

SP2. Some amenity issues may be a result of previous land management practices

Many of the complaints received about the amenity of the estuary relate to wrack and odour. The odour can be caused by the decay of macroalgae which builds up in wrack accumulation zones along the foreshore. Macroalgae is known to respond rapidly to the presence of nutrients in the water column. Seagrass wrack is a natural feature of an estuary. Prior to development, wind driven currents would drive the wrack onto the shore and onto the saltmarsh where it would break down, in turn providing nutrients to stimulate the growth of saltmarsh. The mowing of saltmarsh encourages exotic lawns to extend to the edge, preventing wrack from moving onto the shore, where it breaks down in the water. These managerial activities have contributed to many of the amenity issues that currently face the estuary.

SP3. Management practices on public land can be seen as appropriate practice for private lands

The risk from providing public recreation areas that are managed by beach cleaning, mowing and beach nourishment encourages private citizens with water frontage to adopt the same practices. Approximately 15% of the estuarine foreshores contain private properties which reduces the ability to influence foreshore management in the estuary.

SP4. Existing community perceptions about estuarine health

The estuary drains approximately 800 km² of catchment. In a simplistic sense, it could be considered as a riverine dam that happens to have an opening to the ocean. Some community perceptions exist that relate the location of the estuary near to the ocean as a reason for the estuary being more marine in nature (and having more marine characteristics such as sandy beaches and clear water). These perceptions can influence debate about the “state” and “health” of the estuary. These perceptions should be addressed to mitigate the political pressure for alterations to the functions and processes within the estuary.

SP5. Some existing recreational facilities require upgrading

Some of the public jetties, boat ramps and other facilities require upgrading. The upgrades will maximise public use of the estuary by providing access to the foreshore and lakes. Grant funding is available from the WADAMP programme which is administered by the Maritime Authority (for more detail see Section 1.2.4.3).

8.4.2 Options

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
SP1. Insufficiently defined recreation areas	SP1a. Audit, designate and manage special areas for recreation <ul style="list-style-type: none"> • Foreshores • Beaches • Boating 	<ul style="list-style-type: none"> • Meet public expectations about recreational and aesthetic appeal of the estuary • Focus on specific public areas and improve aesthetics • For beaches – increased sand nourishment, focussed cleaning, wrack removal • For foreshores – improve public facilities, increase landscaping, informative signage, improved boat ramps • More palatable to State authorities if these works are undertaken in combination with reduced interference in non-designated areas (i.e. less mowing, beach cleaning etc) 	<ul style="list-style-type: none"> • May be illegal to conduct these works if threatened species are present • Potential for authorities not to grant Council a licence to undertake the works • Residents with water frontage likely to take Council's lead and insist that their part of the estuary should look the same • Hopefully, the reduction in some services would provide sufficient funds for the new works, but there is potential for funding blow-out 	High	High	WSC, DIPNR, DEC, DPI (Fisheries), Maritime Authority, DEC (Parks & Wildlife)
	SP1b. Do nothing	<ul style="list-style-type: none"> • Council can continue to try and provide a service to most of the public foreshore & nearshore zones of the estuary 	<ul style="list-style-type: none"> • Continued bad publicity about the "state of the lakes" • Complaint based maintenance regime continues 	Medium	Low	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
SP2. Some amenity issues may be a result of previous land management practices	SP2a. Assess areas where amenity is an issue and implement remedial measures where possible	<ul style="list-style-type: none"> Targets areas where problems are evident Provide community with solutions to genuine amenity issues 	<ul style="list-style-type: none"> Resource intensive Some of the remedial measures (i.e. saltmarsh rehab) may be unpopular with residents Council works may encourage private residents to conduct personal programmes 	Med-High	High	WSC
	SP2b. Investigate whether current practices are still having negative effects <ul style="list-style-type: none"> Wrack Management Mowing Beach cleaning 	<ul style="list-style-type: none"> Provides assessment of current practices and determines effects on ecology of foreshores and beaches Allows pending/recent legislation to be considered in terms of current practices (e.g. saltmarsh/Syngnathids) 	<ul style="list-style-type: none"> May result in Council having to stop some practices Potential for increased resource outlay if changes to practices and equipment are required 	Low	High	WSC
	SP2c. Do nothing	<ul style="list-style-type: none"> More resources available for other programmes 	<ul style="list-style-type: none"> Continued amenity complaints in some areas Does not help lakes overall image Some practices may present legal issues for Council 	Low	Low	WSC
SP3. Management practices on public land can be seen as appropriate practice for private lands	SP3a. Educate waterfront residents on rights and responsibilities in their enjoyment of the estuary <ul style="list-style-type: none"> illegal structures illegal removals 	<ul style="list-style-type: none"> Engages residents who are most affected by estuarine health Provides an opportunity to disseminate information on recent developments in estuarine management 	<ul style="list-style-type: none"> Unlikely to persuade sceptical individuals Potentially recommending unpopular courses of action to residents (i.e. no raking of wrack) 	Low	High	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
	SP3b. Conduct audits and fine where activities are found to illegal - illegal structures - illegal removals	<ul style="list-style-type: none"> Targets the few individuals who may not be interested changing habits that are damaging the estuary 	<ul style="list-style-type: none"> Unlikely to win support for estuarine management from fined individuals Significant resource commitment 	Medium	Medium	WSC
	SP3c. Do nothing	<ul style="list-style-type: none"> Residents will not be asked to make changes to lifestyle Minimises political damage from upset residents 	<ul style="list-style-type: none"> Poor management practices on some private foreshores will continue, potentially undermining work being done on public foreshores 	Low	Low	WSC
	SP3d. Council can undertake work on private property	<ul style="list-style-type: none"> Diffuse a long standing argument between Council and waterfront residents 	<ul style="list-style-type: none"> Council funds are expended on private lands – against a Council resolution to only spend funds on public foreshores 	High	Low	WSC
SP4. Existing community perceptions about estuarine health	SP4a. Educate the wider community about estuarine health and management programmes	<ul style="list-style-type: none"> Over time this will reduce the misconceptions that persist within the community Once community has correct information they are in a position to have constructive input into the estuarine management programme 	<ul style="list-style-type: none"> Will not change the opinion of sceptics 	Medium	High	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
	SP4b. Conduct estuarine field trips and open days	<ul style="list-style-type: none"> Provide opportunity for the interested members of the community to get first hand experience and information on the estuarine management issues facing the estuary Important to cultivate relationships with interested members of the community so that they can “spread the word” 	<ul style="list-style-type: none"> Who would resource it? 	Low	Medium	WSC
	SP4c. Increase use of signage	<ul style="list-style-type: none"> Direct method of informing the users of the estuary about management issues and unique characteristics of the estuary 	<ul style="list-style-type: none"> Would require signage updates over time Potential for loss or damage to signs Doesn't access a large audience 	Low	Low-Medium	WSC
	SP4d. Handouts at DPI (Fisheries) and Maritime Authority offices for those getting licences	<ul style="list-style-type: none"> Informs the users of the estuary about management issues and unique characteristics of the estuary 	<ul style="list-style-type: none"> Doesn't access large audiences (especially those that use the estuary for passive recreation – walking etc) 	Low	Low-Med	WSC
	SP4e. Do nothing	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> Community continue to demand options to perceived amenity problems rather than real ecological/social ones Community and Council cannot have meaningful partnership in estuarine management 	Low	Low	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
SP5. Some existing recreational facilities require upgrading	SP5a. Review recreational facilities and consult with the community to determine needs	<ul style="list-style-type: none"> Allow community to direct aspects of lake spending Monies are available from State agencies (e.g. Maritime Authority and WADAMP) 	<ul style="list-style-type: none"> 	Med	High	WSC

8.5 RECOMMENDATIONS

8.5.1 Issues Identified by Reference Groups

The following issues were identified by business, community and technical reference groups as being most important to them out of a list of all social and economic issues.

1. Insufficient settlement, employment and conservation strategies (SC1)
2. Insufficient environmental impact modelling or pre-development ecological assessments (SC2)
3. Compatibility of businesses with the estuary is not well understood (SE2)
4. Environmental degradation is difficult to reverse once it has occurred (SE3)
5. Some amenity issues may be a result of previous land management practices (SP2)

8.5.2 Additional Priorities

- ▶ Insufficiently defined recreation areas (SP1)
- ▶ Some existing recreational facilities require upgrading (SP5)

8.5.3 Suggested Programmes

Programme	Associated Options
Develop a population strategy that is based on what environmental changes the estuary, rivers and catchment can sustain rather than on available land	SC1a, SC1b, SC2a, SC2b, SE2a, SE3c, LS3a, WP1e, VF2a, DC2a, DF3c, WG1b
Designate foreshore recreational areas and manage/encourage maximum recreational use and enjoyment including beach cleaning and wrack management in these areas	SP2a, SP2b
Improve facilities in designated recreation areas based on community consultation including additional seating, BBQ's, picnic areas, educational signage, upgraded boat ramps	SP5a, SP1a

9 Knowledge Gaps

9.1 INTRODUCTION

This section defines the overarching principle and sets future objectives to assess and improve the knowledge of estuarine processes and also to increase the flow of information to the community. In order to meet these objectives, it is necessary to a) define any issues that currently prevent the objectives from being met and b) implement options to address these problems.

While significant improvements in the understanding of the estuary were made with the preparation of the Estuary Process Study (Roberts, 2001), it was recognised that many data gaps and knowledge about estuarine processes remained. In addition, perceptions exist in the community about the so-called “health” of the estuary that do not necessarily reflect the most recent information or management actions. As the Catchment Blueprint did not address knowledge improvement and community education, a new principle was developed.

The remainder of the section examines each objective in detail, focussing on the issues that prevent the objective from being met, and providing potential options to address such issues.

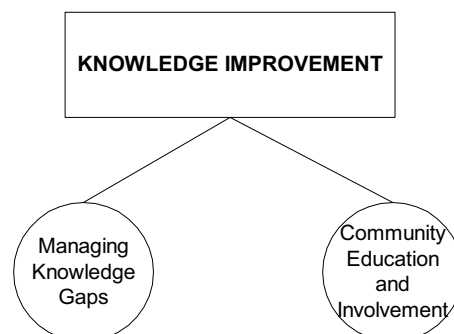
9.1.1 Principle

This principle was not included in the Catchment Blueprint. It was developed in response to the ongoing need to improve knowledge about estuarine processes and also to increase the flow of information to the community.

