Appendix 15: Economic values (benefits) of water quality improvements in the Great Lakes – Draft report

Executive summary[pt50]

This study undertakes an economic analysis of Water Quality Improvement Plan (WQIP) for Wallis Lake, Smiths Lake and Myall Lakes. An integral part of this analysis is the prediction of the biophysical outcomes of policy actions contained in the WQIPs. For this study, the Integrated Catchment Assessment and Management Centre (iCAM) developed a Decision Support System (DSS) for each lake system that enabled modelling of the physical and ecological impacts of WQIP actions. Economic values from the literature and consultations in the region were attached to the predicted biophysical outcomes so that the benefits of WQIPs could be compared to costs, in monetary terms. The estimated benefits and costs of individual action within WQIPs were also estimated to determine their economic efficiency. A brief consideration was given the regional economic impact of the WQIPs.

The results indicated that:

- On the basis of the assumptions made, the Wallis Lake WQIP, Myall Lakes WQIP and drinking water strategy for the Crawford catchment, are estimated to provide net economic benefits and therefore are considered to be justified on economic grounds.
- The benefits of implementing the Smiths Lake WQIP would appear to be modest because of the already pristine state of the estuary and minimal decline predicted if no action is taken. The Benefit Cost Analysis (BCA) indicates that these modest benefits do not outweigh the economic costs and hence the Smiths Lake WQIP is considered to be economically inefficient.
- While the Wallis Lake WQIP, Myall Lakes WQIP and drinking water strategy for the Crawford catchment are estimated to provide net economic benefits, some of the individual actions in these plans provide limited benefits relative to the costs and are considered to be economically inefficient.
- The WQIPs will provide both positive and negative impacts to the Great Lakes regional economy. These can potentially be estimated in terms of direct and indirect output, value-added, income and employment, using input-output analysis techniques. While this type of analysis has not been undertaken, the direct expenditures that would stimulate the regional economy are considerably greater than the reduction in direct expenditures that would lead to a contraction in regional economic activity.
- While the BCA undertaken in this study was heavily reliant on the DSS prediction of water quality impacts, there are a number of problems with integrating the BCA framework into the DSS. Consequently, it is considered that any BCA of future water quality improvement actions will need to be undertaken separately from DSS modelling.

The economic values used in the economic analysis are largely based on benefit transfer from other studies in other contexts. There would be benefit from undertaking primary economic valuation studies,

such as choice modelling, to more directly estimate the values that the community hold for water quality improvements in the Great Lakes and improvements in environmental outcomes in the catchment.

One area of great uncertainty in the analysis is the link between changes in water quality and commercial production values (oysters, commercial fishing) and recreation values (both commercial and non-commercial). Further investigation of this dose-response link is warranted in the future.

1.0 Introduction

The Coastal Catchments Initiative (CCI) is a National Water Quality Improvement Program being implemented in partnership with Australian Government for coastal water quality 'hotspots'. The Great Lakes (Smiths, Myall and Wallis) have been chosen as the first hotspot area for NSW implementation of the CCI.

Under the CCI, Great Lakes Council (GLC) has developed Water Quality Improvement Plan (WQIP) for the lakes and waterways consistent with the Framework for Marine and Estuarine Water Quality Protection.

This study examines the economic dimensions of the WQIPs, in particular, estimation of the economic values of water quality outcomes of the WQIP actions. These economic benefits of the WQIPs are compared to the economic costs in a common yardstick, dollars, thus enabling the economic efficiency (economic desirability) of the WQIPs to be determined.

An integral part of economic analysis is prediction of the biophysical outcomes of potential policy actions contained in the WQIPs. For this study, the Integrated Catchment Assessment and Management Centre (iCAM) developed a Decision Support System (DSS) for Wallis Lake, Smiths Lake and Myall Lakes (integrating information from Department of Environment and Climate Change catchment and estuary models, as well as results from urban stormwater modelling) that enabled modelling of the physical and ecological impacts of WQIP actions. Economic values from the literature and consultations in the region were attached to the predicted biophysical outcomes so that the benefits of WQIPs could be compared to costs.

Section 2.0 provides the conceptual framework for economic analysis. Section 3.0 identifies a range of economic values for each of the lake systems. Section 4.0 reports the economic analysis of the WQIPs for Wallis Lakes, Smiths Lake and Myall Lakes, using the values identified in Section 3.0. Section 5.0 considers the regional economic impacts of the WQIPs, while Section 6.0 discusses the integration of economic values into the DSS. Conclusions and recommendations are reported in Section 7.0.

2.0 Economic framework

2.1 Introduction

Local Government is responsible for the supply of services and facilities appropriate to current and future needs within the local community and of the wider public. Councils also have a range of regulatory functions.

In many of Council's roles it is necessary to consider the impacts on the environment. These impacts are generally assessed in biophysical terms such as the impact on area of native vegetation or the impact on water pollution levels in rivers or streams.

However, impacts on the environment can also be assessed in terms of economic values. Measuring impacts in terms of economic values can help facilitate direct comparisons between the benefits of a proposal or policy and its likely environmental impacts using a common measure, dollars.

This Section aims to clarify the nature of the economic values that arise from the environment and how these values may be used in the decision-making process.

2.2 What has economic value?

Economic values are anthropocentric and so anything that provides enjoyment or utility to producers and consumers (individuals) has economic value, whether or not that value can be easily determined or observed.

2.3 The link between the environment and economic value

The mechanisms that link the environment to producer and consumer utility and hence economic value are:

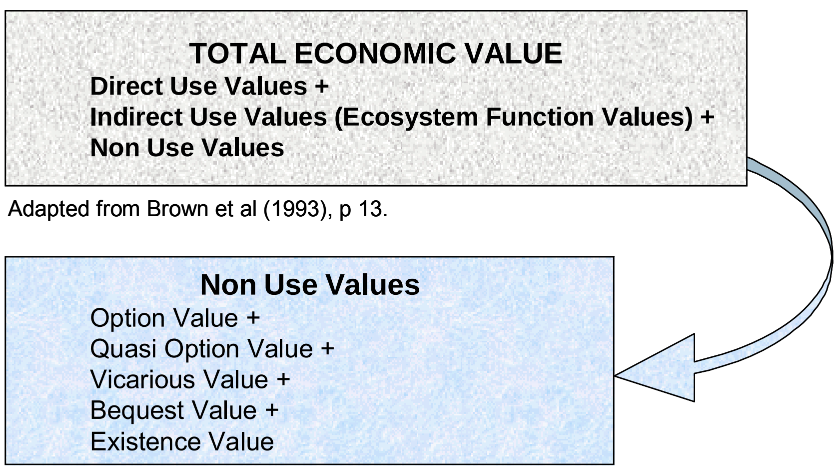
- Direct commercial use of the environment e.g. commercial extraction such as oyster production, commercial fishing, tourism operations, grazing;
- Direct non-commercial use of the environment e.g. recreation, amenity;
- Indirect use of the environment - these values are sometimes referred to as ecosystem function values and relate to the value of the ecosystem services and functions provided by an environmental resource. The concept attempts to capture indirect ecosystem values due to the interconnectedness of ecosystems through a variety of food chain and nutrient cycles (Young 1992). Ecosystem function values of natural areas include protection of biodiversity, assimilation of urban and rural runoff etc. Some economists consider these values as a special category of economic values, but they can usually be decomposed into the categories of use and non-use values.

- Non-use – these values relate to the preservation of natural ecosystems, species or special areas (James and Gillespie 2002). Non-use values comprise option values, quasi-option values, vicarious use values, bequest values and existence values.
  - Option values relate to the benefit of maintaining the right to use resources without necessarily doing so. It may include future use by existing individuals or by future generations.
  - Quasi-option values refer to the welfare obtained from the opportunity to get better information by delaying a decision that may result in irreversible environmental damage.
  - Vicarious use values are gained by people from the knowledge that others may be enjoying use of a natural environment, for instance, for recreational activities, commercial activities and through the indirect consumption of an environmental resource through books and other media.
  - Bequest values refer to the maintenance of environmental attributes for the benefit of future generations.
  - Existence value is the satisfaction that the community derives from simply knowing that certain things exist (including because of ethical concerns), for example, rare species or special ecosystems (James and Gillespie 2002).

2.4 Total economic value

Combined, all the economic values that can be obtained from an environmental resource are often referred to as total economic value.

Figure A15.1. Total economic value.



Reference: DEST et al (1995), p. 18.

2.5 Measures of economic value

The appropriate measures of economic value, come from the basic economic concepts of supply and demand, and are:

- Producer surplus; and
- Consumer surplus.

Producer surplus values are relevant to government operations, such as management of environmental areas, and commercial activities such as forestry, commercial fishing, charter operations etc. Producer surplus is the difference between the costs of the inputs used in the provision of a good or services (economic cost to producers) and the revenue received for the goods and services (total benefit to producers). In practical terms, it is the net revenue that is earned by producers (James and Gillespie 2002) provided that markets are competitive. Where markets are not competitive a shadow price13 is derived. In some instances, for example government management of natural areas, the producer surplus may be negative, as there is a cost of the program but no revenue received by government.

Consumer surplus values are relevant to non-market uses e.g. recreational fishing, boating, bushwalking etc, as well as non-use values, and they can also sometimes be relevant to commercial activities where the price elasticity of demand is not infinitely elastic. Consumer surplus is the difference between what a person would be willing to pay (WTP) for a good or service (the total benefit to the consumers) and what they have to pay (the cost to the consumer i.e. consumer expenditure)

2.6 Valuation methods

Producer surplus values can be estimated directly from market data on revenues and costs of production.

Consumer surplus values are generally estimated using

- Demand analysis for market goods such as water supply; and
- Non-market valuation techniques such as the property valuation method (PVM), travel cost method (TCM), contingent valuation (CV) and choice modelling (CM). With the exception of the property valuation method these techniques require surveying of the community;
- Benefit transfer which involves borrowing values from other studies of similar environments for application to site that is to be evaluated.

2.7 Benefit cost analysis

The total economic value of the environment therefore relates to the:

- Producer surpluses, and where relevant consumer surpluses, associated with each commercial activity;
- Consumer surpluses associated with each non-market use activity;
- Net costs to government; and
- Consumer surpluses associated with non-use values.

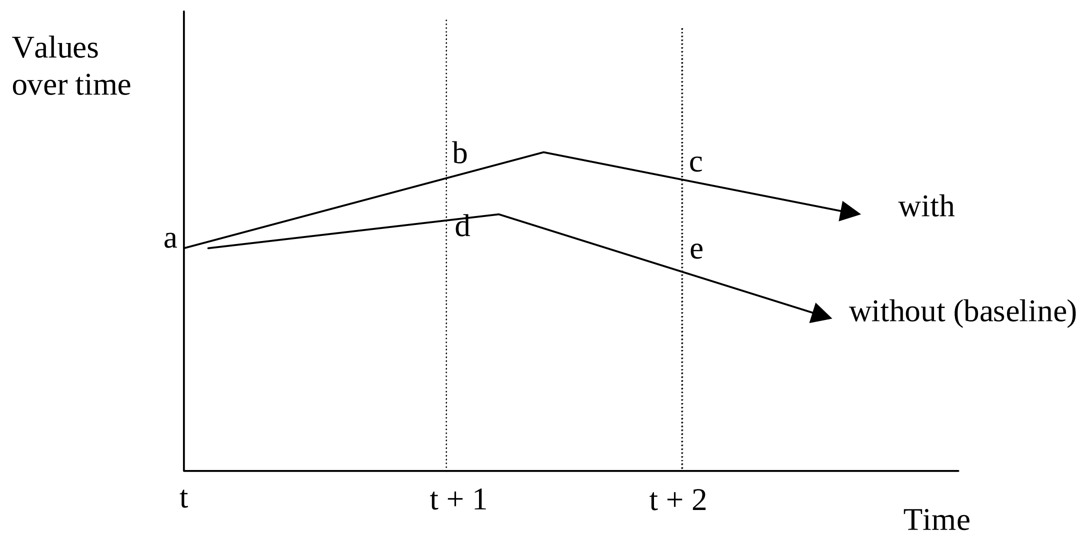
However, it should be noted that where consideration is being given to the economic desirability of policy alternatives, the key economic consideration is the estimation of the incremental change in values. That is, it is relevant to identify and measure how each component of total economic value, and the associated drivers, would change over time between the “with” and “without” alternative policy

13 A shadow price is an estimate of what the price or value would be if a normal market existed.

outcomes (cf. Figure 2). That is, how producer and consumer surpluses as well as net government costs would change over time.

An important step is to first identify the physical changes that will occur and then how these will impact producer and consumer surpluses. This is sometimes referred to as the dose-response pathway.

Figure A15.2. Measurement of Economic Values over Time With and Without a Policy Outcome.



The key principle is that any producer surpluses and / or consumer surpluses that are predicted to occur over time under the “without” or baseline case but are reduced or foregone under the “with” alternative policy scenario case are considered an economic cost, while increased or new producer and consumer surpluses generated from the “with” alternative policy case are considered an economic benefit.

In this benefit cost analysis (BCA) framework, provided the discounted incremental economic benefits (present value of benefits) exceed the discounted incremental economic costs (present value of costs) then the proposal has a positive net present value (NPV) and is considered to provide a net benefit to the community and an improvement in economic efficiency. It is this BCA framework that is reported in Section 3.0 with respect to the WQIP for Wallis Lake, Smiths Lake and Myall Lakes. The framework was also used to undertake a BCA of each of the major actions in each plan to examine which of the actions provides the best return on investment for the community.

2.8 Cost effectiveness analysis

Where it is difficult to value economic benefits, an alternative to estimating net benefits of a proposal via BCA is to examine a proposal’s cost-effectiveness.

Cost effectiveness analysis (CEA) is concerned with assessing the net costs per physical quantity of achievement of some policy goal e.g. $ per kg reduction of nutrients. In this framework, alternatives that achieve the goal e.g. reduction in nutrient loads, at least net cost are preferred. However, without considering the values that the community may hold for specified goals, it raises the question of whether the unquantified environmental benefits of the goal are greater than the estimated quantifiable net costs.

CEA was not undertaken in this analysis as the analysis already included a BCA of each action with the benefits of the action quantified in dollar terms rather than per unit of load reduction.

2.9 Regional economic impacts

All activities that involve expenditure in a region provide some stimulus to economic activity in that region. Hence the following will provide economic stimuli to a region:

- Market based activities;
- Non-market use activities; and
- Government expenditure.

Non-use values do not provide any stimuli to a region since they do not involve any actual expenditure by the producer or the consumer.

Regional economic impact analysis measures regional economic activity in terms of the direct and indirect (multipliers) changes in the following economic indicators:

- **Gross output** - is the gross value of business turnover;
- **Value-added** – is the difference between the gross value of business turnover and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output;
- **Income** – is the wages paid to employees including imputed wages for self employed and business owners; and
- **Employment** – is the number of people employed (including full-time and part-time).

These indicators of regional economic stimulus are different to the net benefit measures of consumer and producer surplus that are used in benefit cost analysis.

Examining how expenditure patterns in the region would change, and modelling these using input-output analysis, can be used to estimate the incremental change in regional economic stimulus “with” and “without” an alternative policy approach.

With respect to this regional economic impact framework, it should be noted that all proposals whether economically efficient or not will provide an economic stimulus to a region. For instance, the Exxon Valdez oil spill generated significant amounts of economic activity, however, it could not be argued that the spill was economically desirable

Hence, while the method can be used to estimate changes in regional economic activity (value-added, output, income and employment) associated with alternative policy scenarios, unlike the benefit cost analysis framework there are no guidelines for interpretation of whether or not an increase or decrease in economic activity is economically desirable. The technique can, however, be useful for social planning purposes.

3.0 Economic values of the Great Lakes

3.1 Introduction

The WQIPs being developed by GLC have the potential to impact a range of values in catchments of the three lake systems. This includes market values as well as non-market values (use and non-use values).

Market values were estimated from market data - program costs were provided by iCAM, estimates of producer surplus values of commercial activities (oyster production, agriculture, commercial fishing, commercial recreation, urban amenity) were made based on a range of data and assumptions. This was necessary because most producer surplus values are commercial-in-confidence.

There are two approaches to estimating non-market values:

- primary valuation studies – which may involve community questionnaires (e.g. choice modelling); or
- benefit transfer – which involves borrowing the results of studies undertaken in other contexts and applying them to the current policy issue.

The resources and timing of this project necessitated the use of benefit transfer.

Value information used in the study is outlined below. The specific application of this information to WQIPs for Wallis Lake, Smiths Lake and Myall Lakes is discussed in Section 4.0. It should be noted that a crucial link between identifying base line value information and estimating impacts of WQIPs is how and to what extent these values will change under different WQIP scenarios e.g. how and to what extent oyster farming producer surplus will change with a 25% decrease in TSS. This is an area of great uncertainty requiring additional attention in the future. However, for the purpose of this analysis, impact scenarios are assumed, and sensitivity testing undertaken to determine if reasonable changes to assumptions are likely to result in different conclusions.

3.2 Estuary protection

Potentially one of the most significant impacts of WQIPs is improvement of the health of the estuaries with associated improvements in overall biodiversity.

Windle and Rolfe (2004) undertook a CM study of community WTP for increases in the percentage of the Fitzroy River estuary (QLD) in good health in 20 years time. They found a WTP of \$3.23 to \$3.89 per household (50% response rate) per annum for 20 years for each 1% (4.3 km2) increase in the area of an estuary in good health.

Applying these values to the 50%[14] of the NSW households and assuming they apply to the Great Lakes gives an annual value of \$4.5M to \$5.4M per 4.3 km2 increase in the area of an estuary in good condition.

14 It is normal practice to extrapolate average WTP levels from non-market valuation studies to the proportion of the sample population represented by the response rate. Others have suggested extrapolating to the proportion of the sample population represented by

3.3 Rivers

Catchment works may also improve the health of rivers flowing into the Great Lakes. There are a number of Australian studies that have examined WTP for river health.

Van Bueren and Bennett (2000) identified a national WTP of $0.08 per household (45% response rate) per annum for every 10 km of waterway restored for fishing or swimming. This is equivalent to a WTP of NSW households of $114,000 per annum for every 10 km of waterway restored.

Bennett and Morrison (2001) examined WTP for improvements in the water quality of NSW Rivers. For NSW northern coast rivers they found of WTP of $0.30 per household (lump sum payment) (38% response rate) per 1% of the river that moves from boatable water quality to fishable water quality and $0.49 per household (lump sum payment) 38% response rate) per 1% of the river that moves from fishable water quality to swimmable water quality. Assuming that there is a single water quality level improvement associated with planting/protection of riparian vegetation this is equivalent to a once-off benefit of between $340,000 and $550,000 per 1% length of river with an improved water quality.

Bennett and Morrison (2001) also examined WTP for an increase in percentage of river length with healthy riverside vegetation. The value per household was between $2.02 and $2.62 per household lump sum (38% response rate). Aggregated to NSW households gives a lump sum value of between $2.3M and $3.0M per percentage of the river length with healthy riverside vegetation.

Windle and Rolfe (2004) examined WTP per km waterway in the Fitzroy Basin (QLD) catchment remaining in good health after 20 years. They found a value of $0.08 to $0.11 per household (50% response rate) per annum for 20 years. Applying these values to the 50% of the NSW households and assuming they apply to the Great Lakes gives an annual value of $110,000 to $152,000 per km increase in the length of waterways in the catchments in good health.

