There is inherent difficulty in managing the Lagoon for waterbirds, whilst at the same time satisfying demands for fish passage and providing low maintenance and low cost recommendations. The Lagoon ecosystem would benefit greatly from increased tidal exchange, however, mangroves must be controlled if the Lagoon is to be managed for waterbirds. There are two facets to controlling mangroves in Teal Lagoon. Firstly, mangroves should be removed from within the lagoon, and secondly, mangrove seeds must be stopped from entering the Lagoon.

Increased tidal flushing can be achieved by replacing the existing pipes with either a larger pipe or drop board structure. A drop board may be preferred as it enables easy manipulation of flows. The drop boards would allow increased fish passage and the greater tidal exchange would reduce nutrient accumulation and improve benthic productivity. If the site is to be managed for waterbirds then there is a definite need to control mangrove growth. The most effective way to achieve this would be remove mangroves from the system and limit the number of mangroves entering the system. A modified drop board structure may be the most appropriate means of limiting mangroves.

5.1.2 Facilities

Various facilities will be required to provide access to the sports fields and educational opportunities. The basic facilities proposed include, walking/bike track, lights for sports fields, bird hides, viewing platform, interpretive signage, bird crossing points and picnic areas. Options have been developed for each of these facilities and the positive and negative aspects of each option considered (Table 5.2). In developing options for facilities the goal has been to minimise impacts on biodiversity but provide an appropriate educational experience and access to the sports fields.

The Do-nothing option has been considered for each type of facility. Whilst this option has low cost, doing nothing is regarded as an inappropriate use of a valuable community asset. Three alternative options are proposed for pedestrian access. These range from a central path with a bridge over Spencers Creek (Option 2) to a path that follows South West Rocks Road, the existing road bridge and Boyters Lane (Option 4). Option Two poses the highest risk of impacts on wetland values, whilst Option Four poses the lowest risk. Option three, which involves the construction of a bridge over Spencers Creek and an eastern path that joins Boyters Lane on the eastern side of Teal Lagoon, would have a medium to low level of impact. The main feature of Option Four would be a loop track that allows interested persons to exit the main access path and walk through the wetlands.

All of the access path options would require facilities for educational purposes. Bird hide/s, viewing platforms and interpretive signage are all proposed to increase the educational experience. These facilities are essential if the wetland is to be used for educational purposes and to minimise the impacts from recreational activities. The primary decision being how many of each facility and where should they be located. Picnic facilities are proposed for the southeast corner of the site.

Two options are proposed to minimise the risk of road strike on waterbirds crossing Boyters lane, traffic calming devices and signage. Ensuring that thick vegetation is retained adjacent to the road/walking path would also assist in providing cover for birds prior to crossing the road.

5.1.3 Important Considerations

As noted previously the type and extent of wetlands on the subject site are indicative of previous management and the site is characteristic of a modified wetland system. Leaving extant management structures such as berms and pipes to deteriorate and ultimately fail with unknown consequences does not equate to good wetland management. Although there is value in removing all berms and pipes and restoring full tidal exchange the consequences of this are difficult predict, although impacts on extant wetland values are expected. Decisions on wetland management must consider broader processes such as climate change (sea-level rise), which is likely to have a substantial influence on wetland habitats and the extent to which different habitats are represented and protected on the Macleay floodplain.

Wetland rehabilitation projects are often undertaken on the premise that they will have a positive environmental benefit. Whilst this is generally the case it must be noted that rehabilitation projects often fall within the definition of an activity under the *Environmental Planning and Assessment Act 1974* and as such require approval. Most importantly the potential environmental impact of these activities must be fully considered, including impacts on threatened species, endangered populations and ecological communities listed under the *Threatened Species Conservation Act 1995* and *Fisheries Management Act 1994*.

It must be recognised that wetlands identified for rehabilitation often occur within highly modified landscapes and species that currently utilise the modified wetland do so because other ‘preferred’ habitats are unavailable. Modification to habitats on the subject site could have a detrimental impact on several threatened species, including, grass owl, black-necked stork and brolga. The DEC will require that impacts on threatened fauna be assessed in an appropriate manner. A flexible management approach will be required to minimise impacts on fauna whilst at the same time restoring wetland values.