Improve knowledge of catchment and estuarine systems where a clear link to management decisions is evident

The following objectives provide greater focus and detail for improving estuarine understanding for both estuarine managers and the community.

9.1.2 Elements



9.2 MANAGING KNOWLEDGE GAPS

Objective KG: Identify extent of information gaps and where appropriate undertake studies to improve understanding

The Tuggerah Lakes estuary has seen an increase in the number of studies done in recent years. Many of these have been in response to the estuarine management planning process. While much has been learned from these studies, there are some fundamental gaps in the understanding of key estuarine processes.

It is important to continue to pursue these knowledge gaps and re-evaluate new information as it becomes available. In this way, managerial decisions can be based on the best knowledge available, and relatively rapid responses can be developed to environmental problems. In committing to this objective, there is an implicit acknowledgement that closing such gaps requires ongoing funding.

9.2.1 Issues & Threats

KG1. Funding and resourcing further studies into estuarine processes, health trends and key management questions

Much of what is known about the estuary has been determined through university research or through the Estuary Process Study (Roberts, 2001). While there has been some substantial new information obtained as part of this process, there are still many questions that need answering to assist in managing activities that affect the estuary. Funding and finding the resources to undertake these studies in the future has not been addressed.

KG2. Further research and management may be the responsibility of a number of organisations and agencies

One of the difficulties in trying to understand and manage a complex natural system like the Tuggerah Lakes is that often catchment and estuarine boundaries cross a number of administrative boundaries. These boundaries can be cumbersome when trying to undertake projects and in particular, encourage a number of parties to fund a study or works. A coordinated independent body with identified responsibility for managing activities that affect the estuary may make it easier to have transparent representation by all groups. There are a number of models for transferring management responsibility from the Crown to an independent estuarine manager including the establishment of reserves, trusts and leases. The implications of such a transfer would need to be thoroughly investigated. It is important to note that ownership of an estuary would stay with the Crown.

KG3. Understanding of key estuarine processes is not complete

While the Estuary Process Study (Roberts, 2001) examined a number of patterns and processes that occur within the Tuggerah Lakes estuary, key knowledge gaps remain. Such gaps include water mixing between shallow seagrass habitats and deeper open waters of the estuary (particularly in relation to the mixing of river discharges).

KG4. Development of bio-indicators as long term indicators of estuarine health

The use of organisms as “indicator species” has been attempted in a wide variety of applications, ranging from the microbial level to the ecosystem. Biological indicators are organisms that by their habit and interactions with the environment provide an easily measurable, easily interpreted indicator for assessing the state of an ecosystems health (see Section 2.4.1).

9.2.2 Options

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
KG1. Funding and resourcing further studies into estuarine processes, health trends and key management questions	KG1a. Utilise new CMA's in funding further estuarine studies	<ul style="list-style-type: none"> CMA's will take on increasing importance in managing catchments and waterways – important to access support for future funding and studies Provides an avenue to federal funding for catchment and estuarine programmes 	<ul style="list-style-type: none"> The new CMA's operate over a large area (a large number of electorates) – funding allocations are likely to be distributed throughout the CMA area, not devoted to individual programmes How the CMA will spend money is not understood – will funds be required to be spent by the CMA, or can the CMA issue funds to other organisations to conduct relevant work 	Low	High	WSC
	KG1b. Aggressively pursue funding from all sources for new studies that assist in closing knowledge gaps	<ul style="list-style-type: none"> Council will be able to better understand where it can source additional funding for studies Potential for obtaining long-term funding for further studies 	<ul style="list-style-type: none"> Council is not obliged to undertake and fund additional studies into the estuary, and may not be sufficiently resourced to manage an increase study role 	Low	High	WSC
	KG1c. Do nothing	<ul style="list-style-type: none"> Council does not assume responsibility for programmes that it is not legally obliged to undertake 	<ul style="list-style-type: none"> Existing knowledge (with gaps) will form the basis for future management decisions Not all data gaps have been closed – additional studies may not be funded 	Low	Low	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
KG2. Further research and management may be the responsibility of a number of organisations and agencies	KG2a. Engage agencies to determine what assistance is available where administrative responsibilities overlap	<ul style="list-style-type: none"> • Clear understanding of which organisations may be able to contribute resources, funding or support to further studies • Reinforces a co-operative dialogue and partnership between Council and State agencies 	<ul style="list-style-type: none"> • Government funding can be sporadic and politically motivated • Requesting funding without clearly defined programmes makes funding success less likely 	Low	High	WSC
	KG2b. Create a central independent body responsible for managing activities that affect the estuary	<ul style="list-style-type: none"> • One organisation is responsible for the day to day management of the estuary • If given funding, could allocate spending only on estuarine programmes • Clearing house for estuarine information 	<ul style="list-style-type: none"> • Those funding the organisation may have less say over how that is spent. • There are a number of models that would need to be considered before pursuing this approach 	High	Medium	WSC
	KG2c. Increase number of collaborative studies (and funding) where administrative responsibilities intersect	<ul style="list-style-type: none"> • Reinforces a co-operative dialogue and partnership between Council and State agencies • Utilises the expertise of both organisations to achieve good outcomes 	<ul style="list-style-type: none"> • Co-operative programmes can sometimes be difficult to project manage with competing priorities 	Medium	High	WSC
KG3. Understanding of key estuarine processes is not complete	KG3a. Undertake a study into the mixing patterns between shallow and open water	<ul style="list-style-type: none"> • Determine location of most appropriate spending on water quality treatment • Increase efficiency of spending 	<ul style="list-style-type: none"> • Potential for localised flow patterns that reduce the amount of mixing and produce local responses 	High	Medium	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
	KG3b. Undertake a study into the effects of permanent, closed, dredged entrance on flooding, tourism, flushing and ecology	<ul style="list-style-type: none"> Provide a detailed analysis of the impacts of the range of entrance management options that are publicly debated Allow for a public decision to be made regarding the long term management of the entrance 	<ul style="list-style-type: none"> If not public, transparent and independent the decision will have little support Significant data gaps will probably exist, making analysis difficult. It may be very costly to close down the data gaps 	Med-High	Medium	WSC, DIPNR, DPI (Fisheries), DEC, DOL, Maritime Authority
	KG3c. Develop a predictive model	<ul style="list-style-type: none"> Allows predictions to be made about likely estuarine responses to a range of disturbances/mgt actions. 	<ul style="list-style-type: none"> Requires collection of significant volumes of data in order to understand patterns In order to test accuracy of model, additional data needs to be collected after its development under the range of modelled scenarios 	Med-High	Medium	WSC
KG4. Development of bio-indicators as long term indicators of estuarine health	KG4a. Meiofauna	<ul style="list-style-type: none"> Interpret the level of stress in the system Qualify the status of Tuggerah Lakes in terms of other estuaries Potential to improve understanding of nutrient cycling status 	<ul style="list-style-type: none"> Results may be interpreted differently by different groups Taxonomic resolution is poor 	Medium	High	WSC, DIPNR (via estuarine indicator work)
	KG4b. Sponges	<ul style="list-style-type: none"> Assess increases in levels of turbidity using transplanted sponges 	<ul style="list-style-type: none"> Population within the estuary is variable and patchy 	Low	Med-High	WSC, DIPNR (via estuarine indicator work)

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
	KG4c. Macroalgae (abundance, distribution, frequency of blooms)	<ul style="list-style-type: none"> Useful as an indicator of increased nutrient status of the estuary 	<ul style="list-style-type: none"> Drift algae are difficult to quantify Blooms can be very localised or not associated with "human sources" Labour intensive 	Medium	Medium	WSC, DIPNR (via estuarine indicator work)
	KG4d. Seagrass (depth, distribution, length, density, epiphytic growth)	<ul style="list-style-type: none"> Extent and growth represent longer time scales of potential human disturbance Abundant and well distributed population 	<ul style="list-style-type: none"> Labour intensive Licences may be required from DPI (Fisheries) Interpretation 	Medium	Medium	WSC, DIPNR (via estuarine indicator work), DPI (Fisheries)
	KG4e. Phytoplankton populations	<ul style="list-style-type: none"> Changes in population represent small scale changes in nutrient status Abundant and well documented spatial and temporal data available for Tuggerah Can indicate changes to eutrophic status Identify toxic species for primary contact 	<ul style="list-style-type: none"> Labour intensive Interpretation 	Medium	Medium	WSC, DIPNR (via estuarine indicator work)

9.3 COMMUNITY EDUCATION AND INVOLVEMENT

Objective KC: Ensure community is pro-actively involved in estuarine health and management

Wyong Shire Council is inextricably linked with the Tuggerah Lakes estuary as almost all of the catchment of the estuary is contained within its administrative boundaries. The community is concerned about the management of the estuary. Unfortunately a number of misconceptions about estuarine issues, health and management exist in the community.

In order to generate meaningful debate within the community and to encourage the community to participate in estuarine management, a significant amount of public education is required. This should increase the visibility and transparency of Council's estuarine management programmes.

9.3.1 Issues & Threats

KC1. Existing community perceptions about estuarine health

The estuary drains approximately 800 km² of catchment. In a simplistic sense, it could be considered as a riverine dam that happens to have an opening to the ocean. Some community perceptions exist that relate the location of the estuary near to the ocean as a reason for the estuary being more marine in nature (and having more marine characteristics such as sandy beaches and clear water). These perceptions can influence debate about the “state” and “health” of the estuary. These perceptions should be addressed to mitigate the political pressure for alterations to the functions and processes within the estuary.

KC2. Community scepticism about available estuarine knowledge, management intentions and management approach

There is some scepticism in the community about the understanding and level of commitment that Council and the State Government have for the estuary. In reality, significant resources and funding have been expended on the estuary, to attempt to both better understand it and in doing so, better manage it. The lack of publicity surrounding each new piece of information, or each new managerial approach have probably fuelled speculation that nothing is being done, and that the estuary is not a high priority. The success of the Estuary Management Plan is contingent on this scepticism being addressed.