For the central analysis, the Van Bueren and Bennett (2000) values is used.

3.4 Native vegetation conservation

There have been a number of studies in Australia of the value of native vegetation conservation.

Table A15.1. Non-market Valuation Studies for Native Vegetation Conservation.

Item Valued	Value	Unit of Value	Reference
Per 10,000ha of native vegetation conserved	$3.80	Per hh, once-off payment	Lockwood and Carberry 1998
Per 1% reduction in area of a unique ecosystem	$3.68	Per hh, once-off payment	Rolfe et al [DG51]
Per 1,000 has of healthy river red gums	$1.45	Per hh per year	URS 2007
Per 1,000 ha of significant rainforest protected	$11.16	Per hh per year	URS 2007
Per 1,000 ha of old growth forest protected	$0.65	Per hh per year	URS 2007
Per 10,000 hectare of farmland repaired or bush protected"	$0.07	Per hh per year for 20 years	Van Bueren and Bennett 2000

the response rate plus one third of the proportion of non-respondents. However, the more conservative approach has been taken here.

These are for native vegetation generally, farmland reparation or bush protection, healthy river red gums, rainforest, old growth and healthy riverside vegetation. These value estimates are all for different base years, different areas and were based on different payment methods i.e. once-off and per annum. It should be noted that many of these studies also suggested an additional value based on the contribution of area of vegetation to species conservation. However, difficulties with physical estimation of this, limits its applicability.

Perhaps the most relevant studies are those by Lockwood and Carberry (1998) and Van Beuren and Bennett (2000). Adjusting for CPI the Lockwood and Carberry (1998) and Van Beuren and Bennett (2000) studies give values between $430 and $630 (lump sum) per ha of vegetation conserved.

3.5 Wetlands

There are a number of studies of the non-use values of wetland conservation. Sappideen (1992) found a WTP of $33.45 per household per annum to preserve water quality from increased salinity to maintain the recreation value of Sale Wetland, Victoria. Stone (1991) found a WTP of $33.45 per household per annum or $3000 per ha (Stone 19[DG52]91) to preserve the Barmah wetlands, Victoria while Gerrans (1994) [DG53]estimated a WTP of $29.92 to $35.08 per household per annum to preserve the Jandakot wetlands, south of Perth, in their current state. Bennett (2000) found the benefits enjoyed by Mildura region residents as a result of projects that would halt the environmental degradation of the Gol Gol wetlands in the order of $8.80 per household.

A choice modelling study undertaken by Morrison et al (1998) examined the non-use environmental values provided by the Macquarie Marshes, a major wetland in NSW. The study revealed a community willingness to pay of:

- $0.40 per household per ha of wetland protected, or aggregated across NSW households $800,000 per ha.
- $21.82 per household per year increase in frequency of bird breeding (say if bird breeding increased from once every 4 years to once every 3 years), or aggregated across NSW households $44M.
- $4.16 per household per additional endangered species in the wetlands, or aggregated across NSW households $8.3M per additional endangered species

Whitten and Bennett 2001 examined the economic values of healthy wetlands in the Murrumbidgee Floodplain of NSW. They found a once-off WTP of $11.39 per 1,000ha of healthy wetland (response rate 31%). Aggregated to 31% of NSW households this is equivalent to $15,000 per ha.

This latter value is used in the central analysis.

3.6 Recreation

There have been numerous studies of the value of non-market recreation. Some of these are reported below.

Table A15.2. Summary of Results of Travel Cost Studies.

Study	Author and Reference	Consumers' Surplus
Grampians State Forest	Greig (1977)	$9 per visitor day ($2002)
Warrumbungle NP	Ulph and Reynolds (1981)	$351 per visitor day ($2002)
Green Island, Great Barrier Reef, Queensland	Economic Associates Australia (1983)	$49 per visitor day ($2002)
Gerringong-Gerroa, NSW	James et al (1993)	$139 per visitor day ($2002)
Gibraltar Range National Park (average stay is almost 2 days)	Bennett (1995)	$23 per visit ($2002)
Dorrigo National Park (average stay is 1/2 a day)	Bennett (1995)	$42 per visit ($2002)
Minnamurra Rainforest Centre, Budderoo National Park (average stay is 1/2 a day)	Gillespie (1997)	$33 to $51 per visit ($2002)
Grampians National Park	Read and Sturgess (1994)[DG54]	$75 per visit or $18 per visitor day ($33 per visit or $7.86 per visitor day if onsite time costs excluded ($1994)
South East Forests	RAC (1992)	$13 per visitor ($1992)
Lake Hume	Crase and Gillespie (2006[DG55])	$33 per visitor (2005)
Various recreation uses	Walsh et al (1992) as reported in Read and Sturgess (1994)	$13-73 per recreation day ($A 1994)
Visits to NSW National Parks	Gillespie (2006[DG56])	$25 - 50 per visit
Visits to Marine Parks	Gillespie (2007)	$16 – 62 per visit

For the purpose of this analysis a conservative value of $20 per recreation visit is used.

3.7 Property values – Pipers Creek

One of the potential impacts of WQIP is on amenity values in the area of Pipers Bay. This is currently the area of Wallis Lakes that has the poorest water quality and hence is likely to experience the greatest improvement. Property values in this area, including Forster Keys range from $400,000 to $900,000.

Property values are a function of the property attributes including:

- Structural attributes – size of land, house size and building constructions etc;
- Access attributes – access shopping centres, schools etc'
- Environmental attributes –views, water quality, etc..

There have been few if any academic studies in Australia looking at the effect of water quality on adjoining residential property values although there have been some overseas studies.

Steinnes (1992) examined the impact of water quality on lakeshore land values in Minnesota, USA. He found that property values increased by $206 per cm below the surface that a secchi disk can be observed. Other studies have found relationships between property prices and water pH levels (Epp & Al-Ani 1979), faecal coliform concentrations (Leggett & Bockstael 2000). Boyle, Lawson, Michael and Bouchard (1998) [DG57]found that properties on China Lake, sold for an average of $107,070, of which 15% ($15,996) was dependent on water quality.

Gillespie Economics (2006a) examined the property value impacts of frontage and views of Merimbula Lake. It was found that higher prices are achieved for Lake foreshore/Lake view blocks and the value of these blocks is also linked to the quality of water in the catchment. A lower level of water quality will reduce the amenity of the block e.g. if water quality drops off, residents will no longer be able to fish or swim from their block. There may also be odour impacts associated with very poor water quality. Advice from local real estate agents and valuers was that Merimbula Lake foreshore blocks and Lake view blocks attracted a 20% premium over similar blocks that do not enjoy Lake amenity. Half this premium would be lost with a sustained deterioration in water quality, e.g. no swimming.

For the purpose of this analysis a 10% increase in the property value (of 300 properties) was considered an upper bound effect of water quality improvements at Forster Keys and Pipers Bay, with 2% used as the central value for analysis.

3.8 Smiths Lake use activities – Market and non-market

Smiths Lake is used for swimming, fishing, boating and sailing. However, there is no quantitative data on the recreational use of the Lake. 2007 Australia data for Great Lakes Shire indicated 1,910,000 visitor nights and 401,000 domestic day visits, with expenditure of $279M. The specific activities undertaken by these visitors is unknown, but 70% of domestic overnight visitor and 60% of day visitors are visiting for holiday/leisure (Tourism Research Australia 2008). Some indication of the magnitude of the economic value (consumer surplus) of recreational experiences associated with Smiths Lake can be obtained by assuming:

- 20% of visitor nights are in the Smiths Lake Catchment15;
- 65% of visitor nights are related to holiday/leisure
- one activity per day related to the estuary and rivers is undertaken by visitors e.g. swimming, fishing, kayaking, water skiing etc;
- the consumer surplus of these activities is on average in the order of $20 per person (see Section 3.6).

These assumptions give a non-market economic value of in the order of $4.9M per annum.

In addition there is some commercial boat hire at Frothy Coffee and the Sandbar and Bushland Holiday Parks. These are estimated to have an annual producer surplus value of in the order of $1.5M16.

Commercial fishing on Smiths Lake is estimated to have a gross value of $202,000 pa (NSW Fisheries 2008). Assuming a producer surplus of 25%17, annual economic value is in the order of $50,500.

15 This is an assumption. However, sensitivity testing later in the report indicates that the results of the analysis are not sensitive to large changes this assumption.
16 Income and profit information is commercial in confidence. To estimate producer surplus it was therefore necessary to make a number of assumptions. The estimate of producer surplus was based on the schedule of fees, an assumed occupancy rate or visitation rate and an assumed producer surplus of 25% of business turnover.
17 This is an assumption, however, the results are not sensitive to large changes in it.

3.9 Myall Lakes use activities – Market and non-market

Myall Lakes is almost completely surrounded by the Myall National Park. The National Park has 22 camping areas with 380 sites. The most accessible sites are around Bombah Broadwater. Revenue generated by the National Park each year is in the order of $180,000 (although for this analysis the costs are also assumed to be $180,000) and annual visitation is estimated at 100,000[18]. Average length of stay is difficult to estimate but for the purposes of this study is assumed to be 5 days[19]. Assuming one water activity per person per day on the Lake and a consumer surplus of $20 per activity, the economic value of use is estimated at $10M per annum.

Myall Lakes is also used for commercial houseboat operations and has the Myall Lakes Ecoresort located on its shores. These are estimated to have an annual producer surplus in the order of $2.7M[20].

Commercial fishing at Port Stephens, Myall Lakes, Myall River and Tea Gardens is estimated to have a gross value of $2.2M pa (NSW Fisheries 2008[DG58]). Assuming 20% is associated with Myall Lakes and producer surplus is 25% of the gross value, annual economic value is in the order of $110,000 pa.

3.10 Wallis Lake use activities – Market and non-market

Wallis Lake provides opportunities for a range of market and non-market activities including commercial fishing, oyster farming, commercial activities directly associated with the lake such as cruises, boat hire, caravan and ski parks and non-market recreation.

Oyster farming

Production of oysters from Wallis Lakes was estimated by NSW Fisheries at $11.9M in 2006/07, although local reports[21] suggest a value of $14M. A survey of Hawkesbury River oyster farmers in 2005 indicated that in the order of 25% of gross income was net profit before interest payments and taxation, a proxy for producer surplus or net benefits of oyster farming. Applying this ratio to Wallis Lakes indicates that the annual producer surplus generated is in the order of $2.7M to $3.5M pa. The Wallis Lakes oyster fishery is a conditionally approved fishery meaning that oysters do not require depuration before sale. However, after rainfall events it can move to a conditionally restricted fishery where depuration is required (36 hour process). In larger rainfall events harvesting may be completed restricted. Reductions in the time that depuration is required and harvesting is restricted increases the producer surplus value of the fishery by reducing costs and allowing product to be sold without delay[22].

Commercial fishing

There are approximately 68 commercial fishers operating on Wallis Lake. Commercial fishing on Wallis Lakes has been estimated by the industry at $2.9M (NSW Fisheries 2008). Assuming a producer surplus of 25%, annual economic value is in the order of $725,000.

Subsistence fishing value

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18 This is based on advice from the NPWS – Booti Booti National Park.
19 This is based on advice from the NPWS.
20 Income and profit information is commercial in confidence. To estimate producer surplus it was therefore necessary to make a number of assumptions. The estimate of producer surplus was based on the schedule of fees, an assumed occupancy rate and an assumed producer surplus of 25%.
21 Discussions with the Fishing Cooperative.
22 Based on advice from oyster growers.

Wallis Lake is also reported to have value to the indigenous community of the region. The value of wild resources harvested by Indigenous people in the Wallis Lake catchment is estimated to be between $468 and $1,200 per adult per year or $232,000 to $646,000 per year to the community (Gray et al 2005).

Other commercial activities

Other commercial activities in Wallis Lakes include two boat cruise operations (Amaroo Cruises, Freespirit), numerous boat hire businesses and in the order of nine caravan parks. A range of assumptions have been made to estimate the turnover of these businesses at in the order of $73M pa. Assuming producer surplus is 20% gives an annual economic value at $15M.

Non-market recreation

Council officers and Tourism Visitor Centre staff advise that no local tourism data is collected for the Great Lakes Shire or the Wallis Lakes Catchment. Indeed, no data is even available on total number of visitors to the region let alone any information on the activities they undertake e.g. no. of recreational fishing events, boating events etc.

However, anecdotal advice is that Forster and the Wallis Lakes offers experience based tourism with most of these "experiences" being water based and inextricably linked to the estuary, beach and rivers e.g. kayaking, fishing, waterskiing, boating, swimming etc.

2007 Tourism Australia data for Great Lakes Shire indicated 1,910,000 visitor nights and 401,000 domestic day visits, with expenditure of $279M. The specific activities undertaken by these visitors is unknown, but 70% of domestic overnight visitors and 60% of day visitors are visiting for holiday/leisure (Tourism Research Australia 2008[DG59]). Anecdotal evidence suggests that visitation is strongly linked to water based activities. Some indication of the magnitude of the economic value (consumer surplus) of recreational experiences associated with the estuary and rivers can be obtained by assuming:

- 80% of visitor nights are in the Wallis Lake Catchment23;
- 65% of visitor nights are related to holiday/leisure
- one activity per person per day related to Wallis Lake is undertaken by visitors e.g. swimming, fishing, kayaking, water skiing etc;
- the consumer surplus of these activities is on average in the order of $20 per person.

These assumptions give an economic value of in the order of $19.8M per annum associated with the Wallis Lake.

3.11 Mid-Coast Water treatment costs, Myall Lakes catchment (Crawford River sub-catchment)

Mid-Coast Water manages a water treatment plant in the Crawford River Catchment for drinking water supply to Bulahdelah. Mid-Coast Water extracts 213 ML/year and has chemical treatment costs of $202/ML24. Some of the chemical treatment costs are for chlorine treatment and would not vary with water quality. The remainder (assumed here to be 50%) are assumed to be variable costs related to TSS levels. Hence, total annual variable chemical treatment costs related to water quality are $21,300

23 This is an assumption, however, the results are not sensitive to large changes in it.
24 Advice from Mid-Coast Water.

per annum. These costs are assumed to vary linearly with changes in catchment loads in the Crawford catchment.

Water quality changes have no implications for capital costs of the water treatment plant.25

3.12 Agricultural values – Grazing and dairy

The main agricultural activity in the region is grazing with a small amount of horticulture/intensive animal production. Beef and dairy cattle grazing are the dominant agricultural enterprises. Grazing takes place on cleared grassland (improved and unimproved grazing) and on privately held land with timber cover (unimproved grazing).

Table A15.3. Agricultural Output Values in the Great Lakes Statistical Local Area.

VALUE OF AGRICULTURAL PRODUCTION - year ended 30 June	$	2001
Value of crops	$m	0.7
Value of livestock slaughterings and other disposals	$m	30.9
Value of livestock products	$m	4.3
Total value of agriculture	$m	35.9

Source: ABS Regional Statistics Great Lakes Statistical Local Area

Dairy gross margins were estimated at $120/ha using ABARE Farm Survey Data (ABARE 2004) while beef gross margins on improved and unimproved pastures have been reported at $139/ha and $40/ha, respectively (NSW DPI – Agriculture 2004). Where land is vegetated (unimproved) and periodic grazing activity occurs – say for 3 months per year at one third of the carrying capacity – a value of $4/ha is assumed.

25 Based on advice from Mid-Coast Water.

4.0 Benefit-cost analysis of WQIPs

4.1 Introduction

BCA involves the following key steps:

- identification of the base case or do nothing option;
- identification of the proposed policy action;
- identification of the physical outcomes of the policy options;
- identification of benefits and costs of the policy options;
- valuation of benefits and costs;
- consolidation of value estimates and application of decision criteria;
- sensitivity testing of key assumptions;
- consideration of non-quantified benefits and costs.

What follows is a BCA of the WQIP for each lake system based on iCAM modelling, consultations with stakeholders such as oyster growers, National Parks and Wildlife Service, Mid-Coast Water, Great Lakes Tourism Visitor Centre, Myall Lakes Eco-resort, Myall Lakes Houseboats and Fishing Co-operatives and the economic values reported in Section 3.0.

4.2 Wallis Lake

4.2.1 Base case

The Wallis Lake estuary is a complex system of lakes, rivers and interconnecting channels which separate Tuncurry and Forster, coastal towns located north and south of Forster Inlet, respectively.

The Entrance and Channels of the Lake are considered to be of high conservation value, Wang Wauk and Cooloongook are still of high conservation value but approaching moderately disturbed classification while Wallamba is moderately disturbed. Pipers creek area is moderately disturbed and approaching being heavily impacted.

Under the base case or no WQIP scenario, the DSS for Wallis Lake predicts that:

- TN levels will increase by over 5%;
- TP levels will decrease by 1%; and
- TSS will decrease by 1%.

4.2.2 WQIP actions

A range of rural and urban remediation and protection actions are proposed in the WQIP for Wallis Lake.

Remediation actions recommended for rural areas of the Wallis Lake catchment included:

- Groundcover management on pasture lands.

- Nutrient (fertilizer) management.
- Infrastructure management including dam refurbishment and/or decommissioning.
- Riparian remediation focusing on areas of active stream bank erosion.

Remediation actions recommended for urban areas of the Wallis Lake catchment included:

- Retrofitting existing urban areas through implementation of Water Sensitive Urban Devices (WSUD)
- Redevelopment of existing urban land in selected subcatchments
- 15% adoption of rainwater tanks in selected subcatchments

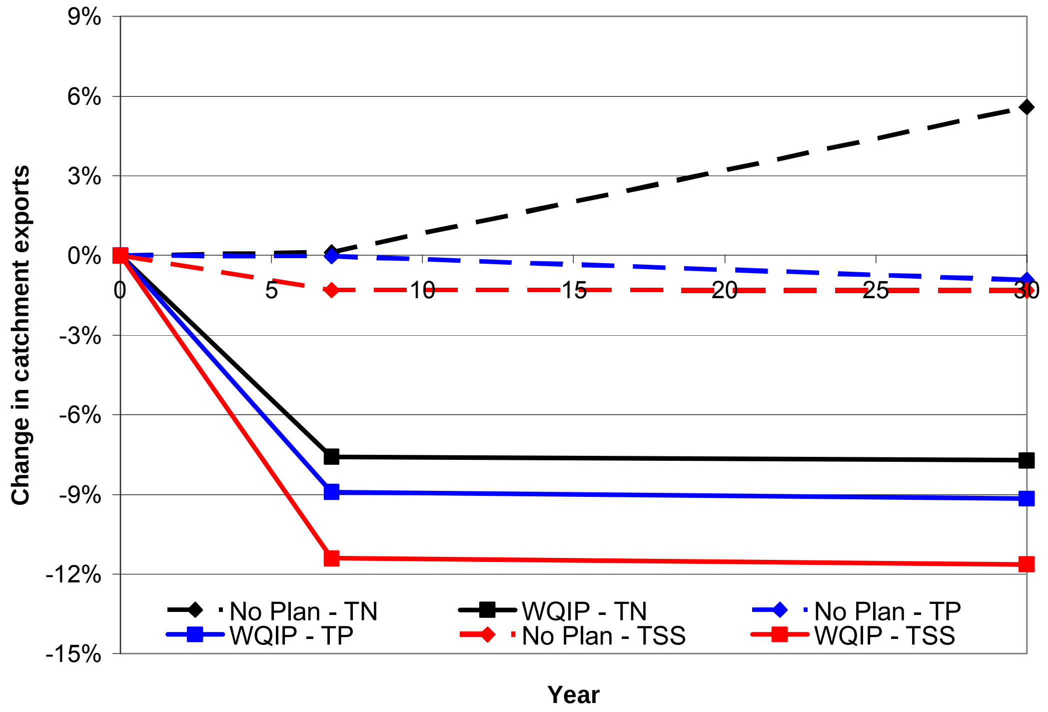
Protection actions recommended for the Wallis Lake catchment included:

- Fencing and/or stock exclusion for areas of remnant riparian revegetation including off-stream watering and some planting where vegetation requires rehabilitation.
- Protection of coastal wetlands including exclusion of stock and buyback of wetlands where necessary.
- DCP provisions on Greenfield development sites in the Wallis lake catchment to enforce 'no net increase' in pollutants as a result of any future urban developments.