Table 5.1: Proposed management options for each management units within the Boyters Lane Wetland complex.

Management Unit	Options			
	One	**Two**	**Three**	**Four**
1. West side of Teal Lagoon **Issue:** Quality and quantity of runoff from playing fields, existing kykuyu grass	*Do nothing.* **Positives:** low cost. **Negatives:** ongoing grass management problems, nutrients and increased runoff from fields enter Teal Lagoon.	*Create freshwater wetland with buffer plantings* **Positives:** biodiversity gain, manage nutrients and peak flows from fields, maintain sight distance for waterbirds, provide a buffer between wetlands and playing fields. **Negatives:** establishment and maintenance costs, potential ASS impacts.	*Revegetate* **Positives:** some filtering of nutrients, reduces ongoing management costs, biodiversity gain. **Negatives:** reduces sight distance for waterbirds, impacts on threatened species.	*Encourage saltmarsh expansion* **Positives:** increased extent of endangered ecological community, biodiversity gain, improved fish habitat, low management cost. **Negatives:** establishment and short-term maintenance cost, potential ASS impacts, possible loss of saltmarsh in long-term if Teal Lagoon berm is removed or eroded, or with sea level rise.
2. North edge of playing fields **Issue:** Quality and quantity of runoff from playing fields, existing kykuyu grass	*Do nothing* **Positives:** no establishment cost. **Negatives:** ongoing management cost, low biodiversity value, no biodiversity gain.	*Encourage expansion of saltmarsh* **Positives:** increased extent of endangered ecological community, biodiversity gain, improved fish habitat, low management cost. **Negatives:** establishment and short-term maintenance cost, potential ASS impacts.	*Create freshwater wetland* **Positives:** biodiversity gain, reduce nutrients entering estuary, maintain sight distance for waterbirds. **Negatives:** establishment costs, potential ASS impacts.	*Revegetate* **Positives:** some filtering of nutrients, reduces ongoing management costs, biodiversity gain. **Negatives:** Impacts on line-of-sight
3. Teal Lagoon **Issue:** Constructed berm is becoming degraded, reduced tidal exchange	*Do nothing* **Positives:** low cost, expansion of mangroves (medium term), improved fish habitat. **Negatives:** loss of waterbird habitat (medium term), altered biodiversity, berm failure, loss of brackish water habitat (long term), reduced educational values, impacts on threatened species habitat, uncertainty.	*Repair berm replace pipes with drop board structure - manage as brackish lagoon for waterbirds, control mangroves, include small low island of appropriate design.* **Positives:** improved waterbird habitat, improved fish passage, reduced nutrient accumulation, educational values, no impact on threatened species. **Negatives:** cost of ongoing management, uncertainty regarding ability to exclude mangrove seedlings, cost of maintenance, risk of future berm and pipe or weir failure, lower fish passage than if berm removed.	*Remove berm and restore fully estuarine habitat* **Positives:** low establishment cost, minimal maintenance cost, increased fish passage and fish habitat, educational values. **Negatives:** altered biodiversity, reduced waterbird values, reduced wetland diversity, impacts on threatened species habitat.	*Repair and Maintain Berm – stop tidal inflows to create freshwater habitat.* **Positives:** Potential increase in a wide range of habitat values, e.g. wetland plants for food and nest material **Negatives:** Reduced fish passage, altered biodiversity values, impacts on threatened species, potential weed issues (e.g. hyacinth), possible nutrient enrichment from birds

Table 5.1 cont.