KC3. Emotional responses

When community meetings are held, attendees generally wish to address specific areas which they are concerned about. Furthermore, press reports can fuel negative sentiment about the estuary by focussing on emotive or “bad news”. In order to get the community at large to be both positive and proud of the estuary, mechanisms need to be found for bringing all available information to their attention, and allowing them to be part of a transparent and accountable estuarine management process.

KC4. General public are not actively informed through the most effective media channels

Negative opinions regarding the health and state of the estuary are often the result of insufficient information about the role of the estuary and in fact, insufficient information on what a healthy Tuggerah Lakes would look like. Information on the estuary (both positive and negative) is not currently delivered in a way that engages or educates the wider public. This can encourage the persistence of negative perceptions about the state of the estuary.

If the community were kept completely informed (through whatever mechanisms are appropriate) of the real issues and the real options, it is likely that the vast majority of the community would support the current managerial approach and perhaps take on a greater sense of ownership in catchment and estuarine management practices.

9.3.2 Options

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
KC1. Existing community perceptions about estuarine health	KC1a. Undertake targeted large-scale education programme about state of estuary and debunking misconceptions <ul style="list-style-type: none"> • Newspapers • Shire wide • Radio interviews • Handouts 	<ul style="list-style-type: none"> • Provide the community with the knowledge that they require to make informed judgements about the state of the estuary and proposed management actions • Community will understand why it appears as though “nothing is being done” 	<ul style="list-style-type: none"> • Will not convince sceptics • May generate responses in excess of what Council can manage 	Med-High	High	WSC
KC2. Community scepticism about available estuarine knowledge, management intentions and management approach	KC2a. Increase transparency and visibility of estuarine knowledge and management approaches <ul style="list-style-type: none"> • Make results and studies available on Council website • Increase role and power of Estuary and Coastal Management Committee to make decisions and allocate funding • Provide online fact sheets about key estuarine issues 	<ul style="list-style-type: none"> • Reassures community that there are no actions being taken “behind closed doors” • Provides interested community members with up to date information on the estuary (important to nurture interested parties) • Web is becoming increasingly important mechanism for distributing information to the community 	<ul style="list-style-type: none"> • May create problems with intellectual property for 3rd party contractors • Increased powers for EMC under current charter is unlikely to be supported 	Low-Med	High	WSC

Issue	Option	Outcomes		Cost	Ability to address Issue?	Responsibility
		Benefits	Difficulties			
KC3. Emotional Responses	KC3a. Investigate ways of harnessing community curiosity and interest in the estuary <ul style="list-style-type: none"> Field days Site visits Fact sheets Create "Lake Watch" groups 	<ul style="list-style-type: none"> More likely to create network with interested members of the community who can then be advocates for the estuary with their peers Site visits can be an opportunity for people to discuss issues of concern and get hands on information about the estuary 	<ul style="list-style-type: none"> Liabilities associated with taking groups on site visits Potential for increase degradation of sensitive areas if groups are not well managed 	Low	High	WSC
KC4. General public are not actively informed through the most effective media channels	KC4a. Increase media reports about estuarine activities and monitoring results – raise awareness and interest <ul style="list-style-type: none"> Newspapers Website Shire wide 	<ul style="list-style-type: none"> Puts the estuary back on the public agenda Attracts interested community members to estuarine management Ensures the public is kept informed, and that the most recent information is available to them 	<ul style="list-style-type: none"> Potential intellectual property issues for 3rd party contractors There are a number of points of view on estuarine management –these may not change with education Education may be challenged as biased towards the environment depending on how the information is presented 	Low-Med	High	WSC

9.4 RECOMMENDATIONS

9.4.1 Issues Identified by Reference Groups

The following issues were identified by business, community and technical reference groups as being most important to them out of a list of all knowledge improvement issues.

1. Community scepticism about available estuarine knowledge, management intentions and management approach (KC2)
2. Funding and resourcing further studies into estuarine processes, health trends and key management questions (KG1)
3. Understanding of key estuarine processes is not complete (KG3)
4. Existing community perceptions about estuarine health (KC1)
5. General public are not actively informed through the most effective media channels (KC4)

9.4.2 Suggested Programmes

Programmes	Associated Options
Prepare and implement an ongoing community information and education programme about estuarine health using websites, newspapers, Council columns and field days	KC1a, KC2a, KC3a, KC4a, SP4a, SP4b, SP4c
Develop partnerships with universities to get innovative approaches to managing the catchment and estuary in a sustainable manner	KG1b, KG2c
Develop funding strategies to ensure on-going and dedicated catchment and estuarine management programmes	KG1a, KG1b
Provide a process for addressing key estuarine processes & management questions such as faecal coliform sources, fishery status, bio-indicators, groundwater, sea level rise and mixing	KG3a, KG4a, KG4b, WH1a
Improve pollution source control through education of community, industry & tourists	WE4c, WE2a, VW3f, VE3b, VR2c, DC3c, DT1e, SP3a
Develop incentives for the community to encourage sustainable use of water and pollutant reduction	WE3b, WS1a, WS1b, WS1c, WS1f, WG1a, WG1b
Explore the development of an independent authority to oversee programmes and expenditure for estuarine management	KG2b, KG1a, KC2a

10 Discussion and Recommendations

10.1 ESTABLISHING PRIORITIES

The list of options contained in Chapters 4 to 9 is extensive. It includes some focused options for improving estuarine or catchment management, and also some new ideas. The options required some prioritisation before consolidating them into programmes that can be actioned in the Estuary Management Plan.

The prioritisation was done by asking the technical, business and community reference groups to rank the issues that were most important to them for each of the principle areas (i.e. water, vegetation etc). The responses from each of the reference groups were given equal weighting, averaged and then ranked highest to lowest. The priority issues were summarised in the conclusions of each of the principle areas. Where it was felt that an important issue had been overlooked, it was included along with the associated options.

The options associated with each of the priority issues were combined where possible to form a more inclusive programme to take to the management planning stage. These programmes are listed in Section 10.2 along with relevant organisational details.

10.2 PRIORITY PROGRAMMES

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
1.	Streambank rehabilitation and erosion protection	<ul style="list-style-type: none"> ▶ Couple with the catchment audit programme to target most affected areas ▶ Incorporate measures to limit activities that cause erosion (boatwash etc) ▶ Link with existing programmes such as Landcare where possible 	WE7, VR3	Catchment streams	Works	WSC, DOL, GWCWA, DIPNR, DPI(Forests), DEC (Parks & Wildlife) Landholders
2.	Stormwater management in new urban areas focussing on sediment and nutrient management, water sensitive urban design and producing more natural flows for downstream environments	<ul style="list-style-type: none"> ▶ Combine with developer partnerships to explore innovative ideas ▶ Set clear, measurable stormwater performance guidelines ▶ Focus on providing natural downstream flow and as close as possible to no net increase in sediment and nutrient load (IWCM and stormwater harvesting can reduce flows) ▶ Place requirements on developers to prove compliance ▶ Link DCP 67 with key stormwater reference material 	WE3, WF1, WG1, VF1, VR1, VR2	Urban	Works	WSC, CMA's, Developers, Community
3.	Retrofit stormwater interventions in existing urban areas focussing on sediment and nutrient management, contaminants and gross pollutants	<ul style="list-style-type: none"> ▶ Couple with the catchment audit programme to target highest polluting catchments ▶ Research models and use to estimate likely loads, calibrate using field data such as GPT sediment collected ▶ Implement treatment train for retrofits. Once priority catchment is identified examine all areas in the catchment for compliance, education and controls 	WE2, WF1, VF1, VR1, VR2	Urban	Works	WSC, Community

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
4.	Undertake a programme of works to restore degraded or threatened habitat through rehabilitation, strategic land protection and active management of invasive species (e.g. weeds)	<ul style="list-style-type: none"> ▶ Use existing Council GIS information to identify habitat ▶ Develop a prioritisation system for remediation ▶ Explore innovative strategies for remediation and future protection ▶ Utilise community and environmental action groups to assist with proposed programmes 	DT1, DC1, VW3, VF3, VR3	Catchment	Works	WSC, DPI (Forests), DEC (Parks & Wildlife), CMA's, Landholders, Community Groups (e.g. Birding NSW)
5.	Foreshore management programme including identification and passive/active rehabilitation of key habitats such as saltmarsh and fringing wetlands, and managing threatening processes on public and private lands	<ul style="list-style-type: none"> ▶ Identify all sensitive and threatened foreshore communities ▶ Appraise effects of recreational and maintenance activity and recommend modifications if necessary ▶ Designate all foreshore areas as recreational zone or passive/active rehabilitation areas ▶ Incorporate an education component for foreshore residents and maintenance workers operating in these areas 	VE1, DT1, VE3, DS1	Foreshore	Works	WSC, DPI (Fisheries), DEC (Parks & Wildlife), Community Groups (e.g. Birding NSW)
6.	Improve facilities in designated recreation areas based on community consultation including additional seating, BBQ's, picnic areas, educational signage, upgraded boat ramps	<ul style="list-style-type: none"> ▶ The aim is to encourage greater use of the foreshore ▶ Undertake some community consultation to determine what improvements are desired ▶ Utilise Maritime Authority WADAMP funding to improve maintenance of boat ramps ▶ Focus on providing facilities that may increase community education (signage) and foreshore interaction (e.g. landscaping) 	SP5, SP1	Foreshore	Works	WSC, Maritime Authority