4.2.3 DSS physical outcomes

Not all the actions proposed in the WQIP were able to be modelled in the DSS. The physical outcomes of the modelled policies are illustrated in Figure 3. This indicates that all measures of water quality will improve relative to the base case or without WQIP scenario.

Figure A15.3. Catchment Exports for Wallis Lake With and Without the WQIP.



4.2.4 Identification of benefits and costs

The potential range of costs and benefits associated with the Wallis Lake WQIP and the predicted water quality outcomes are summarised in Table 4.

Table A15.4. Potential Benefits and Costs of the Wallis Lake WQIP.

Costs	Benefits
Direct Program Costs	*Direct Program Benefits*
• Fertiliser	• Increase in area of estuary in good health
• Dams	• Increase in length of river in good health
• Groundcover	• Increased area of native vegetation conservation
• Riparian rehabilitation	• Increased area of wetland conservation
• Riparian protection	• Benefits to oyster growers
• Wetland protection	• Benefits to commercial fishers
• Greenfield	• Benefits to non-market recreation
• Redevelopment	• Benefits to commercial recreation
• Mitigation	• Urban amenity benefits
Indirect Program Costs	*Indirect Program Benefits*
• Opportunity costs of riparian revegetation and protection	• Reduced fertiliser costs and increase productivity of agricultural land
• Costs of alternative water supplies where dams are eliminated	• Increased agricultural productivity where dams are eliminated

4.2.5 Valuation of benefits and costs

Direct program costs

The undiscounted direct costs of the programs area summarised below.

Table A15.5. Direct Program Costs.

Program Components	Normal Programs
Fertiliser	$1,719,836
Dams	$11,388,800
Groundcover	$8,591,222
Riparian rehabilitation	$1,604,631
Riparian protection	$11,164,800
Wetland protection	$14,205,590
Greenfield	$51,415,618
Redevelopment	$111,263,221
WSUD retrofit and urban community engagement program	$6,585,507
Sea Sponge protection	$1,290,995
WSUD Protection	$799,716
Lake use actions	$575,244
Pollution control systems	$61,621
Adaptive management strategy	$165,933
Ecological monitoring	$730,226
Future Investigation for Farm Scale Action Plan	$733,096
Rainwater tanks	$3,394,358
Total	$225,690,414

Indirect program costs and benefits

Programs may have indirect costs and benefits. For instance, the riparian program imposes an opportunity cost to landholders as replanting and fencing essentially takes land out of production. This opportunity cost would depend on the whether the land is cleared or vegetated. iCAM estimate that under the WQIP 472 ha of existing vegetation would be protected, and 336 ha of revegetation of cleared land would occur. An opportunity cost of $139/ha per annum was used for land that is revegetated and a figure of $4/ha per annum was used for vegetated land.

The dam refurbishment and decommissioning program would impose an additional cost on landholders where dams are decommissioned and alternative water supplies are required for stock. It is assumed that 64 dams in the Wallis Lake catchment are subject to the program and that 50% of these require an alternative water supply comprising a solar pump ($8,000) and trough ($500).

Dam decommissioning also adds to the productive area of a farm (assumed here at 0.5ha per dam) with the net value of productive land assumed to be $139/ha per annum. Groundcover and fertiliser programs potentially reduce the costs of production and increase productivity of the land. 46,215 ha and 4,805 ha will be the subject to the groundcover and fertiliser program respectively, with an assumed 10% increase in productivity i.e. 10% increase in beef gross margin per ha of $139.

Increase in percentage of the estuary in good health

iCAM indicate that the modelled water quality improvements from the proposed actions would have the effect of improving the area of the Wallis Lakes estuary considered healthy by 97ha. Using Windle and Rolfe (2004[DG60]) a hectare increase in the area of an estuary that is healthy has an economic value of $10,000 per annum.

Improvements in river health

iCAM indicate that the modelled water quality improvements from the proposed actions would have the effect of increasing the length of river considered healthy by 506km. Using Windle and Rolfe (2004)[DG61] each kilometre improvement in river health has a value at in the order of $110,000 to $150,000 per annum. Using van Bueren and Bennett (2000) the value is $11,400 per km. The latter more conservative value is used in this analysis.

Increase in area of vegetation conservation

The WQIP actions will increase vegetation conservation by 1,726 ha. Using Van Bueren and Bennett (2000) and Lockwood and Carberry (1998) [DG62]this has an economic value of between $430 and $630 per ha.

Increased area of wetlands

The WQIP actions are estimated to increase the area of healthy wetlands by 1,974ha. Using Whitten and Bennett (2001), wetland conservation has an economic value of $13,700/ha.

Oyster growers and commercial fishers

It is difficult to determine the impact of changes in water quality on oyster growers and commercial fishing. For the purpose of this analysis some linearity between water quality and value is assumed. It is known from water quality modelling that a 19% decline in water quality in the Lower Estuary will lead to it being of modified condition and an 86% decline in the Southern Lake area will lead to it being of modified condition. A modified condition is assumed to reduce oyster and commercial fish values by

50%. Actions proposed in the WQIP have a 5% effect on water quality and hence oyster and commercial fishing benefits are estimated at the average of 5%/19%*50% and 5%/86%*50% of current oyster and commercial fishing values i.e. an 8% improvement, in 30 years time. The improvement in seven years time is 4%. While this is a very rough estimate of impact it will be seen below that the results are not sensitive to large changes in these assumptions.

Benefits to non-market recreation and commercial recreation

It is difficult to determine the impact of changes in water quality on recreation activities. For the purpose of this analysis the same assumption as outlined above for oyster production and commercial fishing is assumed.

Urban amenity benefits

Urban amenity benefits at Pipers Creek, as outlined in Section 3.0 are assumed to accrue from implementation of the WQIP.

4.2.6 Results and sensitivity testing

The present value of costs and benefits, using a 7% discount rate26 are provided in Table 6.

The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the sum of the discounted benefits less the sum of the discounted costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the Project, because the community as a whole would obtain net benefits from the Project. Table 6 indicates that the Wallis Lake WQIP would have a NPV of $32 M, at a central discount rate of 7%, hence it is economically efficient and desirable from a community perspective.

An alternative decision criterion is the benefit cost ratio (BCR). BCR is the sum of discounted benefits divided by the sum of discounted costs. A BCR greater than one indicates that the investment is economically efficient and hence desirable from an economic perspective.

26 The costs and benefits flowing from an investment decision are spread over time. In order to compare the costs and benefits flowing from a project it is necessary to bring them back to a common time dimension. This is done by discounting the value of future costs and benefits in order to determine their present value. The discount rate reflects the social opportunity cost of capital or the social marginal time preference rate.

Table A15.6. Wallis Lake Benefit Cost Analysis Results. [27]

	NPV @ 4%	NPV @ 7%	NPV @ 10%
ECONOMIC COSTS			
Direct Program Costs			
Fertiliser	$991,373	$711,462	$540,514
Dams	$6,564,716	$4,711,072	$3,579,016
Groundcover	$4,952,250	$3,553,979	$2,700,025
Riparian rehabilitation	$924,911	$663,731	$504,224
Riparian protection	$6,435,403	$4,618,149	$3,508,320
Wetland protection	$11,522,006	$9,977,412	$8,728,720
Greenfield	$33,227,720	$25,363,011	$20,070,680
Redevelopment	$54,306,346	$34,359,417	$23,169,932
Mitigation	$4,120,028	$3,133,083	$2,505,393
Sea Sponge protection	$830,810	$646,269	$527,903
WSUD Protection	$485,271	$362,524	$286,218
Lake use actions	$470,041	$408,246	$357,516
Pollution control systems	$57,535	$54,752	$52,184
Adaptive management strategy	$95,644	$68,636	$52,141
Ecological monitoring	$434,446	$320,044	$249,764
Future I and E for FAP	$570,261	$488,729	$426,957
Rainwater tanks	$2,438,417	$2,012,874	$1,715,914
Sub-total	*$128,427,177*	*$91,453,389*	*$68,975,421*
Indirect Program Costs			
Riparian			
Opportunity Costs of Riparian	$843,891	$605,590	$460,055
Dams			
Cost of alternative water supplies for Dams	$260,517	$253,213	$246,307
Sub-total	*$1,104,408*	*$858,803*	*$706,362*
TOTAL COSTS	$129,531,586	$92,312,192	$69,681,783
Benefits			
Improvements in Estuary Health	$13,692,645	$10,673,775	$8,577,661
Improvements in River Health	$78,273,599	$61,016,314	$49,033,942
Increased Native Vegetation Conservation	$488,600	$474,900	$461,949
Increased Wetland Conservation	$21,928,180	$18,988,576	$16,612,120
Benefits to Oyster Growers	$2,921,514	$1,902,271	$1,313,011
Benefits to Commercial Fishers	$613,958	$399,763	$275,930
Benefits to Non-market Recreation	$16,580,842	$10,796,202	$7,451,900
Benefits to Commercial Recreation	$12,155,167	$7,914,534	$5,462,876
Benefits to Urban Amenity	$3,750,000	$3,644,860	$3,545,455
Sub-total	*$150,404,505*	*$115,811,195*	*$92,734,843*
Indirect Program Benefits			
Ground cover and Fertiliser			
Reduce fertiliser costs and increased productivity	$12,263,130	$8,800,219	$6,685,360
Dams			
Increased ag production	$38,307	$27,490	$20,884
Sub-total	*$12,301,437*	*$8,827,709*	*$6,706,244*
TOTAL BENEFITS	$162,705,942	$124,638,904	$99,441,087
NET BENEFITS	$33,174,356	$32,326,713	$29,759,304
BCR	1.3	1.4	1.4

27 The BCA was undertaken of the draft WQIP. Since the draft some additional program costs have been included in the WQIP. However, these are of a small magnitude and would not substantially change the results.

The results are largely insensitive to changes in the discount rate. However, it is evident that the positive result is driven by assumed benefits to commercial and non-commercial recreation, the benefits of improvements in river health and the benefits of wetland conservation. There is considerable uncertainty about the dose-response link between water quality and recreation values. However, even if it is assumed that there are no benefits to recreation, the Wallis Lakes WQIP would still provide a positive NPV ($13.6M).

The other greatest uncertainty relates to the community value for River Health improvement. There are three studies from the literature that are referred to in Section 3.0 that are related to river health improvement. For the economic analysis, Van Buren and Bennett values were used. Results are provided below for alternative values from the literature.

Table A15.7. Sensitivity Testing on River Health Values.

Van Bueren and Bennett (2000)	Windle and Rolfe (2004)	Bennett and Morrison (2001) (healthy riverside vegetation)
$32 M	$563 M	$1M

It is evident that the value used in the central analysis is conservative compared to Windle and Rolfe but generous compared to the Bennett and Morrison value. Nevertheless, the WQIP has a positive NPV under each scenario.

The NPV for the WQIP is also positive even if the value for wetland conservation is assumed to be zero.

The results can also be presented to show the costs and benefits of each of the individual actions in the WQIP. This facilitates consideration of which action is providing the greatest return on investment, as represented by the BCR. Allocation of benefits to each individual action in the WQIP was achieved by estimating the contribution that each action makes to general water quality improvement in the estuary and allocating benefits associated with water quality improvement, accordingly. Non water quality benefits e.g. vegetation conservation, were also allocated to the relevant WQIP action.

Table A15.8. Wallis Lake WQIP BCA of Individual Actions.

Direct Program Costs	Direct Costs	Indirect Costs	Total Costs	Direct Benefits	Indirect WQ Benefits	Total Benefits	BCR
Fertiliser	$711,462		$711,462	$828,794	$483,392	$1,312,186	1.8
Dams	$4,711,072	$253,213	$4,964,285	$27,490	$239,707	$267,197	0.1
Groundcover	$3,553,979		$3,553,979	$7,971,425	$2,113,861	$10,085,287	2.8
Riparian rehabilitation*	$663,731	$431,256	$1,094,987	$25,570,604	$0	$25,570,604	23.4
Riparian protection	$4,618,149	$174,334	$4,792,483	$35,920,611	$2,177,769	$38,098,380	7.9
Wetland protection	$9,977,412		$9,977,412	$18,988,576	$2,770,896	$21,759,472	2.2
Greenfield	$25,363,011		$25,363,011		$10,028,963	$10,028,963	0.4
Redevelopment	$34,359,417		$34,359,417		$4,166,776	$4,166,776	0.1
Mitigation	$3,133,083		$3,133,083		$13,194,051	$13,194,051	4.2
Sea Sponge protection	$646,269		$646,269		NM	NM	
WSUD Protection	$362,524		$362,524		$155,990	$155,990	0.4
Lake use actions	$408,246		$408,246		NM	NM	
Pollution control systems	$54,752		$54,752		NM	NM	
Adaptive management strategy	$68,636		$68,636		NM	NM	
Ecological monitoring	$320,044		$320,044		NM	NM	
Future Investigation for Farm Scale Action Plan	$488,729		$488,729		NM	NM	
Rainwater tanks	$2,012,874		$2,012,874		NM	NM	
Sub-total	$91,453,389	*$858,803*	*$92,312,192*	*$89,307,500*	*$35,331,405*	*$124,638,904*	1.35

NM – the outcomes of these activities were not able to be modelled as part of the DSS

*This action was also not able to be modelled as part of the DSS. However, non water quality benefits associated with riparian rehabilitation were included in the analysis.

This analysis indicates that the greatest return on investment is achieved by Riparian Rehabilitation and Riparian Protection followed by Mitigation, Groundcover Management and Wetland Protection. Although it should be noted that this return on investment is more than just water quality benefits and includes other benefits such as conservation, river health etc. Some actions would appear to have costs that exceed benefits.

4.3 Smiths Lake

4.3.1 Base case

Smiths Lake is currently in a pristine or High Conservation Value status. The catchment is mostly (three quarters) forested (http://www.dnr.nsw.gov.au/estuaries/inventory/smiths.shtmleither) in National Park or managed by State Forests. Other land uses include recreation activities on Smiths Lake such as wading, swimming, canoing, kayaking, sailing, power boating, water skiing and amateur fishing.

Under the base case or without WQIP scenario, the DSS predicts that:

- TN will increase by 2% over 30 years;
- TP will increase by 1.5% over 30 years; and
- TSS and CHL-a increase by less than 0.5%.

4.3.2 WQIP actions

Remediation actions recommended for rural areas of the Smiths Lake catchment included:

- Groundcover management on pasture lands.
- Remediation of unpaved roads.

Remediation actions recommended for urban areas of the Smiths Lake catchment included:

- Retrofitting existing urban areas through implementation of Water Sensitive Urban Devices (WSUD)
- Redevelopment of existing urban land in selected subcatchments

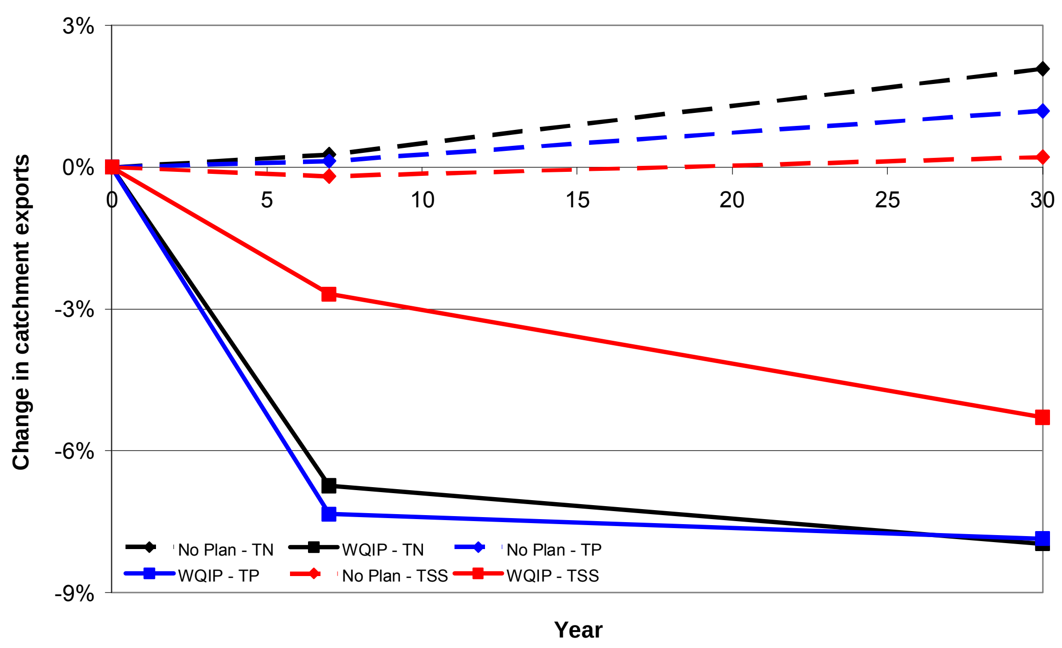
Protection actions recommended for the Smiths lakes catchment included:

- DCP provisions on Greenfield development sites in the Smiths Lake catchment to enforce ‘no net increase’ in pollutants as a result of any future urban developments.

4.3.3 DSS physical outcomes

Not all the actions proposed in the WQIP were able to be modelled in the DSS. The physical outcomes of the modelled policies are illustrated in Figure 4. This indicates that all measures of water quality will improve relative to the base case.

Figure A15.4. Catchment Exports for Smiths Lake With and Without the WQIP.



4.3.4 Identification of benefits and costs

The potential range of costs and benefits associated with the Smiths Lakes WQIP and the predicted water quality outcomes are summarised in Table 9.

Table A15.9. Potential Benefits and Costs of the Smiths Lake WQIP.

Costs	Benefits
Direct Program Costs	*Direct Program Benefits*
• Groundcover	• Increase in area of estuary in good health
• Gravel roads	• Benefits to non-market recreation
• Greenfield	• Benefits to commercial recreation
• Mitigation	
	Indirect Program Benefits
	• Reduced fertiliser costs and increase productivity of agricultural land

4.3.5 Valuation of benefits and costs

Direct program costs

The undiscounted direct costs of the programs area summarised below.

Table A15.10: Direct Program Costs

Program Components	Programs
Groundcover	$38,315
Gravel roads	$720,000
Greenfield	$657,686
WSUD Protection	$4,125
Pollution control systems	$1,586
Adaptive management strategy	$4,271
Ecological monitoring	$18,797
Future I and E for FAP	$18,871
Mitigation	$1,661,396
Total	$3,125,047

Indirect program benefits

Programs may have indirect costs and benefits. Groundcover programs potentially reduce the costs of production and increase productivity of the land. 165 ha of land will be the subject of this program with an assumed 10% increase in productivity i.e. 10% increase in beef gross margin per ha of $139.