Management Unit	Options			
	One	**Two**	**Three**	**Four**
4. Western elevated land	*Do nothing*	*Revegetation - mix of swamp forest and rainforest depending on elevation.*	*Construct freshwater wetland*	*Create native grassland/sedgeland*
Issue: Kykuyu	**Positives:** no establishment cost, maintain threatened species habitat (Grass Owl only). **Negatives:** ongoing maintenance costs, fire risk, low biodiversity, low educational value.	**Positives:** reduced fire risk, low ongoing maintenance cost, increased educational value, increased biodiversity, increased conservation value, threatened species habitat. **Negatives:** establishment costs, intensive management required initially, loss of grass owl habitat, reduced line-of-sight distance for waterbirds, potential ASS impacts.	**Positives:** Increased biodiversity value, maintain line-of-sight distance for waterbirds, educational value, creates threatened species habitat, complement other wetland types. **Negatives:** establishment and maintenance cost, possible ongoing weed management, removal of grass owl habitat, potential ASS impacts.	**Positives:** biodiversity gains, educational value, maintain line-of-sight distance for waterbirds, maintains grass owl habitat, creates threatened species habitat. **Negatives:** establishment and maintenance costs, ongoing weed management (includes *Casuarina* colonisation), potential ASS impacts.
5. Estuary **Issue:** Pipe on edge of site to Spencers Creek	*Do nothing* **Positives:** allow estuarine system, including mangroves to re-establish post grazing, no establishment and maintenance cost. **Negatives:** None	*Remove concrete pipe on eastern inlet.* **Positives:** restoring natural processes. **Negatives:** short term low level erosion, small cost.		
6. Middle Inlet **Issue:** Main Berm is eroding, berm restricts natural tidal flows, *Juncus* has established extensively south-east of berm	*Do nothing* **Positives:** low cost, slow expansion of mangroves, increased fish passage. **Negatives:** erosion of berm (long term), difficult to predict impacts on extant saltmarsh	*Repair berm and manage tidal flows* **Positives:** maintain existing habitat, educational benefits, maintenance of site access. **Negatives:** maintenance cost, reduced fish passage, ongoing management, possible change in habitat upstream of berm, potential ASS disturbance.	*Remove berm and increase tidal flows* **Positives:** improved fish passage, low cost, expansion of mangroves, possible expansion of saltmarsh, educational value. **Negatives:** possible reduction in *Juncus*, uncertainty, altered biodiversity, impacts on grass owl.	*Repair and Maintain Berm – stop tidal inflows to create freshwater habitat.* **Positives:** Potential increase in a wide range of habitat values, e.g. wetland plants for food and nest material **Negatives:** Reduced fish passage, altered biodiversity values, impacts on threatened species, loss of saltmarsh
7. Central elevated land **Issue:** Kykuyu grass, fire risk	*Do nothing* **Positives:** no establishment cost, maintain Grass Owl habitat. **Negatives:** ongoing maintenance costs, fire risk, low biodiversity, low educational value.	*Revegetation - mix of swamp forest, sedges and rainforest depending on elevation.* **Positives:** solves issue of fire and ongoing maintenance, increased educational value, increased biodiversity, increased conservation value. **Negatives:** establishment costs, intensive management required initially, impacts on grass owl habitat.		

Table 5.1 cont.

Management Unit	Options			
	One	**Two**	**Three**	**Four**
8. Dotterel Inlet **Issue:** Freshwater influences, Main Berm restricts saltwater flows, one existing 150mm PVC pipe in berm	*Do nothing* **Positives:** no establishment cost, increased fish passage should berm fail (long-term). **Negatives:** possible berm/pipe failure (long term), reduction of waterbird habitat, reduced wetland diversity, uncertainty.	*Repair berm and maintain existing tidal exchange* **Positives:** ensures that existing management regime is maintained, educational value of another wetland type. **Negatives:** restricting extent of saltmarsh and mangroves, ongoing maintenance of berm, restricted fish passage, potential ASS impacts from berm disturbance.	*Remove berm - increase tidal exchange.* **Positives:** low establishment cost, increased fish passage, possible expansion of mangroves, possible expansion of saltmarsh. **Negatives:** reduction of waterbird habitat, reduced wetland diversity, reduced educational value, uncertainty, potential ASS impacts from berm soil disturbance, threatened species impacts.	*Repair berm and stop tidal inundation – create freshwater habitat* **Positives:** increased wetland diversity, educational values, returns to previous management regime as freshwater wetland (although not the natural condition). **Negatives:** establishment cost, altered biodiversity, loss of fish habitat, loss of saltmarsh, potential ASS impacts from berm soil disturbance.
9. East elevated land **Issue:** Kykuyu grass, fire risk, remnant swamp forest	*Do nothing* **Positives:** no establishment cost, maintain Grass Owl habitat. **Negatives:** ongoing maintenance costs, fire risk, low biodiversity, low educational value.	*Revegetation - mix of swamp forest and rainforest depending on elevation.* **Positives:** solves issue of fire and ongoing maintenance, increased educational value, increased biodiversity, increased conservation value. **Negatives:** higher establishment costs, intensive management required initially, impacts on grass owl habitat.		
10. Roadside vegetation **Issue:** Existing grass and sedges are slashed, thin screen of trees at end of Teal Lagoon	*Do –nothing* **Positives:** low cost. **Negatives:** potential disturbance impacts on wetlands from passing traffic, reduced bird habitat, possible increase in road strike.	*Maintain thick vegetation and plant screen between pedestrian access and wetlands/vegetation.* **Positives:** reduces disturbance impacts, maintains biodiversity values. **Negatives:** establishment costs.	*Regular slashing and maintenance.* **Positives:** improved visibility for pedestrians and motorists. **Negatives:** loss of bird habitat, possible increase in road strike, no buffer to wetland, increased disturbance impacts.	*Maintain, but alter roadside vegetation, by removing mangroves, planting screen & encouraging native rushes* **Positives:** reduced management cost associated with Teal Lagoon (reduction in mangrove propagules to the lagoon), maintain dense screen for waterbirds, reduced disturbance impacts, maintain buffer to wetland. **Negatives:** removal of mangroves, increased level of Environmental Impact Assessment