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
7.	Limit public access to ecologically sensitive areas of the foreshore and estuary where necessary, including saltmarsh (e.g. Tuggerah Bay) and seagrass habitat (e.g. Budgewoi Sandmass)	<ul style="list-style-type: none"> ▶ Determine whether there is an ecological need to do this and if so where it might be appropriate ▶ Examine mechanisms for preventing access if needed ▶ Provide information to the public clearly explaining why the exclusions are necessary (i.e. for rehabilitation or protection) 	DT1, DS1, DF4, VE3, VE4	Foreshore Estuary	Works	WSC, DOL, DEC (Parks & Wildlife), Community Groups (e.g. Birding NSW)
8.	Audit sub-catchments for environmental compliance including sediment/erosion and contaminant controls	<ul style="list-style-type: none"> ▶ Combine with the catchment audit process to target catchments likely to be most pollution ▶ Work through the whole catchment – not just development areas to assess industry and landholders control and compliance measures ▶ Work with people to co-operatively develop solutions rather than fining in the first instance 	LA2, LS2, LS3, WE2, SC3	Catchment	Monitoring	WSC, Industry Community
9.	Develop a catchment audit process for assessing high risk catchments and prioritising interventions	<ul style="list-style-type: none"> ▶ Examine the use of qualitative models to assess likely catchment load contributions ▶ Tie in with the Central Coast Stormwater Monitoring Programme from the Blueprint ▶ Calibrate with field data such as existing water quality information or material collected in GPT's (compare catchment outputs and collection rates) 	WE2, WE4, WH3	Catchment	Monitoring	WSC, CMA's
10.	Continue to monitor faecal coliforms at recreational locations	<ul style="list-style-type: none"> ▶ Continue existing programme ▶ Tie to resolving key management questions about faecal sources in the estuary and target sources 	WH4	Estuary	Monitoring	WSC

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
11.	Monitor key wetlands for degradation and changes in condition	<ul style="list-style-type: none"> ▶ Identify SEPP 14 wetlands and other key natural wetlands considered important habitats and those performing a water quality improvement function (use GIS) ▶ Investigate appropriate monitoring programmes including both qualitative and quantitative methods ▶ Fund and resource an ongoing monitoring programme and develop a series of triggers for action (i.e. undertake Action A when Condition C is reported) ▶ Adhere to wetlands determination 	VW1	Catchment	Monitoring	WSC, CMA's, Landholders
12.	Develop a population strategy that is based on what environmental changes the estuary, rivers and catchment can sustain rather than on available land	<ul style="list-style-type: none"> ▶ Investigate appropriate methods for determining what catchment and runoff changes could be absorbed by the rivers and estuary before health suffers ▶ In particular look to pressures from stormwater quality, water supply extraction and habitat degradation and removal ▶ Use these limits to set sustainable population, employment and development limits 	SC1, SC2, SE2, SE3, LS3, WP1, VF2, DC2, DF3		Strategy	WSC, GWCWA, DIPNR, DPI (Forests), DPI (Fisheries), DPI (Agriculture), DEC, CMA's, Landholders, Universities, Community
13.	Develop partnerships with universities to get innovative approaches to managing the catchment and estuary in a sustainable manner	<ul style="list-style-type: none"> ▶ Examine areas of catchment and estuarine management that require some innovation/new ideas and find local universities that can provide technical expertise in these area ▶ Put together a partnership that enables students and university staff to work with Council on estuarine and catchment issues 	KG1, KG2		Strategy	WSC, Universities

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
14.	Develop partnerships with developers and business operators to get innovative approaches to managing the catchment and estuary in a sustainable manner	<ul style="list-style-type: none"> ▶ Look at ways of using business and operator knowledge to arrive at catchment and estuarine objectives rather than solely using predetermined criteria ▶ Focus on innovative ideas that will clearly provide a better way of managing catchment loads and estuarine health e.g. water reuse ▶ Where new methods are being advocated, there should be provision for assessing their effectiveness before implementing 	LA1, LA2, LD2, LS1, WE3, WP1, DC1, DC3,		Strategy	WSC, Developers, Industry, Landholders
15.	Explore the development of a central body to oversee programmes and expenditure for estuarine management	<ul style="list-style-type: none"> ▶ Gauge community feeling before exploring this option, it is in response to perceptions in the community about a lack of information and transparency regarding estuarine management ▶ Should only be considered after extensive community education has failed to provide confidence to the community ▶ Examine how a central body could work in terms of funding, organisation, reporting, representation and accountability (look at the examples of Lakes Macquarie and Illawarra) ▶ Consider strengthening existing bodies (e.g. giving the Estuary and Coastal Management Committee more power to make decisions and allocate funding) 	KG2, KG1, KC2		Strategy	WSC, DOL, GWCWA, DIPNR, DPI (Fisheries), DEC (Parks & Wildlife), CMA's, Community

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
16.	Develop funding strategies to ensure on-going and dedicated catchment and estuarine management programmes	<ul style="list-style-type: none"> ▶ Examine existing funding arrangements, grant opportunities ▶ Liaise with State/Federal agencies to determine where existing programmes could be used for mutual benefit ▶ Consider approaching the community with a fully costed programme and asking for a general rate rise to fund the works provided they are kept informed of expenditure and can see value for money 	LS4, KG1		Strategy	WSC, CMA's, Community
17.	Develop strategies to identify and manage key remaining catchment habitats	<ul style="list-style-type: none"> ▶ Tie with a sustainable population strategy ▶ Identify priority habitats and strategies for rehabilitation 	VW1, VF2, VR4, DC1, DC2, DC3, DT1, DT2, DS2		Strategy	WSC, DIPNR, DPI (Forests), DPI (Agriculture), DEC (Parks & Wildlife), CMA's, Landholders
18.	Maintain ocean entrance dredging programme	<ul style="list-style-type: none"> ▶ Investigate effects of ocean entrance dredging on physical, chemical & biological processes. ▶ Develop flood, safety and ecological triggers for dredging ▶ Provide funding and resources for an ongoing dredging programme 	WP3, WE6	Estuary	Maintenance	WSC, DIPNR, DPI (Fisheries), DEC, Community
19.	Maintain river mouth dredging on a rolling 5yr programme for Tumbi, Ourimbah, Wyong, and Wallarah/Spring Creeks	<ul style="list-style-type: none"> ▶ Develop triggers to dredge for flooding and navigation ▶ Provide funding and resources for an ongoing dredging programme ▶ Couple with streambank and foreshore erosion programmes and catchment audit programmes and interventions 	WP3, WP2, WF2	Estuary Rivers	Maintenance	WSC, DIPNR, DPI (Fisheries), DEC, Community

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
20.	Continue to maintain stormwater treatment devices ensuring performance data are collected and analysed	<ul style="list-style-type: none"> ▶ Provide funding and resources for maintenance of increasing numbers of devices ▶ Ensure traps comply with OHS legislation ▶ Engage crews in design process to improve ownership ▶ Gather data on quantities of material removed, locations and times 	WE2	Catchment streams	Maintenance	WSC, Community
21.	Designate foreshore recreational areas and manage/encourage maximum recreational use and enjoyment including beach cleaning and wrack management	<ul style="list-style-type: none"> ▶ Investigate areas for rehabilitation and for recreation ▶ In recreation areas, provide for maximum public amenity ▶ Beach cleaning, wrack management, beach nourishment, landscaping 	SP1, SP2	Foreshore	Maintenance	WSC, DOL, DEC (Parks & Wildlife), Landholders, Community
22.	Maintain identified foreshore rehabilitation areas, protect sensitive habitats and educate community about the habitats	<ul style="list-style-type: none"> ▶ Investigate areas for rehabilitation and for recreation ▶ In rehabilitation areas, allocate funding and resources for maximum ecological protection ▶ Provide informative signage for the community to educate them about this environment 	VE3, VE4, DS1	Foreshore	Maintenance	WSC, DOL, DEC (Parks & Wildlife), Landholders, Community Groups (e.g. Birding NSW)
23.	Provide a process for addressing key estuarine process & management questions such as faecal coliform sources, fishery status, bioindicators, groundwater, sea level rise and mixing	<ul style="list-style-type: none"> ▶ Develop a process for continually reviewing and defining key management questions ▶ Consider forming an advisory panel to select important management questions and assist in framing methods for resolving them including resolution of performance indicators ▶ Provide funding for ongoing research as needed 	KG3, KG4, WH1	Estuary	Research	WSC, CMA's

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
24.	Conduct appropriate research into riverine ecological processes and water quality to support environmental flow management	<ul style="list-style-type: none"> ▶ Review the recommendations from the Expert Review Panel and Water Sharing Plans ▶ Investigate the ecology of the streams in order to determine if flow regulation is affecting river and estuarine health ▶ If improving flows to the estuary was thought to be beneficial, examine ways of doing this without impacting on water supply 	WF5, VR5	Catchment Streams	Research	WSC, GWCWA, DIPNR, DPI (Forests), DPI (Fisheries), DPI (Agriculture), CMA's, Landholders
25.	Prepare and implement an ongoing community information and education programme about estuarine health using websites, newspapers, Council columns and field days	<ul style="list-style-type: none"> ▶ Review a range of media for providing this information ▶ Information should be easily understood by the general community ▶ Provide opportunities for the community to get "interactive" with estuarine elements including field trips ▶ Focus specifically on ways of empowering the public to participate in estuarine management, and on improving the image and expectations of the estuary 	KC1, KC2, KC3, KC4, SP4		Education	WSC, CMA's, Community
26.	Improve pollution source control through education of community, industry & tourists	<ul style="list-style-type: none"> ▶ Tie with ongoing community education campaign and auditing catchments for compliance ▶ Develop ways for businesses and the community to improve their own contributions to catchment and estuarine health ▶ Provide funding and resources for signage and leaflets at key locations such as The Entrance ▶ Distribute advisories to public information places such as the Tourist Information and DPI (Fisheries) offices 	WE4, WE2, VW3, VE3, VR2, DC3, DT1, SP3		Education	WSC, CMA's, Community

Item #	Priority Programmes	Components	Issues Addressed	Location	Type	Responsibility
27.	Develop incentives for the community to encourage sustainable use of water and pollutant reduction	<ul style="list-style-type: none"> ▶ Consider a range of incentive schemes from discounting charges to provision of free resources ▶ The aim is to empower the community to make changes at a local level 	WE3, WS1, WG1		Strategy	WSC, GWCWA, CMA's, Landholders, Community

10.3 REPORTING

10.3.1 Community

The community are the largest stakeholder group in the Tuggerah Lakes catchment and have a strong desire to see the estuary managed in a sustainable and responsible way. There are a number of ways that the study recommendations and information on the estuary can be presented to the community such as:

- Council web pages or a separate Tuggerah Lakes website
- The “Shire Wide” newsletter
- Councils column in local newspapers
- Letters in Council mail (such as with rates or water notices)

Providing the community with strong feedback on estuarine health and management achievements should begin to turn the tide of negative sentiment and unrealistic expectations about the appearance of the estuary. The information should be presented in a clear and concise way and be designed to educate as well as inform. Armed with better information, the community will be able to understand the importance of catchment interventions and what they can do in their own backyards to reduce the pressure on the estuary. The community will also be better able to exert political pressure for funding priority programmes if their reasoning is based on robust and up to date information.