Increase in percentage of the estuary in good health

100% of the estuary area is currently considered to be in good health. While the proposed WQIP actions would reduce TN and TP levels and decrease Cl-a levels there would be no noticeable change in the health of the water body. Consequently, no economic benefits associated with improvements in area of healthy estuary can be attributed.

Benefits to non-market recreation, commercial recreation and commercial fishing

It is difficult to determine the impact of changes in water quality on recreation and commercial activities. Given that there will be no noticeable improvement in water quality as a result of the WQIP actions it could be argued that there will be no recreation or commercial benefits. Alternatively, and consistent with the approach taken in the economic analysis of the other Lakes, it can be assumed that there is some linearity between water quality and value even at the high water quality levels of Smiths Lake. It is known from water quality modelling that a 400% decline in water quality in Smiths Lakes will lead to it being of modified condition. A modified condition is assumed to reduce recreation values by 50%. Actions proposed in the WQIP have a 5% effect on water quality and hence recreation and commercial fishing benefits are estimated at 5%/400%*50% of current recreation values i.e. 1%, in 30 years time. Benefits in 7 years time are 0.4%.

4.3.6 Results and sensitivity testing

Table A15.11. Smiths Lake Benefit Cost Analysis Results. [28]

	NPV @ 4%	NPV @ 7%	NPV @ 10%
ECONOMIC COSTS			
Direct Program Costs			
Groundcover	$22,086	$15,850	$12,042
Gravel roads	$415,009	$297,817	$226,246
Greenfield	$414,590	$308,726	$237,329
WSUD Protection	$2,503	$1,870	$1,476
Pollution control systems	$1,481	$1,409	$1,343
Adaptive management strategy	$2,462	$1,767	$1,342
Ecological monitoring	$11,183	$8,238	$6,429
Future I and E for FAP	$14,679	$12,580	$10,990
Mitigation	$1,087,566	$850,576	$695,401
TOTAL COSTS	$1,971,559	$1,498,834	$1,192,599
Benefits			
Improvements in Estuary Health	$0	$0	$0
Improvements in River Health	$0	$0	$0
Increased Native Vegetation Conservation	$0	$0	$0
Increased Wetland Conservation	$0	$0	$0
Benefits to Oyster Growers	$0	$0	$0
Benefits to Commercial Fishers	$3,403	$2,227	$1,545
Benefits to Non-market Recreation	$334,369	$218,830	$151,748
Benefits to Commercial Recreation	$105,913	$69,315	$48,067
Benefits to Urban Amenity	$0	$0	$0
Sub-total	*$443,686*	*$290,373*	*$201,360*
Indirect Program Benefits			
Ground cover and Fertiliser			
Reduce fertiliser costs and increased productivity	$39,659	$28,460	$21,621
Sub-total	*$39,659*	*$28,460*	*$21,621*
TOTAL BENEFITS	$483,345	$318,833	$222,981
NET BENEFITS	-$1,488,214	-$1,180,001	-$969,619
BCR	0.2	0.2	0.2

The present value of costs and benefits, using a 7% discount rate are provided in Table 10.

The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the sum of the discounted benefits less the sum of the discounted costs. A

28 The BCA was undertaken of the draft WQIP. Since the draft some additional program costs have been included in the WQIP. However, these are of a small magnitude and would not substantially change the results.

positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the Project, because the community as a whole would obtain net benefits from the Project. Table 11 indicates that the Project would have a NPV of -$1.2M M at a central discount rate of 7%, hence it is economically inefficient and not desirable from a community perspective.

An alternative decision criterion is benefit cost ratio (BCR). BCR is the sum of discounted benefits divided by the sum of discounted costs. A BCR less than one indicates that the investment is economically inefficient and hence undesirable from an economic perspective.

The results are largely insensitive to changes in the discount rate. The only potential benefit of the program appears to be related to commercial and non-commercial recreation. However, given the current pristine state of the Lake and the minimal and potentially imperceptible water quality decline associated with the base case, it is questionable whether any recreation benefits will arise.

The economic desirability of the WQIP would therefore appear questionable.

The results can also be presented to show the costs and benefits of each of the individual actions in the WQIP. This facilitates consideration of which action is providing the greatest return on investment, as represented by the BCR. Allocation of benefits to each individual action in the WQIP was achieved by estimating the contribution that each action makes to general water quality improvement in the estuary and allocating benefits associated with water quality improvement, accordingly. Non water quality benefits e.g. agricultural productivity benefits, were also allocated to the relevant WQIP action.

Table A15.12. Smiths Lake WQIP BCA of Individual Action.

Direct Program Costs	Direct Costs	Indirect Costs	Total Costs	Direct Benefits	Indirect WQ Benefits	Total Benefits	BCR
Groundcover	$15,850		$15,850	$28,460	$10,305	$38,765	2.4
Gravel roads	$297,817		$297,817		$5,359	$5,359	0.0
Greenfield	$308,726		$308,726		$247,600	$247,600	0.8
WSUD Protection	$1,870		$1,870		$1,553	$1,553	0.8
Pollution control systems	$1,409		$1,409		NM	NM	
Adaptive management strategy	$1,767		$1,767		NM	NM	
Ecological monitoring	$8,238		$8,238		NM	NM	
Future I and E for FAP	$12,580		$12,580		NM	NM	
Mitigation	$850,576		$850,576		$25,557	$25,557	
Total	$1,498,834		$1,498,834	$28,460	$290,373	$318,833	0.2

NM – the outcomes of these activities were not able to be modelled as part of the DSS

This analysis indicates that only Groundcover management provides a positive return on investment, largely as a result of agricultural productivity improvements. All other actions have costs exceed benefits.

4.4 Myall Lakes

4.4.1 Base case

The Myall Lakes comprise a series of three interconnected water bodies, from north to south referred to here as:

- Myall Lake;
- Boolambyte (including Two Mile Creek); and
- Bombah Broadwater.

Myall Lake is mostly fresh while the Boolambyte and Bombah Broadwater are slightly saline (depending on rainfall).

The three water bodies are surrounding by Myall National Park. The Lakes are popular for camping e.g. at Mungo Brush Camping Area, and there is a major commercial resort (Myall Shores Eco Resort) located on the Shores of Bombah Broadwater. Day trippers come up to the lakes via boat from Tea Gardens. The Lakes are also popular with houseboats, with this industry based at Bulladelah.

Myall Lake and Bollambyte are considered to be in pristine condition while Bombah Broadwater is considered to be moderately disturbed. Bombah Broadwater has periodically experienced major algal blooms that last up to 18 months. During April and October 1999 Bombah Broadwater experienced blue green algae blooms that persisted until August 2000.

Under the base case or without WQIP scenario, the DSS predicts that:

- TN will increase by up to 5%
- TP will increase by over 4%;
- TSS will increase by 4%;

4.4.2 WQIP actions

A range of rural and urban remediation and protection actions are proposed in the WQIP for the Myall Lakes.

Remediation actions recommended for rural areas of the Myall lakes catchment included:

- Groundcover management on pasture lands.
- Nutrient (fertilizer) management.
- Infrastructure management including dam refurbishment and/or decommissioning.
- Riparian remediation focusing on areas of active stream bank erosion.

Protection actions recommended for the Myall lakes catchment included:

- Fencing and/or stock exclusion for areas of remnant riparian revegetation including off-stream watering and some planting where vegetation requires rehabilitation.
- Protection of coastal wetlands including exclusion of stock and buyback of wetlands where necessary.
- DCP provisions on Greenfield development sites in the Myall lakes catchment to enforce ‘no net increase’ in pollutants as a result of any future urban developments.

In addition, a specific plan to target the Crawford River catchment – a drinking water catchment – has been assessed. This plan involved investment in nutrient and groundcover management, infrastructure management, and riparian rehabilitation and protection.

4.4.3 DSS physical outcomes

Not all the actions proposed in the WQIP were able to be modelled in the DSS. The physical outcomes of the modelled policies for the Myall Lakes are illustrated in Figure 5. The outcomes for the drinking water strategy for the Crawford catchment are provided in Figure 6. This indicates that all measures of water quality will improve relative to the base case.

Figure A15.5. Catchment Exports for Myall Lake With and Without the WQIP.

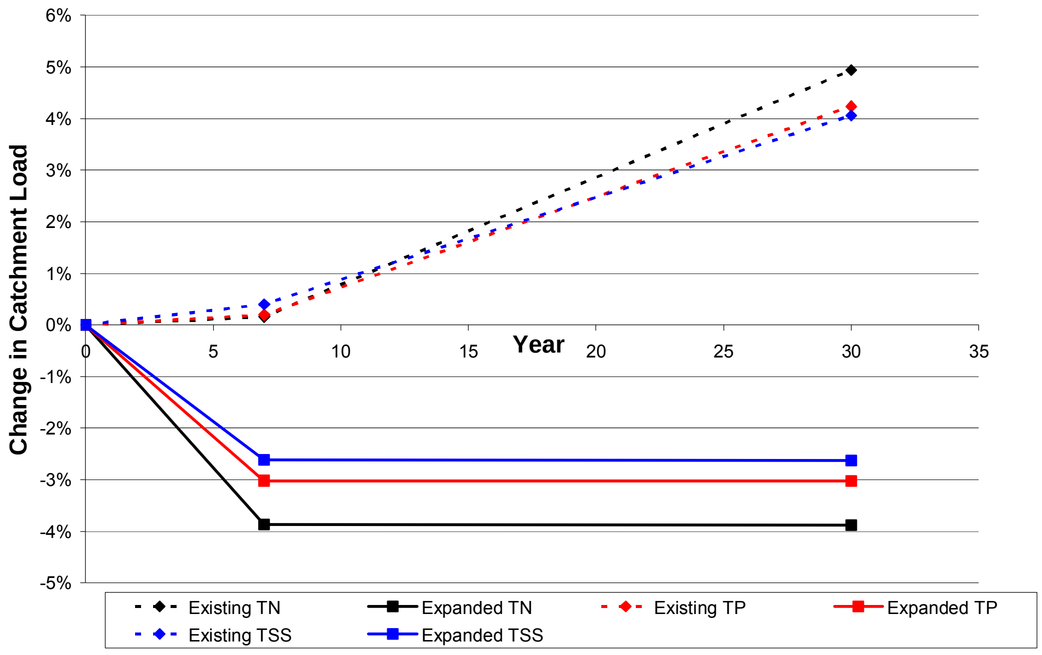
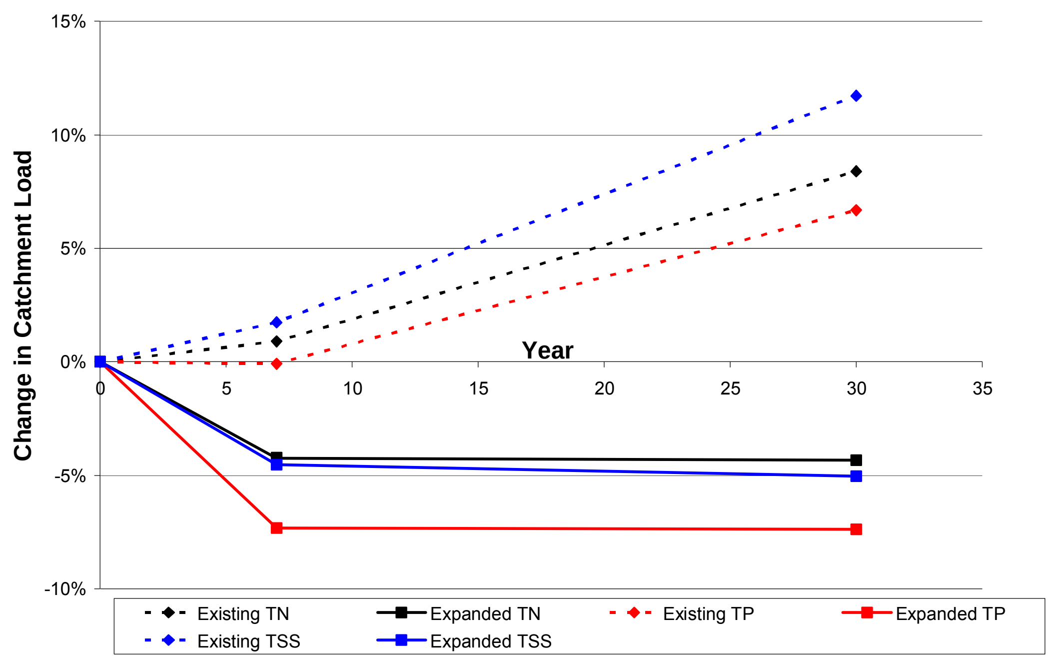


Figure A15.6. Catchment Exports for Myall Lake With and Without the Drinking Water Strategy for the Crawford Catchment.



4.4.4 Identification of benefits and costs

The potential range of costs and benefits associated with the Myall Lakes WQIP and the drinking water strategy for the Crawford catchment are summarised in Table 13 and 14.

Table A15.13. Potential Benefits and Costs of the Myall Lakes WQIP.

Costs	Benefits
Direct Program Costs	*Direct Program Benefits*
• Fertiliser	• Increase in area of estuary in good health
• Dams	• Increase in length of river in good health
• Groundcover	• Increased area of native vegetation conservation
• Riparian remediation	• Increased area of wetland conservation
• Greenfields	• Benefits to non-market recreation
• Riparian protection	• Benefits to commercial recreation
• Wetland protection	• Reduced water treatment costs of mid-coast water
Indirect Program Costs	*Indirect Program Benefits*
• Opportunity costs of riparian revegetation and protection	• Reduced fertiliser costs and increase productivity of agricultural land
• Costs of alternative water supplies where dams are eliminated	• Increased agricultural productivity where dams are eliminated

Table A15.14. Potential Benefits and Costs of the Drinking Water Strategy for the Crawford Catchment.

Costs	Benefits
Direct Program Costs	*Direct Program Benefits*
• Fertiliser	• Increase in area of estuary in good health
• Dams	• Increase in length of river in good health
• Groundcover	• Increased area of native vegetation conservation
• Riparian remediation	• Benefits to non-market recreation
	• Benefits to commercial recreation
	• Reduced water treatment costs of mid-coast water
Indirect Program Costs	*Indirect Program Benefits*
• Costs of alternative water supplies where dams are eliminated	• Reduced fertiliser costs and increase productivity of agricultural land
	• Increased agricultural productivity where dams are eliminated

4.4.5 Valuation of benefits and costs

Direct program costs

The undiscounted direct costs of the programs area summarised below.

Table A15.15. Direct Program Costs.

Program Components	Normal Programs	Crawford Program
Fertiliser	$1,719,836	$1,719,836
Dams	$3,585,625	$1,265,738
Groundcover	$4,467,986	$2,619,471
Riparian remediation	$1,128,451	$2,737,500
Greenfields	$3,007,281	
WSUD Protection	$119,305	
Pollution control systems	$37,492	
Adaptive management strategy	$100,958	
Ecological monitoring	$444,287	
Future I and E for FAP	$446,033	
Riparian protection	$3,776,000	
Wetland protection	$2,584,901	
Total	$21,418,154	$8,342,545

Indirect program costs and benefits

Programs may have indirect costs and benefits. For instance, riparian program imposes an opportunity cost to landholders as replanting and fencing essentially takes land out of production. This opportunity cost would depend on the whether the land is cleared or vegetated. iCAM estimate that under the normal riparian program 134 ha of existing vegetation would be protected, and 26 ha of revegetation of cleared land would occur. An opportunity cost of $139/ha per annum was used for land that is revegetated and a figure of $4/ha per annum was used for vegetated land. The drinking water strategy for the Crawford catchment includes in the direct costs the purchasing of the land and hence no additional opportunity costs are relevant.

The dam refurbishment and decommissioning program would impose an additional cost on landholders where dams are decommissioned and alternative water supplies are required for stock. It is assumed that 21 dam in the Myall Lakes catchment are subject to the program and that 50% of these require an alternative water supply comprising a solar pump ($8,000) and trough ($500). Under the drinking water strategy for the Crawford catchment it is assumed that 8 dams are subject to the program with 50% requiring an alternative water supply.

Dam decommissioning also adds to the productive area of a farm (assumed here at 0.5ha per dam) with the net value productive land assumed to be $139/ha per annum.

Groundcover and fertiliser programs potentially reduce the costs of production and increase productivity of the land. 14,966 ha and 4,977 ha land will be the subject of these programs, respectively, under the Myall WQIP, with an assumed 10% increase in productivity i.e. 10% increase in beef gross margin per ha of $139. Under the drinking water strategy for the Crawford catchment 1,262 ha and 610 ha will be subject to these programs, respectively.

Increase in percentage of the estuary in good health

iCAM indicate that the modelled water quality improvements from the proposed actions would have the effect of improving the area of estuary considered healthy by 4ha for the Myall Lakes WQIP and 4ha for the drinking water strategy for Crawford catchment, compared to the base case. Using Windle and Rolfe (2004) a 4ha increase in the area of an estuary that is healthy has an economic value of $40,000 per annum.

Improvements in river health

iCAM indicate that the modelled WQ improvements from the proposed actions would have the effect of increasing the length of river considered healthy by 137km for the normal option and 16km for the drinking water strategy for the Crawford catchment. Using Windle and Rolfe (2004[DG63]) each km improvement in river health has a value at in the order of $110,000 to $150,000 per annum. Using van Bueren and Bennett (2000) the value is $11,400 per km. The latter is used in this analysis.

Increase in area of vegetation conservation

The actions under the Myall Lakes WQIP and drinking water strategy for the Crawford catchment are estimated to conserve 160 ha and 235 ha of native vegetation, respectively. Using Van Bueren and Bennett (2000) and Lockwood and Carberry (1998) this has an economic value of $430/ha and $630/ha, respectively

Increased area of wetlands

The normal actions are estimated to conserve 235 ha wetlands. There is no additional wetland conservation under the drinking water strategy for the Crawford catchment. Using Whitten and Bennett (2001) wetlands have an economic value of $13,700/ha.

Benefits to non-market recreation, commercial recreation and commercial fishing

It is difficult to determine the impact of changes in water quality on recreation and commercial fishing activities. For the purpose of this analysis some linearity between water quality and value is assumed. It is known from water quality modelling that a 21% decline in water quality in the Myall Lakes will lead to it being of modified condition. A modified condition is estimated to reduce recreation values by 50%. Actions proposed in the WQIP have a 10% effect of water quality and hence recreation and commercial fishing benefits are estimated at 10%/21%*50% of current recreation values i.e. 24%, in 30 years time.

Benefits in 7 years time are estimated at 10%. The same is assumed for the drinking water strategy for the Crawford catchment.

Reduced water treatment costs of mid-coast water

The Crawford Catchment provides water supply to Bulahdelah via Mid-Coast Water.

Water quality improvements have implications for water treatment costs. The estimated $21,300 per annum in chemical treatment costs related to water quality are estimated to change linearly with changes in TSS identified in Figures 5 and 6 e.g. in year 30, instead of these costs increasing by 11.7% they would decrease by 5%. Similar calculations are made for each year of the analysis.

4.4.6 Results and sensitivity testing

The present value of costs and benefits, using a 7% discount rate are provided in Table 14 and 15.

The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the sum of the discounted benefits less the sum of the discounted costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the Project, because the community as a whole would obtain net benefits from the Project. Table 16 and 17 indicate that the Myall Lakes WQIP and drinking water strategy for the Crawford catchment would have a NPV of $29 M and $16 M respectively, at a central discount rate of 7%; hence they are economically efficient and desirable from a community perspective.