Table 5.2: Management options for infrastructure required to support the proposed use of the subject site.

Type of Facility	Options			
	One	Two	Three	Four
1. Playing fields lights **Issue:** High-powered lights for training and playing at night to be installed	*Do nothing* **Positives:** No cost **Negatives:** Intense lights from fields impact on wetland wildlife	*Ensure lights are 'environmental' Type D* **Positives:** Reduction in light pollution from fields. **Negatives:** Cost		
2. Pedestrian access **Issue:** Need for public access to playing fields as well as wetlands	*Do nothing* **Positives:** no cost, no impacts on biodiversity values. **Negatives:** under-utilising an important community asset, reduced community awareness and education.	*Central access track with bridge over Spencers Creek* **Positives:** encourages people to move through the wetland, education and community awareness. **Negatives:** impacts on wetland biodiversity, litter disposal, access by pest species (dogs, cats), high establishment cost, high level of disturbance, potential ASS impacts from bridge and consolidating Main Berm.	*Eastern access track with bridge over Spencers Creek. Track traverses revegetated land and edges of wetlands.* **Positives:** encourages people to move through the wetland without impacts on wetland values, education and community awareness. **Negatives:** high cost of bridge and path construction and maintenance, encourages use by people not interested in the wetland, potential ASS impacts from bridge, access by pest species (local knowledge suggests not currently problematic), disturbance of birds.	*Road-side access track across the existing road bridge and along the edge of Boyters Lane, with loop track/s through revegetated habitat and wetlands.* **Positives:** lower bridge cost, ensures that wetland walkway is used more for educational purposes than for playing field access, lower impacts on wetland biodiversity, improved educational value. **Negatives:** higher cost associated with path construction, pest species.
3. Bird Hides **Issue:** Potential for community enjoyment and education in environmental values	*Do nothing* **Positives:** low cost. **Negatives:** lower educational values, encourage people to move closer to birds possibly increasing disturbance.	*Construct one bird hide near Teal Lagoon.* **Positives:** increased educational value, allows for ongoing use of the wetland by bird watchers. **Negatives:** establishment and maintenance costs, potential vandalism.	*Construct two or more bird hides* **Positives:** provides additional viewing opportunities. **Negatives:** additional construction and maintenance expense, potential vandalism.	
4. Interpretive signage **Issue:** Potential for explanation of the environment increases enjoyment and understanding	*Do nothing* **Positives:** no expenditure required. **Negatives:** does not satisfy educational aims, under-utilises an important community resource.	*Provide interpretive signage at key locations along the walking track and at viewing platform/s, bird hide/s etc. Include explanatory signage regarding prohibition of domestic animals.* **Positives:** Assists with the education of students and the community, ensures that unguided groups gain knowledge about wetlands, potential to involve Aboriginal people. **Negatives:** establishment and maintenance costs.		

Table 5.2 cont.