10.3.2 External Agencies

Council has a commitment under the Local Government Act (1993) to provide an annual State of the Environment (SOE) Report to the Department of Environment and Conservation. The SOE has eight reporting areas some of which overlap with key areas of the Estuary Management Programme. The SOE must be prepared annually and is used to report environmental status internally as well as to the community and State agencies. Given both the timing and the audience of the SOE, the progress of estuarine management planning could easily be reported to external agencies using existing resources.

SOE Components	Corresponding Estuarine Management Study Section
Air	N/A
Biodiversity	Vegetation Management, Diversity & Threatened Species
Heritage	Land Use and Human Settlement

SOE Components	Corresponding Estuarine Management Study Section
Land	Land Use and Human Settlement
Noise	N/A
Water	Water Quality and Quantity
Waste	N/A
Ecologically Sustainable Development	Social and Economic Needs

10.3.3 Reporting Using Indicators

It was the intention to have a range of estuarine and catchment management indicators developed during the preparation of the Estuary Management Study. It has since been decided that the Estuary Management Plan is a more appropriate place to explore these indicators given their low level of development in the scientific and estuarine managerial community.

Most estuarine and catchment management indicators are based on the state of the particular environment being reported on. Expansion of the indicators could be considered to include the full pressure/state/response model (OECD, 1993) as this forms the basis for state of the environment reporting at local, State and Federal levels of government. Using this model, indicators could be developed for the pressures being experienced by the catchment and estuary (e.g. increasing development), the state of the environment (e.g. macroalgal blooms) and the success of the managerial responses (e.g. lower levels of streambank erosion).

10.4 LINKING WITH KEY DOCUMENTS

10.4.1 Catchment Action Plans

The Central Coast Catchment Blueprint identified a number of key actions that were required to meet catchment and managerial targets. The actions are currently being devolved into a Catchment Action Plan (CAP) for the new Hunter Central Rivers Catchment Management Authority (CMA). This plan lists all the fundable actions that will be addressed by the CMA over the next 5 years. There are likely to be several actions identified in the CAP that correspond with the programmes listed in Section 10.2 and these should be assessed as soon as the plan is available. It is important to ensure that these overlaps are identified so that wherever possible external funds and resources can be used to resolve local problems.

10.4.2 Departmental Business Plans

Departments within Wyong Shire Council use documents called Business Plans to direct annual programmes and account for expenditure, which is then reported in Council's annual

Management Plan. The Estuary Management Study is structured to enable a cross-Council team approach to managing identified actions. This team approach will mean that different departments will be required to undertake different catchment and estuarine management actions. Each action required of a particular department should be costed and included in the Business Plan to ensure that it has visibility and forms part of the deliverables in a given year.

10.4.3 Relevant Agency Plans

A number of the State agencies operating in the catchment and estuary have their own managerial documents which are used to direct and fund particular operations. DPI (Forests), Department of Conservation (Parks and Wildlife Division) and DPI (Fisheries) all have plans of management for their respective areas of operation. These documents should be reviewed periodically (in consultation with the agency) to determine if they have programmes and plans in place that can be harnessed to achieve catchment and estuarine outcomes.

11 Estuary Management Plan

11.1 PREPARATION OF THE PLAN

An Estuary Management Plan is the scheduled sequence of recommended activities that need to be undertaken to achieve the estuarine management objectives. Completion of the management study will provide a sound basis for the formulation of the Management Plan, which takes into account the considered views of all stakeholders. The Plan may require trade-offs and compensatory balances if differing viewpoints are to be accommodated. Activities incorporated in a management plan may include nature conservation, rehabilitation, development education and other matters. The Estuary Management Plan will be subject to public display and review. After public display and any necessary amendments, the Estuary Management Plan will be formally adopted (DLWC, 1992). This process will follow the adoption of the Estuary Management Study. The study has been subjected to a process of peer review from academics, technical experts and estuarine managers responsible for implementing actions that will be determined in the Estuary Management Plan. It is expected that a draft Estuary Management Plan will be released for public comment in 2005.

11.1.1 Developing and Implementing Action Plans

A suggestion for implementing the Estuary Management Plan was to have a number of standalone action plans that are divided along the six principle areas (i.e. a Water Action Plan, Vegetation Action Plan etc.). These standalone plans could serve a number of purposes including team development, managing organisational change and capacity building. Team development is very important in a large organisation managing a large natural resource. The issues are complex and resolving them requires input from a number of professional backgrounds. It is hoped that a team approach would be used that enables members to draft, cost and implement actions within each standalone plan. This is important because firstly it encourages a sense of ownership. Secondly, by using multi-disciplinary teams, individuals can become information sources among their colleagues, spreading catchment and estuarine management information through the organisation and into the community. The other advantage of using a team approach for the standalone plans is that people will be exposed to the idea that catchment and estuarine management involve a number of interactive components that all need to be managed. It is not just a case of correcting a single issue or meeting a single objective, nor is it the responsibility of any one department.

11.1.2 Consultation with Stakeholders and Representative Groups

The standalone action plans can be used to obtain and direct input from representative groups during the development of the overall plan. For example, the Chamber of Commerce

may wish to have input into the plan. This can be incorporated within a “Social and Economic Needs” action plan, assuming their input relates to economic issues voiced by their constituents. Likewise, a Rivercare or Landcare group may be concerned about the level of attention given to invasive species or the health of riparian vegetation in the catchment. They could be invited to comment on the Vegetation action plan. In this way, consultation can occur in a targeted way without needing to digest the entire plan.

11.1.3 Securing Funding

Funding the actions that will be identified in the Estuary Management Plan is critical to being able to achieve on-ground results. There are number of ways that such funding could be secured. If the team approach is established correctly, funding could be sourced cross-Council rather than rely on a single department. Using people from various departments as part of a team may expose internal funding opportunities or complimentary projects that could be harnessed to meet the objectives of the team without looking for external funding. Smaller regional Councils (e.g. Albury City Council) do this very effectively because their smaller size tends to preclude the development of large departments which can operate as “silos” in larger organisations.

As mentioned in Section 10.4.3, liaising with State agencies and in particular reviewing their programmes and plans can reveal areas where mutual outcomes could be achieved using agency funds. An example of this is the 50/50 grant funding available through the Maritime Authority’s WADAMP programme that could be directed at boat ramp upgrades around the estuary.

In terms of securing long term funding for catchment and estuarine management, an option that could be used is seeking a levy or rate rise from ratepayers. Other Councils (e.g. Dubbo, Manly, Hornsby, Penrith) have successfully presented this to the community and have had their support. It appears that the community are more supportive when they are presented with clear directions on the programmes required, evidence of the costs and more importantly constant updates on works undertaken, improvements in environmental quality and an indication of how their money is being spent. It seems that the average rise is between \$50-\$70 a year per household. For Wyong, that would equate to between \$2.9 million and \$4.1 million annually for estuarine and catchment management programmes (assuming 58,000 rateable properties).

11.1.4 Measuring Performance

Ideally, some form of performance indicator should be used to determine whether the objectives set in the study are being met. There is some contention about how to define what a “well-managed” or “healthy” estuary would look like. Without identifying this, it is difficult to determine whether the current managerial approach is bringing one closer to a well-managed

or healthy estuary, or whether a change in direction is required. At this stage it is expected that a review panel would be convened to determine an appropriate system of performance measurement using estuarine and catchment indicators.

11.2 PERIODS OF REVIEW

The Estuarine management planning process is not static. Both the Estuary Management Study and Plan are expected to be “living” documents, being updated with new information as it becomes available and ensuring that the management of the estuary is truly “adaptive”.

While the Estuary Management Study produces options, these are not definitive and are intended to guide the development of the detailed actions that will be defined in the management plan. Figure 42 provides a suggested review timeline for the key elements of the Estuary Management Study and Plan.

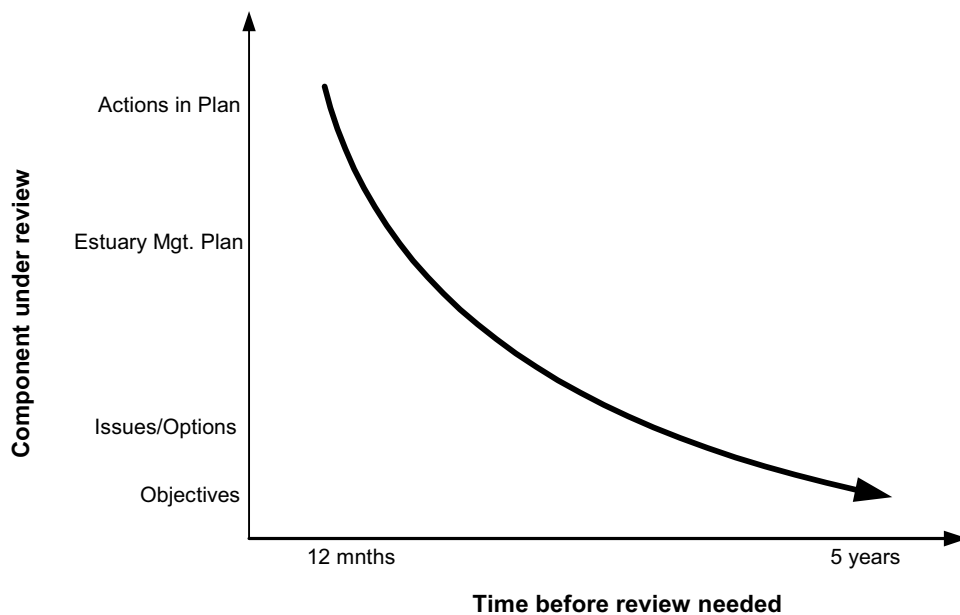


Figure 41. Suggested review periods for various measures in the estuarine management planning process

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Mr Geoff Sainty (Sainty & Associates Pty Ltd)

Prof Bruce Thom (DIPNR - Coastal Policy Unit)

Dr Bob Creese (Department of Primary Industries - Fisheries)

Dr Peter Scanes (Department of Environment and Conservation)

Mr Mike Geary (Coast and River Environmental Engineering)

Mr Bruce Coates (Department of Infrastructure, Planning and Natural Resources)

Organisations and Individuals who made Submissions in the Exhibition Phase

The Entrance Precinct Committee

Community Environment Network Inc.