An alternative decision criterion is the benefit cost ratio (BCR). BCR is the sum of discounted benefits divided by the sum of discounted costs. A BCR greater than one indicates that the investment is economically efficient and hence desirable from an economic perspective.

Table A15.16. Myall Lakes Benefit Cost Analysis Results. [29]

	NPV @ 4%	NPV @ 7%	NPV @ 10%
ECONOMIC COSTS			
Direct Program Costs			
Fertiliser	$991,373	$711,462	$540,514
Dams	$2,066,819	$1,483,221	$1,126,806
Groundcover	$2,575,525	$1,848,348	$1,404,245
Riparian remediation	$650,440	$466,767	$354,594
Greenfields	$1,984,150	$1,544,856	$1,250,261
WSUD Protection	$72,395	$54,083	$42,699
Pollution control systems	$35,006	$33,313	$31,750
Adaptive management strategy	$58,192	$41,760	$31,724
Ecological monitoring	$264,327	$194,723	$151,962
Future I and E for FAP	$346,961	$297,355	$259,771
Riparian protection	$2,176,491	$1,561,885	$1,186,534
Wetland protection	$2,096,586	$1,815,526	$1,588,309
Sub-total	*$13,318,265*	*$10,053,297*	*$7,969,171*
Indirect Program Costs			
Riparian			
Opportunity Costs of Riparian Revegetation	$71,626	$51,400	$39,048
Dams			
Cost of alternative water supplies for Dams	$86,839	$84,404	$82,102
Sub-total	*$158,465*	*$135,804*	*$121,150*
TOTAL COSTS	$13,476,731	$10,189,101	$8,090,321
Benefits			
Improvements in Estuary Health	$569,636	$444,046	$356,844
Improvements in River Health	$21,207,853	$16,532,076	$13,285,510
Increased Native Vegetation Conservation	$96,721	$94,010	$91,446
Increased Wetland Conservation	$2,607,733	$2,258,151	$1,975,539
Benefits to Oyster Growers	$0	$0	$0
Benefits to Commercial Fishers	$233,868	$148,490	$100,098
Benefits to Non-market Recreation	$21,111,720	$13,404,492	$9,036,080
Benefits to Commercial Recreation	$5,166,724	$3,280,515	$2,211,422
Mid Coast Water Treatment Savings	$31,904	$20,169	$13,505
Sub-total	*$51,026,160*	*$36,181,949*	*$27,070,444*
Indirect Program Benefits			
Ground cover and Fertiliser			
Reduce fertiliser costs and increased productivity	$4,793,485	$3,439,882	$2,613,213
Dams			
Increased ag production	$12,769	$9,163	$6,961
Sub-total	*$4,806,254*	*$3,449,045*	*$2,620,174*
TOTAL BENEFITS	$55,832,414	$39,630,994	$29,690,619
NET BENEFITS	$42,355,684	$29,441,893	$21,600,298
BCR	4.1	3.9	3.7

29 The BCA was undertaken of the draft WQIP. Since the draft some additional program costs have been included in the WQIP. However, these are of a small magnitude and would not substantially change the results.

Table A15.17. Myall Lakes Benefit Cost Analysis Results – Drinking Water Strategy for the Crawford Catchment. [30]

	NPV @ 4%	NPV @ 7%	NPV @ 10%
ECONOMIC COSTS			
Direct Program Costs			
Fertiliser	$991,373	$711,462	$540,514
Dams	$729,616	$523,612	$397,800
Groundcover	$1,509,597	$1,083,140	$822,701
Riparian remediation	$1,577,898	$1,132,325	$860,206
Sub-total	*$4,808,483*	*$3,450,538*	*$2,621,222*
Indirect Program Costs			
Riparian			
Opportunity Costs of Riparian	$0	$0	$0
Dams			
Cost of alternative water supplies for Dams	$86,839	$84,404	$82,102
Sub-total	*$86,839*	*$84,404*	*$82,102*
TOTAL COSTS	$4,895,322	$3,534,942	$2,703,324
Benefits			
Improvements in Estuary Health	$553,243	$431,268	$346,575
Improvements in River Health	$2,460,723	$1,918,198	$1,541,503
Increased Native Vegetation Conservation	$141,385	$137,420	$133,673
Increased Wetland Conservation	$0	$0	$0
Benefits to Oyster Growers	$0	$0	$0
Benefits to Commercial Fishers	$233,868	$148,490	$100,098
Benefits to Non-market Recreation	$21,111,720	$13,404,492	$9,036,080
Benefits to Commercial Recreation	$5,166,724	$3,280,515	$2,211,422
Mid Coast Water, Water Treatment Cost Savings	$31,904	$20,169	$13,505
Sub-total	*$29,699,568*	*$19,340,553*	*$13,382,856*
Indirect Program Benefits			
Ground cover and Fertiliser			
Reduce fertiliser costs and increased productivity	$449,953	$322,893	$245,296
Dams			
Increased ag production	$12,769	$9,163	$6,961
Sub-total	*$462,722*	*$332,056*	*$252,257*
TOTAL BENEFITS	$30,162,289	$19,672,609	$13,635,113
NET BENEFITS	$25,266,967	$16,137,667	$10,931,790
BCR	6.2	5.6	5.0

The results are largely insensitive to changes in the discount rate. However, it is evident that the positive result for both is driven by assumed benefits to commercial and non-commercial recreation with the positive result for the Myall WQIP also driven by the benefits of improvements in river health. There is considerable uncertainty about the dose-response link between water quality and recreation values. However, even if it is assumed that there are no benefits to recreation the Myall Lakes WQIP would still provide a positive NPV ($12.7). The same is not the case for the drinking water strategy for the Crawford catchment; this is highly sensitive to changes in assumptions about recreation values.

30 The BCA was undertaken of the draft WQIP. Since the draft some additional program costs have been included in the WQIP. However, these are of a small magnitude and would not substantially change the results.

The other greatest uncertainty for the Myall WQIP relates to the community value for River Health improvement. There are three studies from the literature that are referred to in section 3.0 that are related to river health improvement. For the economic analysis, Van Buren and Bennett (2000) values were used. Results are provided below for alternative values from the literature.

Table A15.18. Sensitivity Testing on River Health Value.

	Van Bueren and Bennett (2000)	Windle and Rolfe (2004)	Bennett and Morrison (2001) (healthy riverside vegetation
Myall Lakes WQIP	$29 M	$173 M	$47
Crawford Option WQIP	$16 M	$33 M	$16 M

It is evident the results of the analysis are insensitive to the economic value used from the literature. Under any of the assumptions the NPV for Myall Lakes WQIP and Crawford Option remain positive.

The results can also be presented to show the costs and benefits of each of the individual actions in the Myall Lakes WQIP and Crawford WQIP. This facilitates consideration of which action is providing the greatest return on investment, as represented by the benefit cost ratio. Allocation of benefits to each individual action in the WQIP was achieved by estimating the contribution that each action makes to general water quality improvement in the estuary and allocating benefits associated with water quality improvement, accordingly. Non water quality benefits e.g. vegetation conservation, were also allocated to the relevant WQIP action.

Table A15.19. Myall Lakes WQIP BCA of Individual Actions.

Direct Program Costs	Direct Costs	Indirect Costs	Total Costs	Direct Benefits	Indirect WQ Benefits	Total Benefits	BCR
Fertiliser	$711,462		$711,462	$858,461	$1,979,428	$2,837,890	4.0
Dams	$1,483,221	$84,404	$1,567,625	$9,163	$159,194	$168,357	0.1
Groundcover	$1,848,348		$1,848,348	$2,581,421	$1,192,126	$3,773,547	2.0
Riparian remediation	$466,767	$20,700	$487,466	$2,701,739	$40,438	$2,742,177	5.6
Greenfields	$1,544,856		$1,544,856		$4,414,337	$4,414,338	2.9
WSUD Protection	$54,083		$54,083		$175,125	$175,126	3.2
Pollution control systems	$33,313		$33,313		NM	NM	
Adaptive management strategy	$41,760		$41,760		NM	NM	
Ecological monitoring	$194,723		$194,723		NM	NM	
Future I and E for FAP	$297,355		$297,355		NM	NM	
Riparian protection	$1,561,885	$30,700	$1,592,585	$13,924,346	$5,542,728	$19,467,075	12.2
Wetland protection	$1,815,526		$1,815,526	$2,258,151	$3,794,333	$6,052,484	3.3
Total	$10,053,297	$135,804	$10,189,101	$22,333,281	$17,297,712	$39,630,994	3.9

NM – the outcomes of these activities were not able to be modelled as part of the DSS

Table A15.20. Drinking Water Strategy for the Crawford Catchment BCA of Individual Actions.

Direct Program Costs	Direct Costs	Indirect Costs	Total Costs	Direct Benefits	Indirect WQ Benefits	Total Benefits	BCR
Fertiliser	$711,462		$711,462	$105,216	$4,132,584	$4,237,800	6.0
Dams	$523,612	$84,404	$608,016	$9,163	$315,979	$325,143	0.5
Groundcover	$1,083,140		$1,083,140	$217,677	$6,455,286	$6,672,963	6.2
Riparian remediation	$1,132,325		$1,132,325	$2,055,619	$6,381,086	$8,436,704	7.5
Total	$3,450,538	$84,404	$3,534,942	$2,387,675	$17,284,934	$19,672,609	5.6

This analysis indicates that the Myall Lakes WQIP actions all provide a positive return on investment, apart from dam refurbishment, with Riparian Protection and Riparian Remediation providing the greatest return on investment largely because of benefits not associated with the estuary.

All actions in the drinking water strategy for the Crawford catchment, apart from Dam Refurbishment, provide a positive return on investment apart from Dam Refurbishment.

5. Regional economic impact assessment

As identified in Section 2.0, activities that involve expenditure in a region provide some stimulus to economic activity in that region while those that reduce expenditure in a region will have the opposite effect.

From the BCA provided in Section 4.0, it is evident that the WQIPs will provide both positive and negative impacts to the Great Lakes regional economy. These can potentially be estimated in terms of direct and indirect output, value-added, income and employment, using input-output analysis techniques. This type of analysis has not been undertaken in this study. However, the aspects of the WQIPs that are likely to alter expenditure patterns in the region are identified below.

Positive impacts to the regional economy are likely to arise from:

- Direct program expenditures;
- Indirect program expenditures e.g. expenditure by landholders that decommission dams, on alternative water supply;
- Expenditure associated with increased use of the lakes by visitors and locals as a result of improved water quality;
- Expenditure of tourism operators associated with increased use of the lakes by visitors and locals as a result of improved water quality;
- Expenditure of commercial fishers associated with increased fishing effort when fish stocks improve31;
- Expenditure associated with increased agricultural activity on rehabilitated dam sites

Aspects of the WQIPs that may result in a reduction in regional economic activity include:

- Reduced expenditure on grazing associated with establishment of riparian buffers;
- Reduced depuration costs for oysters growers with improved water quality;
- Reduced chemical and fertiliser purchases associated with fertiliser and groundcover management programs;
- Reduced chemical purchased by Mid-coast Water, if water requires less treatment.

While it may be tempting to firstly model, and then add-up, all the additions to regional economic activity as a result of the WQIPs, and compare it to all the reductions in economic activity as a result of the WQIPs, this would make little sense.

Unlike BCA where if benefits of an action exceed its costs it is considered to be economically efficient and desirable from a community perspective, there is no similar decision rule for regional economic activity. More is not necessarily better. This is illustrated by the situation with oyster production whereby declining water quality in Wallis Lakes will lead to greater operating costs associated with more

31 Note that the converse may also be the case i.e. when fish stocks decline due to water quality decline fisher may require increased effort to catch the same quantities of fish and hence may provide a greater economic stimulus to the region when water quality is poorer.

depuration and will provide additional regional economic stimulus. However, it would be difficult to argue that because of this increased regional economic activity it is desirable to let water quality decline.

Nevertheless, it would appear that the direct expenditures that would stimulate the regional economy are considerably greater than the reduction in direct expenditures that would lead to a contraction in regional economic activity

6. Integration of economic values with the DSS

The BCA undertaken in this study was heavily reliant on the DSS prediction of water quality impacts "with" and "without" implementation of each of the WQIPs.

However, the BCA was undertaken externally to the DSS as the BCA framework is not easily integrated into the DSS. Full integration is problematic for the following reasons:

- The DSSs estimate water quality outcomes in terms of a number of parameters such as total nitrogen, total phosphorus, total suspended solids and Chlorophyll-a. However, water quality outcomes of themselves have no economic value. What is important is how changes in water quality impact on the welfare of producers and consumers. To undertake a BCA therefore requires a number of additional steps i.e. determination of how changes in water quality are likely to affect producers and consumers, what the values producers and consumers have that are impacted and to what extent these values are impacted.
- The DSS is static in the sense that it is run for a single year, although for the BCA the DSSs were run for three single years, current year, year 7 and year 30. BCA is dynamic in that it is concerned with costs and benefits in each individual year over the 30 year period. Consequently, water quality benefits had to be estimated for year 7 and 30 and then interpolated for intervening years.
- Some costs do not lend themselves to integration with the DSS. For instance, some program costs are not proportional to the area of land that is rehabilitated or protected. They cannot therefore be linked to physical measures that are modelled in the DSS and therefore need to be considered separately.

While some of the economic values estimated in this study may be able to be incorporated into the DSS it is considered the issues of full integration are so problematic that benefit cost analysis of WQIP actions is best undertaken externally to the DSS.

7. Conclusions and recommendations

- On the basis of the assumptions made, the Wallis Lake WQIP, Myall Lakes WQIP and drinking water strategy for the Crawford catchment, are estimated to provide net economic benefits and therefore are considered to be justified on economic grounds.
- The benefits of implementing the Smiths Lake WQIP would appear to be modest because of the already pristine state of the estuary and minimal decline predicted if no action is taken. The BCA indicates that these modest benefits do not outweigh the economic costs and hence the Smiths Lake WQIP is considered to be economically inefficient.
- The economic values are largely based on benefit transfer from other studies in other contexts. There would be benefit from undertaking primary economic valuation studies such as choice modelling to more directly estimate the values that the community hold for water quality improvements in the Great Lakes and improvements in environmental outcomes in the catchment.
- One area of great uncertainty in the analysis is the link between changes in water quality and commercial production values (oysters, commercial fishing) and recreation values (both commercial and non-commercial). Further investigation of this dose-response link is warranted in the future.
- While the Wallis Lake WQIP, Myall Lakes WQIP and drinking water strategy for the Crawford catchment are estimated to provide net economic benefits, some of the individual actions in these plans are estimated to provided limited benefits relative to the costs and are considered to be economically inefficient. For Myall Lakes riparian remediation, fertiliser management and WSUD are the most economically efficient actions. For Smiths Lake only groundcover management was considered economically efficient. For Wallis Lake riparian rehabilitation, riparian protection and mitigation were the most economically efficient actions.
- The WQIPs will provide both positive and negative impacts to the Great Lakes regional economy. These can potentially be estimated in terms of direct and indirect output, value-added, income and employment, using input-output analysis techniques. While this type of analysis has not been undertaken, the direct expenditures that would stimulate the regional economy are considerably greater than the reduction in direct expenditures that would lead to a contraction in regional economic activity.
- While the BCA undertaken in this study was heavily reliant on the DSS prediction of water quality impacts there are a number of problems integrating the BCA framework into the DSS. Consequently, it is considered that any BCA of future water quality improvement actions will need to be undertaken separately from DSS modelling.

Appendix 16: Background information on Smiths Lake and catchment

This appendix has two purposes: to provide a background to the Smiths Lake system and catchment; and to provide the context and history to the catchment management actions and approach to catchment management. The first section on Smiths Lake and its catchment includes descriptions of the key sub-catchments, catchment topography, history, land uses and ecology. The second section on catchment management includes discussion of land use planning, focussing on further expansion of urban and rural residential areas, and the development and implementation of catchment and estuary management plans.

1. Smiths Lake and its catchment

Smiths Lake is a small coastal barrier lagoon situated approximately 25 km south of the township of Forster on the lower mid-north coast of New South Wales (Figure A16.1). The lake has a catchment area of 35.89 km^2 and a total waterway area of approximately 10 km^2, physically divided into three similar-sized basins (Webb, McKeown & Associates 1998). The most easterly of the three basins is relatively shallow, averaging <1.0 m, with substantial sand deposits surrounding the intermittently open entrance to the ocean. The middle and western basins are somewhat deeper drowned valleys, averaging 2.4 m and 1.6 m deep, respectively (Webb, McKeown & Associates 2001).

No large river networks drain into Smiths Lake. When the lake is closed to the ocean, the principal source of water flowing into the lake is from several small creek networks draining the northern and north-western portions of the catchment. The largest of these are Wamwarra and Tarbuck creeks, both of which drain areas where the catchment remains predominantly forested. Some rural residential development is occurring along the mid and lower sections of the Wamwarra Creek catchment.

The Smiths Lake catchment falls wholly within the Great Lakes local government area.

2. Entrance behaviour and management

Smiths Lake is often referred to as an intermittently closed or open lake or lagoon (ICOLL). Normally such coastal waterways are closed to the ocean unless opened mechanically. Without human interference, ICOLL water bodies will, on rare occasions, overtop the retaining beach berm, particularly after significant catchment rainfall events. Such overtopping events can trigger sufficient erosion to naturally breach the berm. Once breached, lake water levels are reduced rapidly and the lake comes under the influence of the diurnal tidal cycle through the open channel, until sand accumulation again closes the channel (NSW Maritime 2005; Webb, McKeown & Associates 1998).

The ocean entrance for Smiths Lake has been opened mechanically at regular intervals since 1932 (Webb, McKeown & Associates 1998, 2001). Initially this process was instigated by local fishers to facilitate prawn and estuarine fish catches. However, since the 1960s, Great Lakes Council has initiated the channel opening process (Webb, McKeown & Associates 2001). Generally the lake waters are released to prevent the inundation of low-lying properties along the lake foreshore. However, there have been occasions when the entrance channel has been opened to improve water quality or to allow civil construction works along the lake foreshore (Webb, McKeown & Associates 2001).

Prior to 1999, the entrance channel was opened once the lake waters reached 1.7 m AHD. (Australian Height Datum is the measurement system for the determination of elevations above and below sea level in Australia; mean sea level is set as zero elevation.) In 1999, the trigger height was increased to 2.1 m AHD to reduce the number of opening events and to closer replicate a natural opening regime. Council records kept since 1996 indicate that, on average, the channel is opened every 15 months. The length of time the excavated channel remains open is highly variable; in May 1999 and March 2005 excavated openings closed naturally after 10 days, while in November 2006 an excavated opening remained open until January 2008 – a period of 14 months. In 2007, Great Lakes Council commissioned an assessment of the lake's flood dynamics given the current catchment conditions. This assessment is the first stage of a four-part process to formalise the flood risk management process and entrance opening procedure (Webb, McKeown & Associates 2001).