Management Unit	Options			
	One	**Two**	**Three**	**Four**
5. Viewing Platform **Issue:** Opportunity for better observations of wetlands	*Do nothing* **Positives:** no cost, no risk of ongoing disturbance impacts. **Negatives:** reduced educational experience, under-utilised resource.	*Construct one viewing platform near the southern end of the central inlet and the constructed wetland.* **Positives:** Enhanced educational experience. **Negatives:** establishment and maintenance costs, disturbance to waterfowl, potential vandalism.	*Construct two or more platforms.* **Positives:** Enhanced educational experience. **Negatives:** establishment and maintenance costs, risk of disturbance to waterfowl, potential vandalism.	
6. Vehicle control **Issue:** Increased vehicle presence along Boyters Lane	*Do nothing* **Positives:** no additional costs. **Negatives:** ongoing impact of vehicle strike on birds crossing Boyters Lane.	*Integrate traffic calming devices into road design.* **Positives:** reduced road strike. **Negatives:** increased cost, risk of injury to drivers.	*Enforce a 40km/hr speed zone and install signage.* **Positives:** reduced risk of road strike, lower costs, lower risk of injury to public. **Negatives:** establishment cost.	
7. Picnic facilities **Issue:** Opportunity for community to enjoy creek-side environment	*Do nothing* **Positives:** no establishment or maintenance cost. **Negatives:** reduced community use, reduced educational experience, impacts from informal use.	*Provide picnic facilities near the southeastern corner of the site* **Positives:** enables management of recreational use, reduced impacts, enhanced wetland and creek experience **Negatives:** establishment and maintenance cost, possible disturbance impacts unless facilities are appropriately designed, increased need for other facilities such as toilets.		

5.2 MANAGEMENT OBJECTIVES

Biodiversity

Ensure that management results in a net gain in biodiversity over the entire site and specifically no loss of biodiversity in extant wetlands and a gain in degraded terrestrial grasslands.

Wetland Diversity

Promote the development of a mosaic of different wetland types that reflect the diversity of wetland habitats on the Macleay River Floodplain.

Education

Provide an educational experience that is both unique and informative and has a central aim of increasing the communities' awareness of the role of floodplain and estuarine wetlands.

Provide opportunities for a-hands-on wetland experience that has minimal impact on wetland values.

Community

Provide facilities and promotional material that enable the community to appreciate and learn about the Boyters Lane wetland.

Management

Implement an adaptive management approach that balances the biodiversity values of the existing wetlands with the need to restore degraded wetland habitats.

6 PREFERRED MANAGEMENT OPTIONS

Preferred management options for each management units and facilities are listed below, with a justification for why that option is preferred.

Table 6.1: Preferred management options for each land management unit.

Management Unit	Preferred Option	Rationale
West Side of Teal Lagoon	*Create freshwater wetland with buffer plantings* (Option 1.2 in Table 5.1).	Biodiversity benefits and reduces the potential for impacts on Teal Lagoon.
North edge of Playing Fields	*Encourage expansion of saltmarsh* (Option 2.2 in Table 5.1).	Promotes the expansion of an Endangered Ecological Community and provides a buffer between extant saltmarsh and mangroves and the playing fields.
Teal Lagoon	*Repair berm replace pipes with drop board structure - manage as brackish lagoon for waterbirds, control mangroves, inlcude small low island of appropriate design* (Option 3.2 in Table 5.2)	This option increases fish passage and improves water quality and wetland health, whilst at the same time maintaining waterbird values. There is some level of uncertainty regarding the feasibility of excluding mangrove seeds.
Western Elevated Land	*Create native grassland/sedgeland* (Option 4.4 in Table 5.1).	Provides long-term foraging habitat for grass owl, increases the biodiversity value of degraded grassland habitat and maintains sight distances for waterbirds using Teal Lagoon.
Estuary	*Remove concrete pipe on eastern inlet* (Option 5.2 in Table 5.1).	Maintains the current management regime, with the removal of a pipe that is currently having no influence on water movement.
Middle Inlet	*Remove berm and increase tidal flows* (Option 6.3 in Table 5.1).	Increase fish passage, improve wetland health and reduces the potential for ongoing management of the berm.
Central Elevated	*Revegetation – mix of swamp forest, sedges and rainforest depending on elevation* (Option 7.2 in Table 5.1).	Increased biodiversity and educational value of degraded grassland.
Dotterel Inlet	*Repair berm and maintain existing tidal exchange* {**in the short term** (Option 8.2 in Table 5.1)}	Maintain current management regime for 3-5 years and observe how habitat in the Middle Inlet responds to increased tidal exchange.
East Elevated	*Revegetation – mix of swamp forest, sedges and rainforest depending on elevation* (Option 9.2 in Table 5.1).	Increased biodiversity and educational value of degraded grassland.
Roadside Vegetation	*Maintain, but alter roadside vegetation, by removing mangroves, planting screen & encouraging native rushes* (Option 10.4 in Table 5.1).	Encourages fauna habitat, provides a buffer to wetlands and reduces ongoing cost of mangrove control in Teal Lagoon.