Mr Tom Lyons (Long Jetty)

Mr B. J. Smith (Norahville)

Birding NSW, Field Ornithologist Club Inc.

Toby Scheitel (Wyongah)

Forests NSW

The Combined Community Organisation (Gosford District) Inc.

Gosford Wyong Councils Water Authority

13 References

- Abal, E. G., Lonergan, N., Bowen, P., Perry, C. J., Udy, J. W., Dennison, W. C. (1994). Physiological and morphological responses of the seagrass *Zostera capricorni* Aschers to light intensity. *J. Exp. Mar. Biol. Ecol.*, 178: 113-129.
- Adams, J. (2000). Distribution and abundance of wrack associated macrofauna and the effects of wrack cleaning activities, Tuggerah Lakes, New South Wales. Honours Thesis. University of Newcastle.
- ANZECC, (1992). Australian water quality guidelines for fresh and marine waters, Australian and New Zealand Environment and Conservation Council.
- ANZECC (1998). Australian water quality guidelines for fresh and marine waters. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council.
- Barnes, P. (2004). The ecology of Suberites in NSW coastal lakes. University of Wollongong.
- Batley, G. E., Body, N., Cook, B, Dibb, L, Fleming, P.M., Skyring, G. (1990). The ecology of the Tuggerah Lakes system. A review: with special reference to the impact of the Munmorah Power Station. CSIRO Division of Fuel Technology and The Murray Darling Freshwater Research Centre.
- Bayne, B. L., Grant, A. J., Trautman, D. A. (1999). Effects of added nutrients on the increase in biomass of benthic macroalgae in the Tuggerah Lakes. *Ecological Impacts of Coastal Cities*, University of Sydney.
- BOM (2004). Climate Change. Bureau of Meteorology website
<http://www.bom.gov.au/lam/climate/levelthree/climch/climch.htm>. Bureau of Meteorology. Melbourne.
- Bourguès, S., Ajani, P., Carpenter, M., Coade, G., Scanes, P., Koop, K. (1998b). Nutrients and phytoplankton status in the Tuggerah Lake after a flood event. NSW Environment Protection Authority, Sydney.
- Bourguès, S., Carpenter, M., Coade, G., Scanes, P., Koop, K. (1998a). Sediment-water fluxes of oxygen and nutrients in Tuggerah Lakes. NSW Environment Protection Authority, Sydney.
- Casey, K. J. (2001). The spatial and temporal variation associated with seagrass, fauna and water quality in the Tuggerah Lakes, NSW, with an assessment of an aquatic wrack harvester. PhD Thesis, University of Newcastle.
- CCCMB (2003). Central coast catchment blueprint. Central Coast Catchment Management Board, Sydney, NSW.
- Chapman, M. G. (2004). A preliminary survey of macrofauna adjacent to seawalls in Lake Macquarie. Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney.

Chapman, M. G., Roberts, D. E. (2004). The use of seagrass wrack in restoring disturbed Australian saltmarshes. *Ecol. Man. Rest.*, 5: 183-190.

Chapman, M. G., Underwood, A. J. (1997). Concepts and issues in restoration of mangrove forests in urban environments. *Frontiers in Ecology, Building the links*. Elsevier Science, Oxford Ltd.

Chapman, M. G., Underwood, A. J. (2003). Variable growth of the green alga, *Chaetomorpha linum* in the Tuggerah Lakes, Final report to Wyong Shire Council. Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney.

Cheng, D. (1997). Phytoplankton monitoring in the Tuggerah Lakes. University of Technology, Sydney.

Collett, L. C., Collins, A. J., Gibbs, P. J., West, R. J. (1981). Shallow dredging as a strategy for the control of sublittoral macrophytes: a case study in Tuggerah Lakes New South Wales Australia. *Aust. J. Mar. Freshw. Res.*, 32: 563-572.

Commonwealth of Australia, (1992). Intergovernmental Agreement on the Environment. Commonwealth of Australia. Canberra.

Constable, A. J., Fairweather, P. G. (1999). Ecology of estuaries and soft-sediment habitats: symposium introduction. *Aust. J. Ecol.*, 24: 289-290.

Conyers, B. (2004). Correspondence: Tuggerah Lakes estuary study. NPWS Central Coast Hunter Range Region.

Coull, B. C. (1999). Role of meiofauna in estuarine soft-bottom habitats. *Aust. J. Ecol.*, 24: 327-343.

Cummins, S. P. (2000). The distribution and abundance of macrobenthic organisms in a shallow, coastal lagoon. Honours thesis, University of Newcastle.

Cummins, S. P., Daley, H., Roberts, D. E., Walkerden, G. (2000). Macroalgal distribution in relation to developed and undeveloped foreshores around the Tuggerah Lakes estuary, NSW. Wyong Shire Council.

Cummins, S. P., Roberts, D. E., Ajani, P., Underwood, A. J. (2004a). Comparisons of assemblages of phytoplankton between open-water and seagrass habitats in a shallow coastal lagoon. *Mar. Freshwater Res.*, 55: 447-456.

Cummins, S., Roberts, D., Church, A., Ling, J. (1997). Invertebrate associations in macrophyte assemblages within the Hawkesbury-Nepean River, NSW. *Science and Technology in the Management of the Hawkesbury-Nepean Catchment*, Geographical Society NSW, 14: 36-40.

- Cummins, S. P., Roberts, D. E., Walkerden, G. (1999). Water quality dynamics in the Tuggerah Lakes estuary. Wyong Shire Council.
- Cummins, S. P., Roberts, D. E., Zimmerman, K. D. (2004b). Effects of the green macroalgae *Enteromorpha intestinalis* on macrobenthic and seagrass assemblages in a shallow coastal estuary. *Mar. Ecol. Prog. Ser.*, 266: 77-87.
- Daley, H. (1997). Seagrass and macrofaunal distributions in Tuggerah Lake: a comparison of disturbed and undisturbed locations. Honours Thesis, University of Newcastle.
- Day, J. W., Hall, C. A. S., Kemp, W. M., Yáñez-Arancibia, A. (1989). *Estuarine ecology*. John Wiley & Sons, Brisbane.
- Davis, J. (1999). Epiphytes as indicators of nutrient status in the Tuggerah Lakes estuary. Progress Report. University of Newcastle.
- Dennison, W. C. (1987). Effects of light on seagrass photosynthesis, growth and depth distribution. *Aquat. Bot.*, 27: 15-26.
- Dickinson, T. (1997). The sediments of Tuggerah Lakes: their composition, importance and management. Environmental Engineering Thesis, University of Newcastle.
- Dickinson, T. (1999). Urban stormwater management plan for the Tuggerah Lakes and coastal catchments. Wyong Shire Council.
- Dickinson, T. G., Roberts, D. E., Hunter, G. J., Sainty, G. R. (2005). Stormwater quality and hydrology monitoring programme for the central coast. Report to DIPNR. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology, Narara.
- DIPNR (2003a). Water sharing plan for the Jilliby Jilliby Creek water source. Department of Infrastructure, Planning and Natural Resources, Sydney.
- DIPNR (2003b). Ourimbah Creek water sharing plan. Department of Infrastructure, Planning and Natural Resources, Sydney.
- DIPNR (2003c) Catchment Management Authorities – their role in delivering the reform programme. Department of Infrastructure, Planning and Natural Resources, Sydney.
- DIPNR (2003d). Water sharing plan for the Ourimbah Creek water source. Department of Infrastructure, Planning and Natural Resources, Sydney.
- DLWC (1992). Estuary management manual. New South Wales Government.
- DLWC (1997). Water reform fact sheet number 10. NSW Department of Land and Water Conservation, Sydney.

- DLWC (2001). Floodplain management manual. Department of Land and Water Conservation, Sydney.
- DLWC (2002). Regional vegetation management planning in New South Wales. Department of Land and Water Conservation, Sydney.
- DPI Fisheries (2004). Fishery management strategies performance report 2004. NSW Department of Primary Industries.
- DPWS (2002). Gosford-Wyong Joint Water Supply Scheme investigation of options for further development. Working Paper 8 catchment and forest hydrology issues. Gosford-Wyong Councils Water Authority.
- Duarte, C. M. (1995). Submerged aquatic vegetation in relation to different nutrient regimes. *Ophelia*, 41: 87-112.
- Duchatel, K. (1998). Colongra Wetland subsidence impact assessment. Sainty and Associates Pty Ltd., Potts Point.
- Duncan, S., Smith, T. (2004). Capacity building and community consultation workshops for the Tuggerah Lakes estuary management study and plan. SD Environmental Management, Valentine.
- Dye, A. H. (2004). A survey of meiobenthos in the Tuggerah Lakes system, NSW. Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney.
- Dye, A. H., Barros, F. (2004). Spatial patterns in meiobenthic assemblages in intermittently open/closed coastal lakes in New South Wales, Australia. *Est. Coastal Shelf Sci.*, 62: 575–593.
- Erskine, W. (2004). Response to question regarding State Forest activities in the Wyong Catchment. Letter from NSW State Forests.
- EPA (1997). Managing urban stormwater: treatment techniques – draft. NSW Environment Protection Authority, Sydney.
- Fawcett, A. (2005). Comments on draft Tuggerah Lakes estuary management study. Letter from NSW Department of Primary Industries, Forests. Hunter Region. Maitland.
- Fletcher, W. J. (1998). Strategic plan for research on the fisheries resources of NSW 1998 – 2002. NSW Advisory Council on Fisheries Research.
- Garofalow, F. (1998). The exchange of nutrients in the Tuggerah Lakes estuary, NSW, Australia. Wyong Shire Council.

Geary, M. (2004). Draft Tuggerah Lakes estuary management study - peer review. Coast and River Environmental Engineering Pty Ltd, East Gosford.

Gehrke, P. C. (1997). Differences in composition and structure of fish communities associated with flow regulation in New South Wales rivers. In: Fish and Rivers in Stress – The NSW Rivers Survey. DPI (Fisheries), CRC Freshwater Ecology and RACAC.