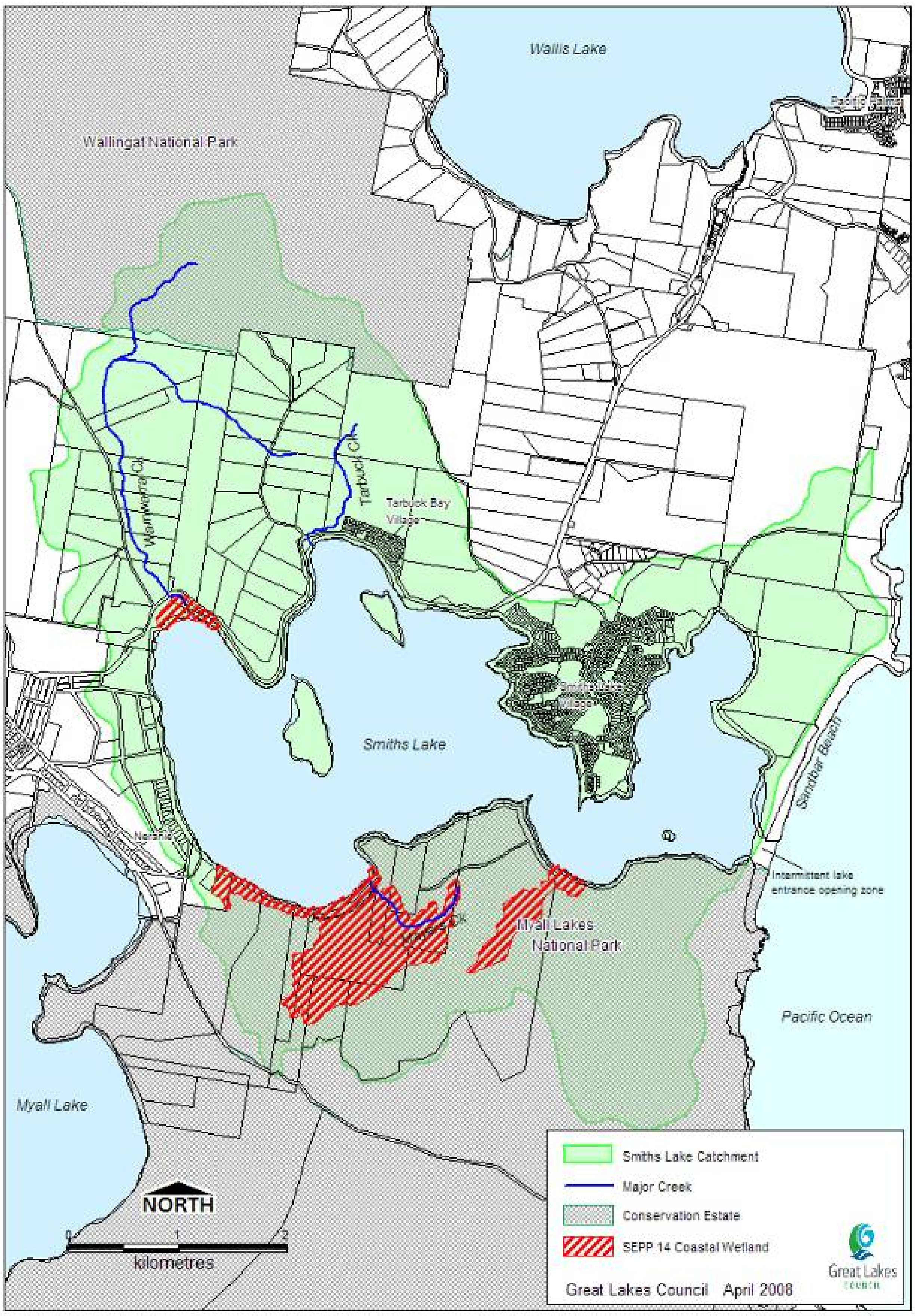


Figure A16.1. Location of Smiths Lake and its catchment relative to Wallis Lake and Myall Lake. Also shown are the two largest developed areas with the catchment – Smiths Lake village and Tarbuck Bay village.

When the lake's entrance channel is open, the lake is subject to the prevailing oceanic tidal regime plus influences associated with the general coastal environment such as wind, swell and currents. The typical channel size is approximately 60 m wide by 1 m deep. On average, the tidal exchange experienced by the lake is 10% of the full oceanic range. When the lake is open to regular tidal exchange, salinity levels within the lake approach that found in the ocean. However, once the entrance is closed, salinity begins to fall as freshwater catchment inflows and direct rainfall gradually refill the lake basin. Rain falling directly onto the lake surface can contribute up to 35% of the total water recharge into the lake during storm events (Webb, McKeown & Associates 1998).

3. Catchment topography

The Smiths Lake catchment can be subdivided into two broad topographical units: the barrier dunes to the south and east of the lake; and sedimentary slopes to the north and west of the lake.

To the south of the lake are extensive aeolian dunes rising to approximately 70 m AHD; the eastern shore of the lake directly abuts the barrier dune system rising to 50 m AHD. The lake bed is generally flat, averaging 1 to 2m in depth. The deepest areas of the lake, reaching approximately 3.5 m, are just off the south-eastern end of Big Island, the Simons Point channel and the north-western corner of Symes Bay.

The Smiths Lake catchment lies generally along a north-west / south-east axis, extending approximately 7.8 km inland from its coastal barrier berm. The northern and western parts of the catchment rise relatively steeply up from the lake foreshore; slope grades of 20% are typical of this area. The highest points of the catchment are the hill crests immediately north of the village of Tarbuck Bay (220 m AHD) and to the west of the lake (150 m AHD).

The northern and western areas of the catchment are principally Carboniferous sedimentary deposits. The eroded remnants of these deposits now form the hills bordering the northern and western catchment boundaries. To the south and east, Quaternary sand deposits have formed an extensive dune complex overlaying the older Carboniferous substrate. Minor alluvial deposits have accumulated along the catchment's creeklines and at the points where creeks and gullies enter the lake.

4. Catchment soils

As is the case in the Wallis Lake and Myall Lakes catchments, soils within the Smiths Lake catchment are sourced from similar sedimentary and volcanic parent material, and are typically of low fertility. Colluvial soil landscapes are the dominant soil landscape type within the Smiths Lake catchment, and are found across 21.2% of the catchment (Table A16.1).

Table A16.1. Soil landscape types of the Smiths Lake catchment.

Soil landscape group	Area (ha)	Proportion of catchment (%)
Aeolian	559.218	15.58
Colluvial	761.503	21.22
Disturbed	130.083	3.63
Erosional	322.589	8.99
Estuarine / Alluvial	80.643	2.25
Residual	466.440	12.99
Swamp	157.097	4.38
Transferral	144.018	3.18
Water	996.778	27.78
Total	**3,618.369**	**100.00**

Colluvial soils are a product of unconsolidated soil and rock, and are mobilised by gravitational forces. These soils are typical of the steeper hillslopes along the northern and western parts of the catchment, and are readily erodible once the vegetative cover is removed. At the present, most of the colluvial landscape within the Smiths Lake catchment retains its protective forest canopy.

Aeolian soil landscapes are the dominant soil landscape type across the eastern and southern parts of the catchment. This landscape type covers approximately 15.5% of the catchment. Aeolian landscapes develop via the deposition of wind-driven sand particles. Such deposits form the barrier dune complex east of the lake as well as the more elevated dune system found across the southern parts of the catchment. This dune system extends unbroken into the adjacent Myall Lakes catchment and forms the physical barrier between the two lakes. Swamp and estuarine / alluvial landscapes are associated with the aeolian dune complex. Swamp soil landscapes typically exhibit permanently or at least seasonally wet surfaces, high or above-surface water tables, and can feature significant amounts of accumulated decayed organic matter in the form of organic acid peats.

Estuarine / alluvial soil landscapes are found where the catchment watercourses have discharged eroded material onto the lake bed, thereby exposing upper catchment material to periodic exposure to saline / brackish conditions. These two landscape types cover approximately 6.6% of the catchment. Residual soil landscapes result from in situ weathering of parent material to form a relatively deep soil body. Within the Smiths Lake catchment, such landscapes are found in the upper reaches of the Wamwarra Creek catchment and in the areas surrounding Smiths Lake village.

5. Historical land use

The cultural heritage of Wallis Lake and its catchment includes a rich Aboriginal heritage and significant land use changes under European Settlement. The extent of vegetation and ecosystem modification attributable to Aboriginal land use within the Wallis Lake Catchment is difficult to quantify. However, the arrival of European settlement defines a major alteration in catchment land use.

As with the neighbouring Myall and Wallis Lake catchments, the earliest European land use within the Smiths Lake catchment was timber harvesting. Initially, cedar was the likely target, although the scarcity of detailed historical records of the catchment makes this difficult to confirm. Commercial logging evolved into the dominant land use within the Smiths Lake catchment. Harvested species included turpentine, blackbutt, tallowwood, flooded gum and coachwood. Cabbage tree palms were also felled for use in the expanding oyster production industry in Wallis Lake, the northern neighbour of the Smiths Lake catchment.

Historical records indicate commercial fishers were mechanically opening the lake from 1932 to encourage prawn migration runs. Exactly when commercial-scale fishing was introduced at Smiths Lake is not clear, but it is likely to have commenced around the late 1800s, when commercial fishing and oyster production began in the Wallis Lake and Myall Lakes.

The most significant change in land use within the catchment occurred from the late 1960s when road improvements allowed greater access to the area. Although the steep and relatively infertile landscape has limited development across much of the catchment, several pockets of urban development have been established around the lake shores.

6. Land use today

Dominant land use types and economic activities in the Smiths Lake catchment and upon the lake itself include conservation, forested land, agriculture and urban development. The proportions and locations of the land use areas within the Smiths Lake catchment are detailed in Figure A16.2 and Table A16.2.

At 35.89 km^2, the Smiths Lakes catchment is small and still remains relatively undeveloped. Approximately 30% (10.70 km^2) of the catchment is contained within Myall Lakes and Wallingat national parks estate. A further 32% (11.74 km^2) of the catchment remains forested, either under private ownership or within state forest estate.

Table A16.2. Land use summary for the Smiths Lake catchment.

Smiths Lake catchment land use – Mapped classes		**Area (ha)**	**% area**
CONSERVATION AREA	National park or nature reserve	1,069.99	29.85
GRAZING	Volunteer, naturalised, native or improved pastures	43.63	1.22
STATE FOREST		21.84	0.61
TRANSPORT & OTHER CORRIDORS	Road or road reserve	20.16	0.56
TREE COVER	On private or unreserved lands	1,141.04	31.83
URBAN	Residential and urban infrastructure	195.51	5.45
	Rural residential / small rural holdings	82.97	2.31
WATER BODY	Coastal lake, sand spit or estuarine feature	995.42	27.77
WETLAND	Coastal marsh, mangrove, mudflat or swamp	13.79	0.38
Total mapped area		**3,584.35**	**100.00**[DG64]

Conservation

Conservation land use, in the form of national parks or foreshore protection zones, cover approximately 10.7 km^2 (30%) of the catchment and is the dominant land use. The catchment sits partly in the Myall Lakes National Park and the Wallingat National Park, and the lake and tributaries are part of the Port Stephens–Great Lakes Marine Park. If Smiths Lake and its tidal tributaries (9.96 km^2) are included as conservation estate, the total area of the catchment dedicated to conservation purposes would be 20.66 km^2, or 57.6 % of the total catchment area.

The Myall Lakes National Park extends across much of the southern parts of the catchment and is managed under a formally adopted management plan (NPWS 2002). The aeolian dune complex found across the southern catchment area was mined for heavy minerals in the late 1960s to early 1970s prior to the area's inclusion in the Myall Lakes National Park. Since the cessation of mining, extensive rehabilitation and revegetation of the area has been undertaken, although the mined area is still visible in current aerial imagery.

Wallingat National Park occupies approximately 2 km^2 of the northern parts of the catchment. A plan of management for the Wallingat National Park is in draft form and currently under review in preparation for formal adoption.

In September 2005, Smiths Lake and its tributaries, to the tidal limit, became part of the Port Stephens–Great Lakes Marine Park. The Port Stephens–Great Lakes Marine Park covers an area in excess of 980 km^2 and encompasses coastal waters from Birubi Point in the south to the southern end of One Mile Beach at Forster in the north, and extends seaward to the three nautical mile limit of New South Wales state waters. The park also includes the waters of Port Stephens, the Karuah River, the Lower Myall River and the Myall Lakes to their respective tidal limits.

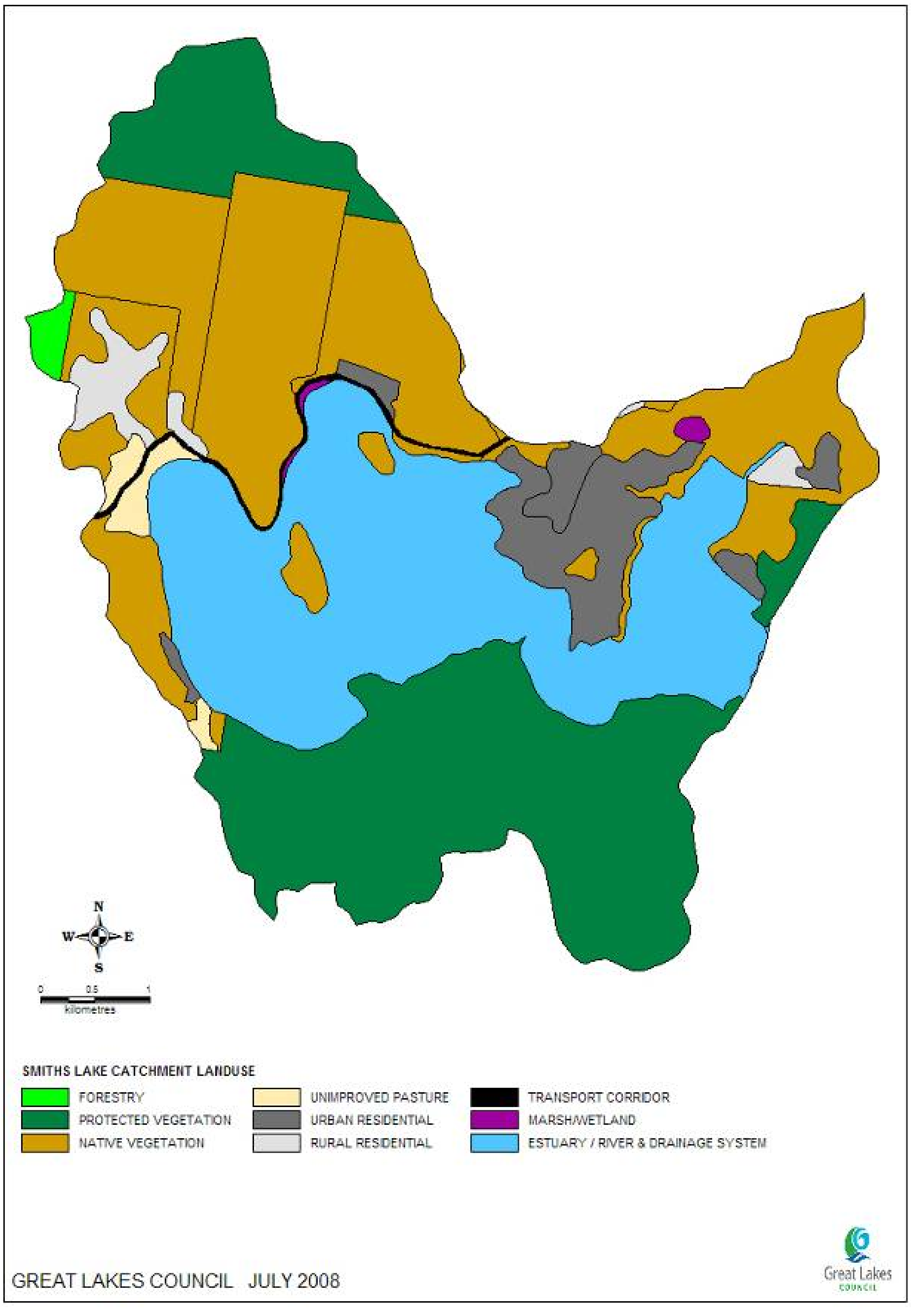


Figure A16.2. Distribution and extent of land use activities within the Smiths Lake catchment.

Forested land

A further 11.5 km^2 (32%) of the catchment, outside conservation estate, remains largely forested and undeveloped. The larger proportion of forested land is in the steeper, northern parts of the catchment.

Agriculture

Approximately 0.44 km^2 (1.22%) of the catchment is utilised for grazing or other agricultural activity. Land cleared for grazing is primarily located in the lower Wamwarra Creek valley. In this area, commercial-scale grazing is unlikely and any grazed stock is generally for domestic pets or for hobby farm activity.

More detailed information on the agricultural land uses that occur in the Great Lakes (in general) can be found in Appendix 9 of the WQIP.

Commercial fishing

Fishing is now the main commercial activity carried out in the Smiths Lake water body. No other aquaculture occurs within the lake's waters. Commercial fishing activity within Smiths Lake is not permissible outside Port Stephens–Great Lakes Marine Park general use zones. The general use zone applicable to Smiths Lake covers an area of 3.198 km^2, surrounding Simons Point in the central section of the lake. Up to 11 commercial fishers utilise the lake at various times throughout the year. Most of those working the lake engage in netting for fish, prawns and crabs. A good prawn season can see up to 20 professionals working the lake, the additional fishers travelling down from the adjacent Wallis Lake fishery. As per the Smiths Lake Estuary Management Study and Management Plan (Webb, McKeown & Associates 2001) fishing methods used include mesh-netting and hauling, with set-pockets mainly being used for prawns. The level of commercial fishing is linked to the opening of the lake and seasonal fluctuations. Refer to Section 2 of this appendix for more information on entrance behaviour and management.

The most commonly targeted species include sea and sand mullet, bream, luderick, leatherjacket, tarwhine, flathead and sand whiting. Commercial quantities of mud crab, blue swimmer crab and several species of prawns are also taken from the lake. Trapping for eels also occurs when eels are known to be plentiful in the lake. In 1997 the NSW Fisheries Research Institute stocked Smiths Lake with 21,600 juvenile mulloway. Substantial numbers of mulloway have since been taken from the lake, both as commercial catch and for further analysis as to the success of the restocking program (Fielder *et al*. 1999).

Urban development

Urban and rural residential development, and its associated infrastructure, cover approximately 2.8 km^2 (8.0 %) of the Smiths Lake catchment and supports a total population of approximately 907 (2001 census data). The main area of development in the catchment is the Smiths Lake village. The village is located on an elevated northwest–southeast oriented ridgeline that projects into the easternmost lake basin. Development within the village area consists of a mix of permanent and holiday residences with a small neighbourhood commercial precinct situated on the main thoroughfare into the village. Several smaller outlying residential areas exist at Tarbuck Bay, Neranie and the lower Wamwarra Creek valley. Recent aerial imagery suggests forested areas adjacent to the Smiths Lake village and in the Tarbuck Park Road area are gradually being cleared for dwelling establishment and fire risk mitigation purposes. Low-level development – of a caravan park / camping ground and a small golf course – is located on the north-eastern shore of the lake.

In total, 1,075 properties in the Smiths Lake village and Tarbuck Bay village areas are serviced by reticulated sewer and water. Effluent is pumped from these locations north to the South Forster sewer treatment plant. A further 55 landholdings within the catchment are serviced by on-site effluent disposal systems.