Table 6.2: Preferred management options for each type of facility.

Type of Facility	Preferred Option	Rationale
Playing fields lights	*Ensure lights are 'environmental' Type D* (Option 1.2 in Table 5.2)	Reduces the impact of lights on waterbirds and other wetland fauna.
Pedestrian Access	*Road-side access track across the existing road bridge and along the edge of Boyters Lane, with loop track/s through revegetated habitat and wetlands.* (Option 2.4 in Table 5.2)	Reduces the likelihood of through traffic, which will reduce littering and the occurrence of domestic animals.
Bird Hides	*Construct one bird hide near Teal Lagoon* (Option 3.2 in Table 5.2).	A bird hide would increase community enjoyment and education. One hide is considered appropriate given the type and size of wetlands present.
Interpretive Signage	*Provide interpretive signage at key locations along the walking track and at viewing platform/s, bird hide/s etc. Include explanatory signage regarding prohibition of domestic animals* (Option 4.2 in Table 5.2).	Interpretive signage is considered as fundamental to enhance the educational experience of persons using the wetland.
Viewing Platform	Do-nothing (in the short term) until it can be determined that an observation platform is beneficial. (Option 5.1 in Table 5.2)	A viewing platform is not considered essential in the initial (3-5 year) stage of this plan.
Vehicle Control (along Boyters Lane)	Enforce a 40km/hr speed zone and install signage to warn motorists that wildlife cross in that area (Option 6.3 in Table 5.2).	Reducing the speed limit and providing signage may reduce the risk of road strike to fauna crossing Boyters Lane.
Picnic Facilities	Provide picnic facilities near the southeastern corner of the site (Option 7.2 in Table 5.2)	Picnic facilities would compliment the interpretive signage in increase both the recreational and education experience of visitors to the wetland. It also provides a means of controlling visitor use of the site.

7 CONCLUSION AND RECOMMENDATIONS

The Boyters Lane wetland provides an insight into the range of issues that affect the management of many floodplain wetlands in northern NSW. Management of modified wetlands requires a balance between restoring degraded habitats whilst at the same time considering the requirements of species that have colonised the modified system. There is a general trend towards full restoration of tidal floodplain wetlands, however, this process is occurring without *strategic* consideration of the extent to which other wetland types have been modified and are continuing to degrade.

Boyters Lane provides an opportunity to manage a site to ensure the long-term viability of a variety of wetland types and manage waterbird and fish habitat. Management of the estuarine and elevated lands is fairly straightforward, however a flexible approach is required for other management units. It is proposed to restore tidal exchange to Middle Inlet, monitor Dotterel Inlet in the short-term to assess the affect of full tidal exchange on the nearby Middle Inlet and manage Teal Lagoon to promote waterbird habitat.

Management of Teal Lagoon provides the greatest challenge. There is a good argument for removing the berm and restoring full tidal exchange to the lagoon, however, this would reduce

the value of the lagoon for waterbirds and possibly reduce the educational experience by removing a good waterbird habitat from the subject site.

The concept of limiting the spread of mangrove seeds or controlling extant mangroves in Teal Lagoon is controversial and would require additional cost. An appropriate structure to allow fish passage, stop mangrove seeds and improve tidal flushing is not available, although it is likely that one of the existing pipe/culvert designs could be modified to satisfy these requirements. One point that seems clear is that increased tidal flushing of the Lagoon is likely to improve water quality and the value of habitat to waterbirds.