Gehrke, P. G., Harris, J. H. (1996). Effects of river flow diversion on fish communities in the Hawkesbury-Nepean River system, Australia. In: Fish and fisheries of the Hawkesbury-Nepean River system. Final report to Sydney Water Corporation.

Gourlay, M. R. (1996). History of coastal engineering in Australia. In Kraus, N.C. (ed), History and Heritage of Coastal Engineering. Am. Soc. Civ. Eng., New York, pp 1 to 80.

Griggs, D. (2001). Synthesis report. Contribution of working groups I, II, III to the third assessment report of the inter-governmental panel on climate change. Cambridge University Press.

Growns, I. O., Growns, J. E. (1997). The relationship between biota and hydrology in the Hawkesbury-Nepean River system and their implications for environmental flow allocation decisions. Science and Technology in the Management of the Hawkesbury-Nepean Catchment, Geographical Society NSW, 14: 54-60.

Harris, G. P. (1996). Catchments and aquatic ecosystems: nutrient ratios, flow regulation and ecosystem impacts in rivers like the Hawkesbury-Nepean. Cooperative Research Centre for Freshwater Ecology Discussion Paper. CRC for Freshwater Ecology, University of Canberra.

HCCREMS, (2005). HCCREMS Website <http://www.hccrems.com.au>. Hunter and Central Coast Regional Environment Strategy, Thornton, NSW.

Henry, G. W., Virgona, J. L. (1981). The impact of the Munmorah Power Station on the recreational and commercial finfish fisheries of Tuggerah Lakes. Electricity Commission of NSW.

Higginson, F. R. (1965). The distribution of aquatic angiosperms in the Tuggerah Lakes ecosystem. Linnean Soc. NSW, 90: 329-334.

HRC (2002). Coastal Lakes. Independent inquiry into coastal lakes. Final report. Healthy Rivers Commission of NSW, Sydney.

HRC (2003). Statement of intent – coastal lakes. Healthy Rivers Commission, Sydney.

Hunter, J. (1996). Estimates of the flushing of Tuggerah Lakes. In Adaptive Environmental Assessment & Management (AEAM) programme for the Tuggerah Lakes system and associated catchments - Final Report, Macquarie Research Ltd.

HCRCMA (2003). Catchment Management Establishment Authority Team - Update 1. DIPNR, Sydney.

HCRCMA (2005). Hunter Central Rivers Catchment Management Authority Boundaries Map. Hunter Central Rivers Catchment Management Authority, Paterson, NSW.

Inter-Departmental Committee (1979). Tuggerah Lakes study report. Ministry for Public Works, Sydney.

Kay, W. R., Smith, M. J., Pinder, A. M., McRae, J. M., Davis, J. A, Halse, S. A. (1999). Patterns of distribution of macroinvertebrate families in rivers of north-western Australia. *Fresh. Biol.*, 41: 299-316.

Kelleher, N. (2003). Requirements for dredging activities. Department of Infrastructure, Planning and Natural Resources, Gosford.

Kelleher, N. (2004). Preliminary comments on the draft Tuggerah Lakes estuary management study. Department of Infrastructure, Planning and Natural Resources, Gosford.

Kerry, B. (1998). Groundwater nutrient loads, Tuggerah Lakes. University of Newcastle.

King, R., Hodgson, B. (1995). Tuggerah Lakes System, New South Wales Australia. In *Eutrophic Shallow Estuaries and Lagoons*, CRC Press. London.

Kinhill Pty Ltd (1998). Warnervale floodplain management strategy. Report for Wyong Shire Council.

Long, E. R., MacDonald, D. D., Smith, S. L., Calder, F. D. (1995). Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environ. Man.*, 19: 81-97.

Lynch, S. (2004). Correspondence: Tuggerah Lakes estuary management study – NSW Maritime Authority role. NSW Maritime Authority – Tuggerah Lakes, The Entrance.

McCarthy, N. S. (2003). Factors influencing the pattern of growth of the seagrass *Zostera capricorni* in three estuaries on the central coast, New South Wales. Honours Thesis, University of Newcastle.

Mackey, P. (1999). A preliminary investigation into the diversity and abundance of birds found utilising the fringing vegetation habitat of the Tuggerah Lakes estuary. *Aquatic Ecological Investigations*, Sydney.

Mann, R. A., Jung, R. F., Huang, B. (1996). Contaminants in sediments from Calabash Point, Berowra Creek. CSIRO Division of Coal and Energy Technology.

MDBC (2001). Rivers as ecological systems: the Murray Darling Basin. Murray Darling Basin Commission, ACT.

- Minello, T. J., Able, K. W., Weinstein, M. P., Hays, C. G. (2003). Saltmarshes as nurseries for nekton: testing hypotheses on density, growth, and survival through meta analysis. *Mar. Ecol. Prog. Ser.*, 246: 39–59.
- Morris, A. K. (2005). Submission and comments on the draft Tuggerah Lakes estuary management study. Birding NSW, Field Ornithologists Club Inc., Central Coast Group.
- Muston, R. (1999). Gosford-Wyong joint water supply environmental flows strategy. Quality Environmental Management Pty Ltd, Fairy Meadow.
- Muston, R. (2000). Gosford-Wyong Joint Water Supply Authority: Environmental Flows - Expert Panel's Recommendations. Quality Environmental Management Pty Ltd, Fairy Meadow.
- NHMRC (1990). Australian guidelines for recreational use of water. National Health and Medical Research Council, Department of Community Services and Health, Canberra.
- Nielsen, J., Jernakoff, P. (1996). A review of the interaction of sediment and water quality with benthic communities. CSIRO Port Phillip Bay Environmental Study. Technical Report No. 25.
- OECD (1993). OECD core set of indicators for environmental performance reviews. OECD Environment Monographs No. 83. Organisation for Economic Co-operation and Development. Paris.
- Otway, N. M., Macbeth, W. G. (1999). Physical effects of hauling on seagrass beds. NSW Fisheries Final Report Series No. 15. Cronulla.
- Owen, V. (2003). Variation in sponge-dominated 'deep reef' habitat: An evaluation of estuarine influence. Honours Thesis, University of Newcastle.
- Owen, V., Gladstone, W. (2003). Impacts of jetties on seagrasses and their management: a review. Centre for Sustainable Use of Coasts and Catchments, University of Newcastle.
- Patterson Britton & Partners (1992). Tuggerah Lake restoration project: status report. Patterson Britton & Partners Pty Ltd., North Sydney.
- Peckol, P., DeMeo-Anderson, B., Rivers, J., Valiela, I. M. M., Yates, J. (1994). Growth, nutrient uptake capabilities and tissue constituents of the macroalgae *Cladophora vagabunda* and *Gracilaria tikvahiae* related to site-specific nitrogen loading rates. *Mar. Biol.*, 121: 175-185.
- Peel, M. C., Watson, F. G. R., Vertessy, R. A., Lau, J. A., Watson, I. S., Sutton, M. W., Rhodes, B. G. (2000). Predicting the water yield impacts of forest disturbance in the Maroondah and Thomson catchments using the Macaque model, Cooperative research Centre for Catchment Hydrology, Rep. No. 2000-00/14. Melbourne. 71 pp.
- Piriou, J-Y, Ménesguen, A. (1992). Environmental factors controlling the *Ulva* sp. bloom in Brittany, France. In *Marine Eutrophication and Population Dynamics*. Eds G. Colombo, I. Ferrari, V. U. Ceccherelli, R. Rossi. Olsen & Olsen, Fredensborg, Denmark.

Poore, G. C. B. (1992). Soft-bottom macrobenthos of Port Phillip Bay: a literature review. Port Phillip Bay Environmental Study. Technical Report No. 2. CSIRO.

Powis, B. J. (1973). The effect of power station discharges upon benthic infauna. Honours Thesis, University of NSW.

Resource Planning Pty Ltd (1991). Environmental impact statement for extraction of sand from Budgewoi Lake. Resource Planning Pty Ltd.

Roberts, D. E. (2001). Tuggerah Lakes estuary process study. Wyong Shire Council, Wyong.

Roberts, D. E. (2004). Spatial and temporal patterns in macroinvertebrate assemblages in central coast streams. Report to the Gosford Wyong Joint Water Supply. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology, Narara.

Roberts, D. E., Barnes, P. B. (2004). Spatial and temporal variability in water quality and assemblages of phytoplankton in Tuggerah lakes, Lake Macquarie and Brisbane Waters. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology, Narara.

Roberts, D. E., Chapman, G. M. (2003). Ecologically sustainable management of estuarine foreshores and saltmarsh. Coast and Cleans Seas Report, WSC and EICC.

Roberts, D. E., Church, A. G., Cummins, S. P. (1999). Invasion of *egeria* into the Hawkesbury-Nepean River, Australia. *J. Aquat. Plant Man.*, 37: 31-34.

Roberts, D. E., Cummins, S. P. (2001). Revegetation trials on the Williams River, NSW – Final Report. Bio-analysis, Narara.

Roberts, D. E., Murray, S. N. (2005a). Spatial patterns of Syngnathids in the Tuggerah Lakes estuary: potential impacts associated with the weed harvester. Report to Wyong Shire Council. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology, Narara.

Roberts, D. E., Murray, S. N. (2005b). Assessment of Syngnathid by-catch associated with the weed harvester in Tuggerah Lakes estuary. Report to Wyong Shire Council. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology, Narara.

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., Nichol, S. (2001). Structure and function of South-east Australian estuaries. *Est. Coast. Shelf Sci.*, 53: 351-384.

Sainty, G. R. (1998). Assessment of the saltmarsh and fringing wetland vegetation of the Tuggerah Lakes estuary, NSW. Sainty and Associates, Potts Point.

Sainty, G. R. (2002). Survey of the saltmarsh along the foreshore adjacent to Tumbi Creek. Sainty and Associates, Potts Point, NSW.

Sainty, G. R., Duchatel, K. (2000). Management of fragmented disturbed saltmarsh habitats surrounding the Tuggerah Lakes estuary. Sainty and Associates Pty Ltd., Potts Point.

Sainty, G. R., Hunter, G. (1997). Tuggerah Lakes stormwater treatment study. Sainty and Associates, Potts Point.