Recreation

Smiths Lake is a popular holiday destination within the Great Lakes area, particularly with waterskiers. Due to its scenic beauty, the lake is also a popular holiday destination for those more interested in passive or slower-paced recreation, such as families with young children, recreational fishers, skiff sailors and canoeists. This has at times caused conflict between users of the lake, and has consequently led to restrictions being placed on boat speeds and the area available for waterskiing in certain parts of the lake. In 2005 NSW Maritime released the Smiths Lake Boating Plan of Management 2005–2010 (NSW Maritime 2005; Waterways Authority 2003). The stated objectives of the boating plan are to be responsive to changing boating activities on the lake while maximising user safety and enjoyment, and minimising adverse environmental impacts. The plan also aims to promote the provision of appropriate boating infrastructure on the lake (NSW Maritime 2005).

7. Ecological significance

The Smiths Lake catchment is an important ecological system, with significant proportion of the catchment under conservation and the lake sectioned as part of the Port Stephens–Great Lakes Marine Park. There are three gazetted SEPP 14 Coastal Wetlands along the lake margins.

The Smiths Lake catchment has two national parks located within its boundary:

- Wallingat National Park
- Myall Lakes National Park.

These two parks support a diverse range of vegetation communities including littoral rainforest, coastal heath, coastal forests, cabbage palm forests and moist eucalypt forests.

The entire body of Smiths Lake (9.9 km^2) is contained within the Port Stephens–Great Lakes Marine Park (Figure ~~Figure~~ A16.3). The inclusion of Smiths Lake into the Port Stephens–Great Lakes Marine Park ensures the lake is managed to conserve biodiversity while still allowing for recreational and commercial activity. All of the four types of marine park management zones are represented in Smiths Lake: sanctuary, habitat protection, general use and special purpose (refer to zoning maps in Marine Parks Authority NSW 2008). The western third of the lake is classed as a sanctuary zone – the highest level of protection, with management aimed towards activities that do no harm the marine habitat or animals, e.g. boating, snorkelling. The middle third is classed general use, managing for a wide range of commercial and recreational activities including fishing. The eastern third of the lake and entrance is classed as a habitat protection zone, with management to protect marine habitat by reducing high-impact activities, while still allowing recreational fishing, some types of commercial fishing and tourism. The Port Stephens–Great Lakes Marine Park Authority is in the process of preparing an operational plan as required under the *Marine Parks Act 1997*. The operational plan will formally set out the operations the Authority will undertake or permit within the park's boundaries.

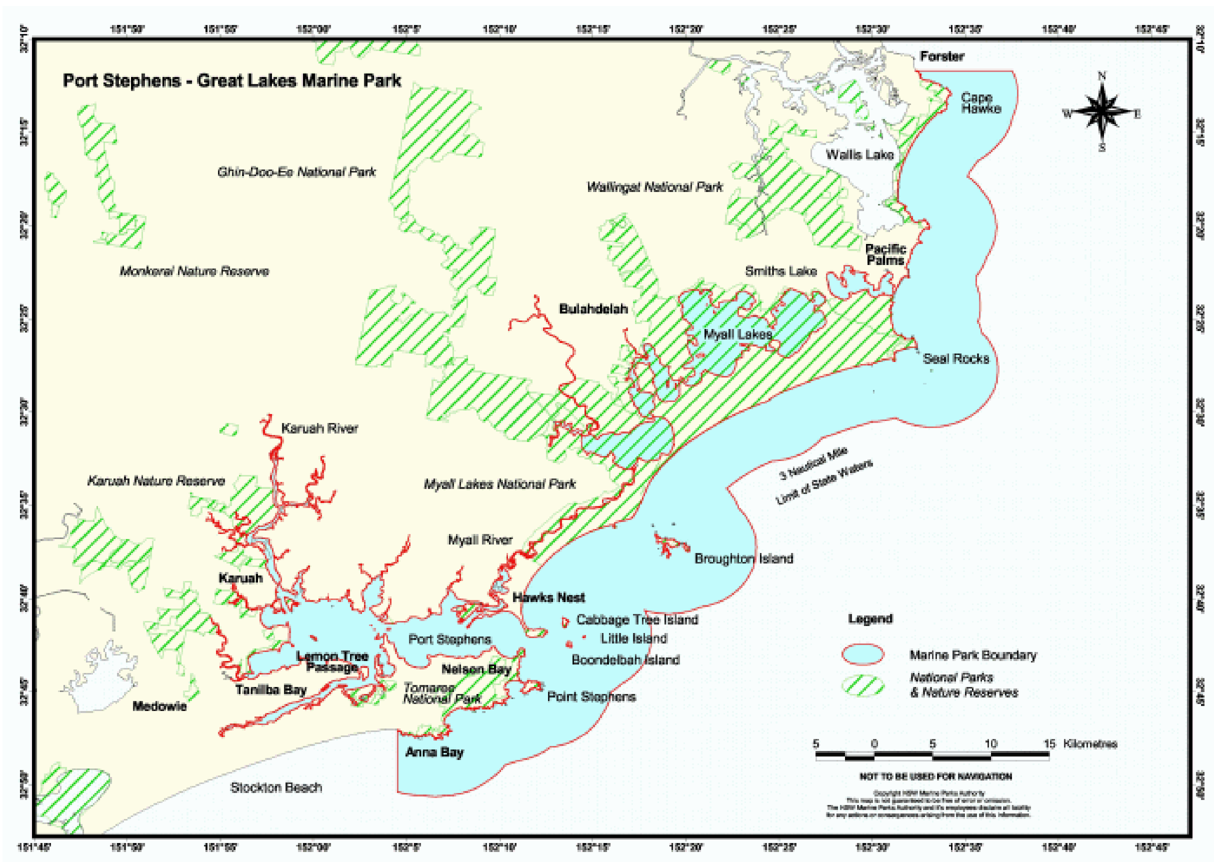


Figure A16.3. Smiths Lake is contained within the Port Stephens–Great Lakes Marine Park. This map also shows the area of land conservation (national parks and nature reserves).

Aquatic vegetation

The most prominent aquatic vegetation community in Smiths Lake is seagrass, covering 2.960 km^2 of the 10 km^2 waterway (Fisheries 2006/07 data – see map in Figure ~~Figure~~ A16.4, sourced from DECC Estuaries website: http://www.naturalresources.nsw.gov.au/estuaries/inventory/smiths.shtml, accessed April 2008). The seagrass species makeup includes Eelgrass (*Zostera capricornia* and *Z. muelleri*, *Heterozostera tasmanica*), Paddleweed (*Halophila ovalis* and *H. decipiens*) and *Ruppia* spp. (West *et al*. 1985). Seagrass communities are specifically protected under the *Fisheries Management Act 1994*, largely due to their productivity and value as fishery habitat.

Three wetlands adjoining the western and southern edges of Smiths Lake are classified under the SEPP 14, and as many as sixteen vulnerable species of fauna have been identified in these habitat areas. The three SEPP 14 wetlands are found at: the mouth of Wamwarra Bay; an area south of Horse Point; and part of Mayers Creek.

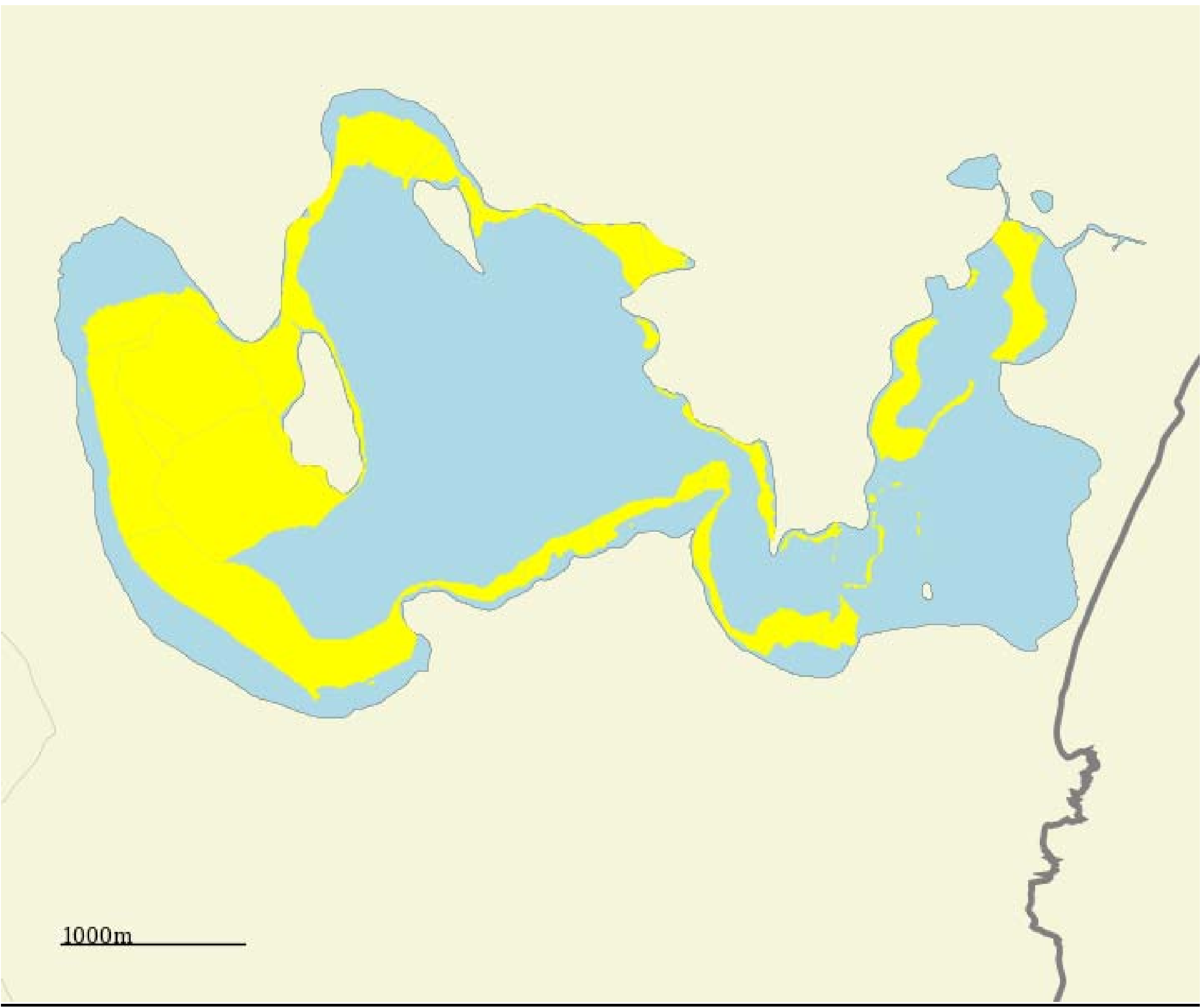


Figure A16.4. Seagrass habitat within Smiths Lake. © New South Wales Government (Department of Primary Industries, Department of Lands, Department of Planning, Department of Natural Resources 2006/07).

Terrestrial vegetation

The Smiths Lake catchment contains a diverse assemblage of native terrestrial vegetation community types. This is a result of the location of the catchment near a region where two botanical biogeographic regions converge (being the NSW North Coast and Sydney Basin biogeographic regions), and due to the variety of landscapes and soil types present.

Within the Smiths Lake Planning Study (WBM Oceanics Australia 2000) – which considered a larger area than the Smiths Lake catchment, but which is a useful reference – 25 separate vegetation communities were identified in the Smiths Lake area. The vegetation communities identified included those as diverse as palm forest, myrtle rainforest, littoral rainforest, swamp mahogany swamp forest, swamp oak forest, blackbutt dry forest, tallowwood dry forest, Sydney blue gum moist forest, spotted gum / ironbark / grey gum dry forest, smooth-barked apple dry forest and banksia scrub. The report identified that some of these communities were of high vegetation conservation value and indeed some such communities comprise listed endangered ecological communities. WBM Oceanics Australia (2000) also detected two threatened flora species in the Smiths Lake area (*Cynanchum elegans* and *Melaleuca biconvexa*).

Important features of these habitat systems, as identified in the Estuary Processes Study, include beach dunes, woodland and open forest, and coastal heath (Webb, McKeown & Associates 2001). The following information is taken from the Estuary Management Study and Plan:

Beach dunes: The barrier dune system at the lake entrance supports coastal spurge (*Chamaesyce psammogeton)*, an endangered plant species. Threats to the dune vegetation include human over-use of the foredunes, rabbits and bitou bush (*Chrysanthemoides monilifera*).

Woodland and open forest: The northern section of the catchment supports woodland and open forest. Recent alteration through fire and logging has led to a poor scrub and grasscover understorey. The less impacted gullies show rainforest elements (a tall understorey and creepers).

Coastal heath: In the southern catchment there is typical coastal heath vegetation in sandy soils, as well as paperbark and casuarina swamp.

Aquatic fauna

Smiths Lake provides a habitat for a wide variety of aquatic fauna species and supports a commercial fishery.

A total of 78 species of fish have been recorded in Smiths Lake, including the more abundant commercial species: sea mullet, tarwhine, sand mullet, yellowfin bream, garfish, and school and eastern king prawns. The Smiths Lake Estuary Management Plan identifies the entrance opening regime as the main factor determining fish and mobile invertebrate distribution, diversity, and abundance (Webb, McKeown & Associates 2001). Marine fish rely on the opening of the lake for spawning migrations and subsequent recruitment of juveniles. However, there is a counter-argument to entrance openings benefits for fish populations, with Jones and West (2005) commenting on the negative impact upon fish populations when entrance opening resulted in a large loss of seagrass beds.

The benthic communities of Smiths Lake include nemerteans, crustaceans, polychaetes and molluscs, and are comparable to other NSW intermittently closed / open lakes / lagoons (Webb, McKeown & Associates 2001). The lake has a section of rocky shoreline and sub-tidal rocky reef – areas that molluscs such as oysters colonise during open entrance conditions. However, they die off after closure due to the relatively fixed water level and falling salinities (Webb, McKeown & Associates 1998).

Terrestrial faunal communities

While the Smiths Lake catchment is relatively small in geographic area, it is a region of significant and characteristically high faunal species diversity. This is due to the diversity of vegetation community types (coastal, estuarine, rainforest, forest, woodland, heath and wetland habitats), the relative intactness of habitat units (when compared to other regions), and the location of the region in a zone where it receives influences from both tropical and temperate faunal groups. Due to this zone of overlap of major faunal assemblages, the region contains a number of species at or near the limit of their natural distribution, such as the eastern blossom-bat (*Syconycteris australis*).

While the Smiths Lake Planning Study (WBM Oceanics Australia 2000) provided some information on the faunal assemblage of the Smiths Lake area, there has never been a truly systematic and representative inventory of the fauna species of the Smiths Lake catchment. Nor have the results of specific faunal studies on lands within the catchment – particularly for environmental assessments of development proposals – been collated. A current program to catalogue the faunal species diversity of the wider Great Lakes local government area has identified that 67 native mammal species, 38 frog species, 59 reptile species and 303 native bird species have been recorded in the region. Within these faunal groups, the local government area in which the Smiths Lake catchment occurs contains habitats for 26 threatened mammal species, six threatened frog species, one threatened reptile species and 39 threatened bird species (as listed on the *Threatened Species Conservation Act 1995*). The Smiths Lake Estuary Management Study and Management Plan (Webb, McKeown & Associates 2001) describes the wetlands edging the lake as supporting diverse and abundant avifauna, and a number of significant mammals. Vulnerable species listed in this plan include six mammal species, nine bird species and one reptile species. The plan warns that the survival of these species in the catchment hinges on the maintenance of a wide variety of habitats, both within and adjacent to the lake. Characteristic threatened species in the Smiths Lake catchment are listed in Table~~Table~~ A16.3.

Table A16.3. Threatened terrestrial faunal species detected in the Smiths Lake catchment by WBM (2000).

Koala	*Petaurus norfolcensis*
Squirrel glider	*Phascolarctos cinereus*
Rufous bettong	*Aepyprymnus rufescens*
Long-nosed potoroo	*Potorous tridactylus*
Eastern chestnut mouse	*Pseudomys gracilicaudatus*
Eastern bentwing-bat	*Miniopterus schreibersii*
Little bentwing-bat	*Miniopterus australis*
Greater broad-nosed bat	*Scoteanax rueppellii*
Hoary bat	*Chalinolobus nigrogriseus*
Golden-tipped bat	*Kerivoula papuensis*
Grey-headed flying-fox	*Pteropus poliocephalus*
Wompoo fruit-dove	*Ptilinopus magnificus*
Masked owl	*Tyto novaehollandiae*

Additional threatened faunal species are also known to occur from recent faunal surveys in the catchment.

The terrestrial faunal assemblages of the Smiths Lake catchment are under pressure from a range of threats. Such threats include, but are not limited to, clearing, modification or fragmentation of habitat, pollution, inappropriate fire regimes, effects of exotic fauna and flora, altered drainage patterns, disease, road kills, and effects of climate change. Such threats must be recognised, managed and reversed in order to protect and enhance the biodiversity of the Smiths Lake catchment.

International conservation agreements

Australia has two international agreements for the protection of migratory birds that have implications for the management of the Smiths Lakes system:

- JAMBA: Australian Treaty Series 1981, No. 6 – The agreement between the government of Australia and the government of Japan for the protection of migratory birds, and birds in danger of extinction and their environment
- CAMBA: Australian Treaty Series 1988, No. 22 – The agreement between the government of Australia and the government of the People's Republic of China for the protection of migratory birds and their environment.

These agreements list terrestrial, water and shore bird species that migrate between Australia and the respective countries, the majority of which are shorebirds. They require both parties to "protect migratory birds from take or trade except under limited circumstances, protect and conserve habitats, exchange information, and build cooperative relationships" (*Bilateral migratory bird agreements* 2007). The JAMBA agreement also includes specific provisions for cooperation on conservation of threatened birds.

Smiths Lake is utilised by JAMBA and CAMBA-listed migratory bird species, including the White-bellied sea-eagle. However, there has been no formal survey or assessment of international migratory bird species, and especially waderbirds of the estuary and lake margins.

8. Planning and management

Planning and management strategies developed for the Smiths Lake catchment can be considered in terms of land use planning (strategic planning), and also catchment and estuary planning.

Land use planning

A key issue facing the Great Lakes Council across its local government area is that of future expansion of urban and rural residential land use, and the design of suitable planning instruments for future development strategies.

Smiths Lake and its surrounds has been the subject of several planning and environmental studies examining the constraints on further development in the area, and the suitability of the area for further urban and / or less intense forms of development (Great Lakes Council 2003[DG65]c).

Two areas, totalling approximately 9 ha, have been identified as potentially suitable for urban development within the Smiths Lake village (Great Lakes Council 2003[DG66]c). The areas, located at the southern end of Macwood Drive (4 ha) and at the eastern end of Tropic Gardens Drive (5 ha) are proposed to be a combination of village residential, open space and recreational opportunities. Development of these areas may accommodate up to an additional 85 people, potentially bringing the Smiths Lake population to 1,700 people. Significant management issues in these areas include flora and fauna protection, high bushfire hazard, steep land and sediment transport (Great Lakes Council 2003[DG67]c). Both areas discussed here contain high conservation value biodiversity, and any future development will need to mindful of the need to protect or enhance the ecological value of the surrounding terrestrial and aquatic habitats.

Strategies have been prepared by Great Lakes Council with the aim of ensuring a long-term sustainable future for those lands impacted by urban expansion within the Great Lakes local government area. The strategies consider the social, environmental and economic needs of the region's communities. While outlining a template for growth into the future, the strategies also outline an appropriate framework that will ensure the critical elements of water quality and ecological integrity remain intact, and continue to serve as assets to the catchment community. Of particular relevance to the maintenance and enhancement of water quality within the Smiths Lake catchment is Great Lakes Council's Rural Living Strategy (Great Lakes Council 2004).