Recommendations

- Liaise with a local university to encourage research into fish and invertebrate communities on the subject site. Research could also consider how any changes in tidal exchange influence fish passage.
- Remove all mangroves from within Teal Lagoon to reduce the ongoing management cost associated with mangrove control.
- The screen currently created by mangroves at the southern end of Teal Lagoon should be replaced by native shrubs and Phragmites.
- Refuge sites for frogs and reptiles should be created as part of rehabilitation work. Refuge sites may include placing fallen timber or fence posts throughout rehabilitation areas.
- The revegetation of grassland habitat should be staged to minimise impacts on grass owls.
- Elevated land to the east of Teal Lagoon should be planted with native sedges and grasses to provide foraging habitat for grass owls and maintain sight distances for waterbirds.
- Restrict slashing of roadside vegetation to within 1m of the road edge.
- The impact of any works on threatened species should be assessed in accordance with the *Environmental Planning & Assessment Act 1979*.
- Integrate and osprey nesting pole into the design of the sports fields to reduce the likelihood that ospreys will construct nests on the sports field lights. The osprey pole could be situated near Teal Lagoon or the estuarine habitat and should be higher than the light poles, with a nest platform and roost perches integrated into the design.

8 REFERENCES

Higgins, P. J. & Davies, S. J. J. (1996). Handbook of Australian, New Zealand and Antarctic Birds. Volume 3: Snipe to pigeons. Oxford University Press, Melbourne.

Kempsey Shire Council (2004). Consultant Brief: Boyters Lane Wetland & Playing Fields Management Plan. Kempsey Shire Council.

Kingsford, R. T. & Norman, F. I. (2002). Australian waterbirds – products of the continents ecology. *Emu:* **102,** 47-70.

Lawler, W. (1996). *Guidelines for management of migratory shorebird habitat in southern east coast estuaries, Australia*. Unpublished Masters of Resource Science, University of New England, Armidale.

Marchant, S. & Higgins, P. J. (1991). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings.* Oxford University Press, Melbourne.

McNeil, R., Drapeau, P, & Goss-Custard, J. D. (1992). The occurrence and adaptive significance of nocturnal habits in waterfowl. *Biological Review:* **67,** 381-419.

Melville, D. S. (1997). Threats to waders along the East Asian-Australasian Flyway, pages 15 – 34 *in* Shorebird Conservation in the Asia-Pacific Region, (ed P. Straw), Australasian Wader Studies Group, Melbourne.

Nelson, D. C. (1994). The effect & management of human disturbances on wading birds, Richmond River Estuary, Ballina, NSW. Unpublished Integrated Project, Southern Cross University, Lismore.

Pressey, R. L. & Harris, J. H. (1988). Wetlands of NSW, pages 35-57 *in* The Conservation of Australian Wetlands (Eds A. J. McComb & P. S. Lake), Surrey Beatty & Sons, Chipping Norton.

Priest, B., Straw, P. & Weston, M. (2002). *Shorebird Conservation in Australia*. Supplement to Wingspan, vol 12, no. 4. Birds Australia, Melbourne.

Rohweder, D. A. (2000). *Day-Night habitat use by five species of migratory shorebird in the Richmond River Estuary, northern NSW, Australia*. Unpublished PhD Thesis, SCU.

Rohweder, D. A. & Baverstock, P. R. (1996). Preliminary investigation of nocturnal habitat use by migratory waders in northern NSW. Wildlife Research: ***23,*** 169-184.

Rohweder, D. A. & Lewis B. L. (2001). Day-night habitat use by Double-banded Plovers (Charadrius bicinctus) in the Richmond River Estuary, northern NSW. *Corella:*

Saintilan, N. & Williams, R. J. (1999). Mangrove transgression into saltmarsh environments in southeast Australia. *Global Ecology & Biogeography:* **8,** 117-124.

Saintilan, N. (2003). Balancing shorebird habitat requirements with mangrove conservation, pages 15-19 *in* Status and Management of Migratory Shorebirds in Sydney (ed P. Straw), Sydney Olympic Park Authority, Sydney.