Saintilan, N., Williams, R. J. (2000). The decline of saltmarsh in southeast Australia: Results of recent surveys. *Wetlands (Australia)*, 18: 49-54.

Schratzberger, M., Warwick, R. M. (1998). Effects of physical disturbance on nematode communities in sand and mud: a microcosm experiment. *Marine Biology* 130: 643-650.

Scott, A. (2002). Tuggerah Lakes: way back when... Sainty & Associates, CSIRO Aust, Wyong Shire Council.

Smith, A. K., Holliday, J. E., Pollard, D. A. (1997). Management of seagrass habitats in NSW estuaries. *Wetlands (Australia)*, 16: 48-55.

Smith, A. K., Pollard, D. A. (1998). Policy and guidelines – aquatic habitat management and fish conservation 1998. NSW Fisheries, Sydney.

Stricker, J. (1995). Reviving wetlands. *Wetlands (Aust.)*, 14: 13-19.

TEL (1999). Water supply activities in the Wyong and Gosford catchment areas: Review of existing ecological information and statistical analysis of water quality data. The Ecology Lab Pty. Ltd., Balgowlah.

Thresher, A., Ward, T., Crossland, C. (1993). An assessment of the impacts of Munmorah Power Station on the fauna of Tuggerah Lakes. Pacific Power.

Towell, S. (2000). The instream ecology of the tributary creeks entering the Tuggerah Lakes estuary. Honours Thesis, University of Newcastle.

Underwood, A. J., Chapman, M. G., Roberts, D. E. (2003). A practical protocol to assess impacts of unplanned disturbance: a case study in Tuggerah Lakes estuary, NSW. *Ecol. Man. Rest.*, 4: 4-11.

Underwood, A. J. (2005). Report on Tuggerah Lakes estuary management study. Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney.

van Senden, D. (1997). Flushing characteristics of Tuggerah Lakes. Manly Hydraulics Laboratory, Manly Vale.

- Walkerden, G. (1999). Scoping workshop notes on the management study for Tuggerah Lakes. Wyong Shire Council.
- Walkerden, G., Gilmour, A. J. (1996). Adaptive environmental assessment and management programme for the Tuggerah Lakes system and associated catchments. Macquarie Research Limited.
- Wallace, T. R. (1999). The entrance channel – impact on lake level statistics. Staff Memorandum. Wyong Shire Council, Wyong.
- Wanless, M. J. (1998). A review of the commercial and recreational fisheries of the Tuggerah Lakes estuary; sustainability, conflicts and disturbance. University of Newcastle.
- Warwick, R. M. (1971). Nematode associations in the Exe estuary. *J. Mar. Biol. Assoc. UK*, 51: 439-454.
- Warwick, R. M. (1993). Environmental impact studies on marine communities: pragmatical considerations. *Aust. J. Ecol.*, 18: 63-80.
- Wilcox, D. (2003). Stormwater management plan issues paper. Wyong Shire Council.
- Wright, I. A., Chessman, B. C., Fairweather, P. G., Benson, L. J. (1995). Measuring the impact of sewage effluent on the macroinvertebrate community of an upland stream: the effect of different levels of taxonomic resolution and quantification. *Aust. J. Ecol.*, 20: 142-149.
- WSC (1994). Wyong's critical wetland areas of conservation value – draft local environmental plan. Wyong Shire Council.
- WSC (1995). State of the environment report. Wyong Shire Council.
- WSC (1997). State of the environment. Wyong Shire Council.
- WSC (1998a). State of the environment, Wyong Shire 1997/1998. Wyong Shire Council.
- WSC (1998b). Wyong valleys planning report. Wyong Shire Council.
- WSC (1999). State of the environment, Wyong Shire 1998/1999. Wyong Shire Council.
- WSC (2001). State of the environment, Wyong Shire 2000/2001, Wyong Shire Council.
- WSC (2002). Wyong Shire state of the environment report. Wyong Shire Council.

WSC (2003a). Wyong Shire state of the environment report. Wyong Shire Council.

WSC (2003b). Review of environmental factors - maintenance dredging at the mouth of Tumby Creek, Killarney Vale. Wyong Shire Council.

WSC (2004). Review of environmental factors – maintenance dredging at the mouth of Tumby Creek, Killarney Vale. Wyong Shire Council.

Wynn, J. (2005a). Comments on draft Tuggerah Lakes estuary management study. Gosford Wyong Councils Water Authority. Wyong Shire Council, NSW.

Wynn, J. (2005b). Correspondence RE: water supply information. Gosford Wyong Councils Water Authority, NSW.

14 Glossary

Actions: Specific works or programmes that have been timetabled, costed and resourced. For the Tuggerah Lakes, actions will appear in the Estuary Management Plan as they are a sub-set of the options identified in this report.

AEAM: Adaptive Environmental Assessment and Management

Algae: Aquatic plants with no root systems. Include microscopic phytoplankton and seaweeds.

Algal Bloom: Excessive growth of phytoplankton or macroalgae which may be in response to increased nutrients.

Anoxic sediments: Bottom sediments that no longer have any oxygen within their interstitial spaces.

Anthropogenic Disturbance: Disturbances caused by humans. Includes sewage discharges, dredging, stormwater etc.

Bathymetry: Depth profile of a water body.

Benthic: The sea bottom. Can be comprised of mud, sand or rock. When referring to benthic organisms: those animals or plants that live on the bottom.

Bio-indicators: Biological organisms used to measure some aspect of environmental condition or health.

Biomass: The mass of living organic material which can include both plants and animals.

Catchment Blueprint: A management document put together for the Central Coast Catchment Management Area by the board. This area takes in Lake Macquarie, Tuggerah Lakes and Brisbane Water.

DEC: NSW Department of Environment and Conservation, formerly the Environment Protection Authority which now manages Parks and Wildlife, the Botanic Gardens Trust, policy, science, environmental protection and regulation.

DEC (Parks & Wildlife): NSW Department of Environment and Conservation's Parks and Wildlife Division, formerly the NSW National Parks and Wildlife Service.

Detritivore: Organisms that feed on detritus, eg. protozoans, worms.

Detritus: Non-living organic material.

DIPNR: NSW Department of Infrastructure, Planning and Natural Resources. This is an amalgamation of the former Planning NSW and Department of Land and Water Conservation.

DPI (Fisheries): NSW Department of Industries Fisheries Division, formerly NSW Fisheries.

DPI (Forests): NSW Department of Industries Forests Division, formerly State Forests of NSW.

Ecological health: Generally refers to an ecosystem that is not pristine but is healthy enough to serve human needs in a sustainable way.

Ecological integrity: Generally refers to an ecosystem of pristine condition.

Ecologically Sustainable Development: Development that does not interfere with the short and long-term well being, health and viability of the ecosystem.

Ephemeral: Changing from one time to another.

Epibenthic: Generally refers to organisms that live on the surface of the seafloor.

Epiphytes: Organisms living attached to the surface of other organisms.

Estuarine Processes: Processes that affect physical, chemical and biological interactions in the estuary.

Estuary: An enclosed or semi-enclosed body of water having an open or intermittently open connection to the sea.

Eutrophic: Water with elevated levels of nutrients and excessive plant growth.

Eutrophication: Enrichment of waters with nutrients resulting in excessive growth of aquatic plants and algae.

Flushing: The process by which water enters and exits an estuary.

GWCWA: Gosford Wyong Councils Water Authority also known as the Joint Water Supply (JWS).

HCRCMA: The Hunter Central Rivers Catchment Management Authority. This body takes over from the Central Coast Catchment Management Board and is the state body responsible for catchment management north to Taree, west to near Gulgong and south to the Hawkesbury River.

Hydrodynamics: The various mechanisms by which water moves within an estuary or river; includes circulation, mixing and flushing.

Invertebrates: Animals without backbones.

Issues: Are the things that prevent us from meeting our objectives,

IWCM: Integrated Water Cycle Management refers to using elements of the urban water cycle (e.g. stormwater runoff) to supplement water supply.

Macroalgae: Small to large seaweeds (reds, greens and browns) which grow attached to the seabed or other structures or drift around the estuary (drift algae).

Macrobenthos: Large benthic animals and plants generally visible to the naked eye.

Macrophytes: Aquatic plants with root systems.

Meiobenthos: Group of very small benthic invertebrates less than 0.5mm in size.

Mesotrophic: Medium nutrient levels within a body of water.

Mixing: Process by which one body of water joins with another.

Nekton: Fish and invertebrates that are considered pelagic.

NHT: Natural Heritage Trust is a Commonwealth body that distributes funding to environmental projects in Australia.

Objective: A specific target for managing the catchment or estuary – in this document, objectives help protect the principles.

Oligotrophic: Nutrient-poor body of water.

Options: Actions or programmes that can help us address the issues that prevent objectives from being met.

Pelagic: Organisms that are free living within the water column.

Phytoplankton: Microscopic single celled algae.

Polychaete: A segmented marine worm that lives in the sediments.

Principles: Are the catchment and estuarine characteristics that we are trying to protect. For the Estuary Management Study, the principles were sourced from the Catchment Blueprint.

Riffle zones: Areas within creeks where rocks or other structures constrict flow and cause turbulence.

Salinity: Total mass of dissolved salts per unit of mass of water. Seawater has a salinity of 35 parts per thousand (ppt).

Saltmarsh: A coastal wetland subjected to inundation by the tide and consisting of salt tolerant plants.

SWOT analysis: An analysis of an organisation or person's strengths, weaknesses, opportunities and threats.

Subsidence: Process by which the land drops as a result of mining.

Tidal delta: The build up of shallow shoals and flats in the lower reaches of an estuary due to the accumulation of sand transported in through the entrance.

Tidal prism: The total volume of water moving past a fixed point in an estuary during flood or ebb tide.

Turbidity: A measure of the ability of water to absorb light. The greater the concentration of suspended matter in the water, the higher the turbidity.

WSUD: Water Sensitive Urban Design – a planning and engineering approach to ensuring that development areas are designed in a way that minimises their reliance on water supplies through landscaping, reusing and recycling urban water and rainfall.

Wrack: The floating leaves of seagrasses and drift algae. Also includes flotsam and jetsam.

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