Strategies and plans are discussed in more detail in Appendix 29.

Catchment and estuary planning

Landscape clearing and modification within the Smiths Lake catchment has been minimal in comparison to what has occurred in the neighbouring Wallis and Myall lakes catchments. Historical records indicate the presence of large tree stumps throughout much of the existing forested areas of the catchment – a likely indication of past logging activity. However, due to the relatively steep and infertile nature of much of the catchment, little agricultural activity has occurred. The lack of interest in grazing or other agricultural activity within the catchment has ensured that much of the catchment remains forested. Consequently, little catchment management activity has occurred away from the lake and the more developed areas.

Conservation areas within the catchment are managed under formal management structures. The Myall Lakes National Park operates under a formally adopted management plan and the Wallingat National Park operates under a draft plan of management. The Wallingat National Park draft plan of management is in review and will be formally adopted subject to any final recommendations. The newly created Port Stephens–Great Lakes Marine Park has a formally adopted zone plan defining the various management zones within its boundaries.

The recent catchment management approaches that have taken place in the Smiths Lake Catchment are summarised in Table~~Table~~ A16.4. Some of these approaches have ongoing associated plans, strategies or programs, and are discussed in Appendix 29.

Table A16.4. Smiths Lake – Catchment management to date[pt68].

Program	History	Current operation
Landcare	Several landcare groups have been active in the Smiths Lake area since the early 1990s. Regular landcare works first began in the bushland reserves and rainforest gullies within the Smiths Lake village precinct in 1993. The works were primarily weed control / removal and revegetation utilising tree and shrub species indigenous to the specific worksite. In 1997, the group commenced works on weed removal in the littoral rainforest and dune vegetation on Sandbar Beach, the barrier dune retaining Smiths Lake. The group remained active until 2002/03 and completed weed control and revegetation works across approximately 29 ha of urban bushland reserve, beach dune and littoral rainforest communities. The Karuah Great Lakes Landcare Management Committee oversees the strategy, activities and funding of the landcare groups in the region. The committee is comprised of members of each landcare group within its management area (the Karuah River catchment, Smiths Lake catchment, Myall Lakes catchment and Wallis Lake catchment). The committee is voluntary and meets regularly. It oversees the activities of the various groups, attracts / sources project funding for their area of responsibility, and liaises with federal and state government departments associated with land and environmental management. The committee also engages a landcare officer to work with and offer advice to local landholders to assist them in improving the sustainability of their farming operations. This officer also organises field days at various local properties to demonstrate property management techniques such as rotational grazing, dung beetle release and off-stream watering systems. While there is a limited amount of land under agriculture in the Smiths Lake catchment, programs such as the sustainable grazing program (landcare) and the implementation of the Catchment Action Plan are available to landholders in the Smiths Lake area.	In 2007 the original Smiths Lake Landcare group re-formed, and has continued weed control / removal and revegetation works on the Sandbar Beach dune complex and its littoral rainforest communities. In 2005 a landcare group formed to continue weed control work and revegetation within the Smiths Lake village area and Smiths Lake foreshore. A third landcare group is now active in the Tarbuck Bay area. Landcare across the Great Lakes catchments is coordinated through Karuah Great Lakes Landcare Management Committee.
Smiths Lake Estuary Management Committee	The Smiths Lake EMC was established to develop plans for the sustainable use of the estuary and its immediate catchment, bringing together representatives of local and State government authorities, estuary user groups and community to ensure inclusion of a broad array of interests and values in the planning process. The EMC has representatives from Great Lakes Council, State Government Agencies (DPI Maritime; DECC; NPWS), Coastcare, Industry (Wallis Lake Fishermans' Co-Op), Research institutions (UNSW, UTS), Great Lakes Environment Association, and Community Members	Smiths Lake Estuary Management Plan (2001) Smiths Lake Flood Study (2007)

Catchment management achievements

Due to the relatively undeveloped nature of the Smiths Lake catchment, little in the way of specific catchment management works has been completed away from the Smiths Lake village and Sandbar Beach area. Great Lakes Council's Management Tracking System has recorded erosion control, vegetation management and protective fencing works within the Smiths Lake catchment.

Protective fencing

Currently a total of 195.1 m of protective fencing has been put in place to restrict stock access to revegetation or vegetation management areas within the catchment.

Protective fencing is used as a means of controlling or preventing stock access to riparian margins or native vegetation management / revegetation areas. Restricting direct stock access to the catchment's waterways has been given a high priority in efforts to maintain or improve water quality with the Great Lakes local government area. Therefore, where protective riparian fencing is employed, it is considered more beneficial to restrict stock access from both sides of the watercourse. Achieving this can be a complex process, as it is common for a given length stream bank to be bordered by several landholders. Currently, no protective riparian fencing has been put in place as part of funded environmental works within the Smiths Lake catchment. The potential does exist for protective fencing to actually be in place within the catchment. Such fencing is, from time to time, put in place by landholders, to act as barriers to stock access of watercourses on their property. However, logistical difficulties and time constraints have precluded the collation of such detailed data.

Vegetation management

Approximately 10.8 ha of native vegetation or revegetation plantings have been placed under protective management within the Smiths Lake catchment.

Erosion control

Approximately 3,249 m^2 of erosion control measures have been completed on Tarbuck Park Road. The control measures consist of table drain and road surface sealing to reduce sediment transport off the road surface and drain channels, and into the nearby Tarbuck Creek.

Urban catchment management

Stormwater management systems in the villages of Smiths Lake and Tarbuck Bay discharge directly into Smiths Lake. Smaller urban areas, such as Neranie and the lower Wamwarra Creek valley, have no formal stormwater management systems.

Stormwater in the village of Tarbuck Bay is managed via a roadside kerb and gutter network, contributing to a piped stormwater system, which then channels the collected surface flows directly into Smiths Lake. Stormwater in the Smiths Lake village area is managed via a mixture of formal roadside kerb and guttering, grassed swales, table drains and modified natural watercourses. Surface flows are either piped directly into the lake or into natural watercourses, which then discharge directly into the lake. All natural watercourses in the village area drain directly into Smiths Lake.

Two ski-jump gross pollutant traps are in use to remove pollutants from stormwater outlets on Patsy's Flat Road.

Deep incision erosion of roadside table drains is a significant source of sediment flow into the lake and has been raised as an issue of concern by residents of the Smiths Lake village area. Sheet erosion on steep slopes facing the lake or natural drainage lines can also be a significant source of sediment flows into the lake once the protective vegetative cover is disturbed. No sediment control devices are in use to limit sediment transport into the lake via the stormwater drainage network.

Appendix 17: WQIP scenario descriptions for Smiths Lake

This appendix describes scenarios for the WQIP that were modelled using the DSS developed as part of the Great Lakes CCI. Rural scenarios were developed by iCAM, GLC and the CCI Rural Management Practices Technical Group. Urban scenarios were based on urban stormwater modelling undertaken as part of the CCI project by BMT WBM and discussions with key staff on engaging the urban community.

This Plan presents water quality improvement actions required to achieve the ‘feasible reduction in chlorophyll-a’ over a seven-year time frame. Some of the actions identified in the Plan cannot be completed during this time frame. For example, wetland protection and water-sensitive design of Greenfield sites will occur over a much longer period. For the purposes of benefit-cost analysis (Appendix 15), the costs and benefits of these programs were estimated over a 30-year period.

Most rural actions developed in this plan were designed as seven-year programs. Costs of maintaining these levels of change past Year 7 were estimated, but no option for ramping-up programs after Year 7 were considered. It is important to note that it is likely that additional benefits would have been achieved if the rural programs were increased between Year 8 and Year 30. However, in recognition of the inherent difficulties associated with making predictions about the implementation of actions in the first seven years, the Rural Management Practice Technical Group was not confident estimating what program actions would be implemented beyond the seven-year time frame. Two of the rural actions – unpaved road remediation and riparian remediation – were developed as 30 year on-going programs. Urban management options were typically run over 30 years because they depend on redevelopment rates that are likely to occur over the coming decades. Protection and management actions were costed over 30 years, as this time period is appropriate for the benefit-cost analysis presented in Appendix 15.

For summary purposes, the time frames that apply to the proposed remediation, protection and management support actions developed for this Plan are summarised in Table A17.1.

Table A17.1. Smiths Lake – Proposed remediation, protection and management support actions for this Plan and the time frame for their implementation.

Actions	Time frame for implementation
Remediation actions – modelled using the DSS	
Groundcover management	Seven years to implement and 30 years of maintenance of the program
Unpaved road remediation	Implement over 30 years
Urban Mitigation (Water Sensitive Urban Design)	Implement over seven years
Protection actions – not modelled with the DSS	
Water Sensitive Development of Greenfield sites	Implement over 30 years
Best management of unpaved roads	Implement over seven years
Improved pollution control systems / management systems	Implement over seven years
Improved management of lake use activities	Ongoing
Water Sensitive Redevelopment	Implement over 30 years
Management support actions – not modelled with the DSS	
Adaptive Management Strategy / Ecological monitoring program	Undertake over 30 years
Future investigation relating to the Farm Scale Action Plan	Undertake over 30 years

General cost assumptions

Table A17.2 summarises the general assumptions made in the costing of the WQIP and its component actions. These assumptions cover the range of workshop types as well as all of the general expenses that might occur in implementing the WQIP. It should be noted that:

- the time lag between holding the education programs and the changing of practice will depend on the program being run, and could range from months to years
- there is crossover between programs, particularly in relation to the Catchment Officer role (the Catchment Officer would need to be assessing the whole farm and all of the farm features at the same time). The proportion of the person's job that relate to the specific action is described in this appendix
- the expanded groundcover program is assumed to be fully implemented by Year 7. Annual plan costs to Year 30 are assumed the same as Years 0 to 7 to reflect increasing turnover rates in rural areas, subdivisions of farm land to smaller rural residential properties, and increases in costs and the consequent need for programs to be ongoing to maintain levels
- the healthy lakes program (current program) for urban education and capacity-building covers the cost of general community awareness-raising in relation to stormwater management, so the additional costs of showcasing the WSUD devices is the only additional cost outlined here in relation to engaging with the general community
- Council staff member time should be costed at $108,465 / year (this includes on-costs) = $417.17 / day
- consultant costs are costed at $1,120 per day
- additional costs for workshops include a cost for catering at $250 per workshop

- advertising = $250
- bus for field trips = $600 / day
- WSUD remediation and protection should be costed per plan according to the proportion of urban area
- total costs for each program have been rounded to the nearest $5,000 or $1,000 (depending on their scale) to reflect the level of uncertainty in these estimates.

Table A17.2. Smiths Lake – Assumptions in costing the Water Quality Improvement Plan and its actions.

Description	Assumptions
Catchment Officer	• One full-time person would cost $80,000 per year to operate (including on-costs) • Each full-time person would have a mobile phone with a one-off cost of $450 plus $550 worth of line rental and calls per year • Each full-time person would need a car costing $18,200 per year (including petrol and hire) ($350 / week) **Total** to operate the person = $99,200 in the first year and $98,750 per year in the years that follow, given additional costs of mobile phone purchase in the first year
Technical Officer	As above **Total** to run the person = $99,200 in the first year and $98,750 per year in the years that follow
Formal workshop	• 30 people attending at $15 / head catering = $450 • Hall or toilet hire of $100 • Materials $450 (photocopying $150, advertising $200, mail-out $100) • $3,000 per person per day (guest speaker) • Average of 1.5 persons per workshop = $4,500 for guest speaker **Total** to run a formal workshop= $5,500 / day
Basic field days	• Demonstration / Field day on a landholder's property similar to those run through the Sustainable Grazing program • **Total** to run basic field day = $500 / day • Morning tea $100 • Toilet or hall hire $100 • Materials / Consumables $300 This includes demonstration sites that could be returned to each year; the funding for the actions that are being demonstrated would come from the other actions (e.g. if it is a riparian management trial then the funding for that work would come from the riparian management section)

Groundcover

This scenario group is based on assumptions defined by the Rural Management Practices Technical Group. It was applied to all pasture (grazing) areas on both low and high slope areas. This scenario consists of an assumed proportion of the grazing lands with different levels of groundcover. Groundcover levels are given in Table A17.3.

Table A17.3. Smiths Lake – Description for each level of groundcover.

Level	Description	Groundcover
1	• overstocked all of the time • preferential grazing • only grass cover • bare / scalded / erosion • noxious weeds, pests • no feral animal control • poorly designed access • regular burning • non-strategic water supply (isolated) • no dung beetles • cultivation • no drought management plan	<60%
2	• overstocked in adverse conditions • periodic burning (up to every five years)	60–80%
3	• stocking rate to maintain 80–90% cover • drought management plan	80–90%
4	• non-cultivated • maintain groundcover • maintain native vegetation (shrubs, grasses, trees) • land use matches capability – stock exclusion • build well-designed access tracks • rehabilitate erosion sites • prevent tracks and fences downslope • hazard reduction burning only • care with management of dispersible soils • match stock to feed • allow paddock resting • provide multiple stock watering points for even grazing • control weeds and pests • dung beetles, monitoring • drought management plan • stock exclusion during rainfall periods	>90%

The groundcover scenarios consider different proportions of the grazing lands to be under these different management levels as follows.

Table A17.4. Smiths Lake – Proportion of grazing lands at each level of groundcover condition, by management scenario.

Level	Existing situation (base case) (%)	Existing programs (%)	Expanded programs (%)
1	10	10	10
2	82	78	65
3	5	9	17
4	3	3	8

Note that existing programs and expanded programs both refer to the impact of programs over a seven-year time frame.

These values were then used to calculate an effective groundcover level for each of these scenarios. These proportions were used to weight values for each of the groundcover levels: level 1 is 50%; level 2 is 70%; level 3 is 85% and level 4 is 95%. The effective groundcover levels calculated across all steep pasture lands for each of the scenarios is then as follows:

- existing situation is 69.5%
- existing programs is 70.1%
- expanded programs is 72.55%.

The AnnAGNPS model has been used to estimate the effect of changes in groundcover on pollutant loads. The results from this model imply that a shift from current groundcover level (equivalent to 69.5% groundcover) to 100% groundcover on steep, sloping pasture lands would have the effect of decreasing pollutant loads generated from these lands by:

- 90% for TN
- 94% for TP
- 95% for TSS.

Note this is the median value by sub-catchment in the catchment – there are some small differences by sub-catchment but the method is the same.

The effect of existing programs and expanded programs were then estimated proportionally using these decreases and the calculated effective groundcover. The multiplier on load implied by these changes was used as the basis of the interpolation. Note actual values for each sub-catchment were used directly within the DSS. These values are just used for illustrative purposes.

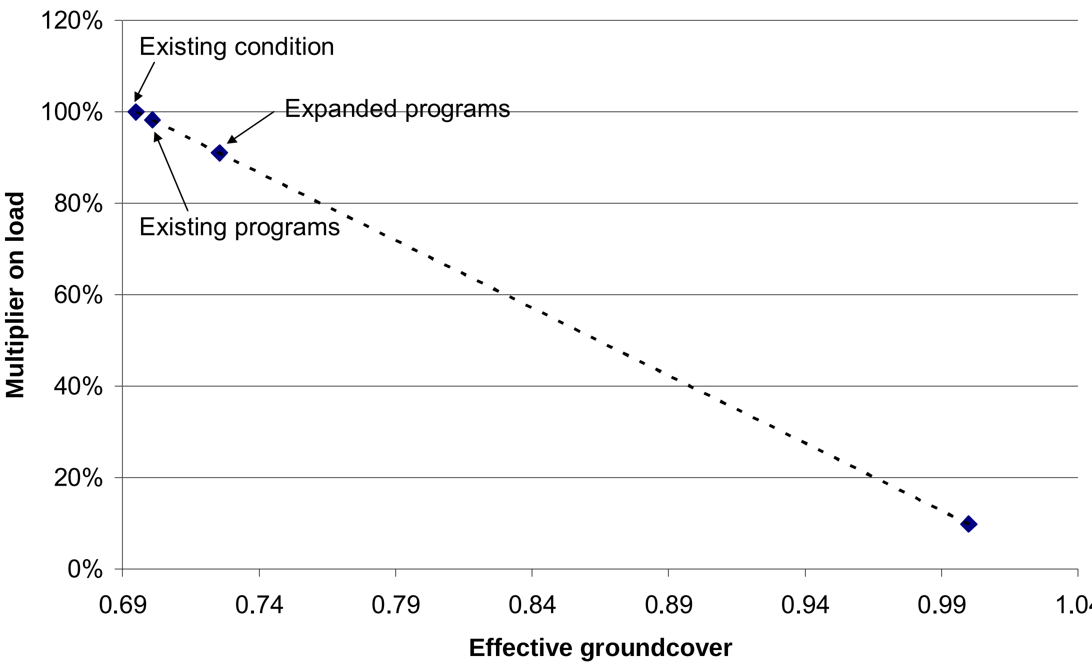


Figure A17.1. Interpolated effect of management programs for groundcover.

These were then applied in the model using the input settings allowed. Note the DSS allows for five groundcover levels to be applied to proportions of the catchment. Current groundcover corresponds to level 3. This meant that an equivalent proportion of area set to level 4 was calculated and run as the scenario to capture the effect of these changes in groundcover. The total cost for groundcover programs in Smiths Lake catchment is $38,000 over 30 years.

Action-specific costs

No specific costings were made for Smiths Lake, given the small area to which this scenario applies. Groundcover costs were estimated for Smiths using average per unit area costs for Wallis and Myall lakes.

Scenario implementation

A trajectory of impacts over 30 years is used to demonstrate the benefits of implementing the Plan compared with the current condition ('WQIP'), and the effects of development and redevelopment under current controls ('No Plan'). The scenario combinations for the 'No Plan' and 'WQIP' scenarios are shown below.

Table A17.5. Smiths Lake – Scenarios for Plan implementation for groundcover management.

Component scenario	No Plan		WQIP	
	Seven years	30 years	Seven years	30 years
Groundcover	Existing programs	Existing programs	Expanded programs	Expanded programs

Unsealed road remediation

Costs associated with upgrading an existing rural road (unsealed) to a consolidated and sealed surface with associated drainage / sediment controls were explored for three different unsealed road upgrades carried out by GLC. These projects provide broad examples of the locations and geology likely to be encountered within the local government area and provide examples of the difficulties associated and the consequent range of costs involved (see Table A14.16 in Appendix 14).

In all situations, preparatory works are required to bring an existing unsealed road and its substrate up to a standard capable of providing an appropriate carriageway surface for sealing.

Such works can include:

- realignment or widening of the existing road
- adding or augmenting drainage systems to the existing roadway
- excavation of the road footprint followed by stabilisation and reconsolidation of the roadway structure to suit anticipated traffic loads
- extensive rock excavation and removal (including the use of explosives)
- elevation of the new road surface (via the importation and compaction of suitable gravels)
- implementation of sediment and erosion control structures
- clearing of near-roadside vegetation for rehabilitation, safe clear distances and establishment of table drains.

Given the extreme variability in the requirements of any given road project – and the additional complications of site location, availability of suitable plant and equipment, geological substrates and the availability of appropriate construction materials – each project is unique and accordingly, is usually costed on an individual basis.

Once a road substrate and surface has been improved to a suitable standard, costing further improvements becomes simplified:

To provide sealing coat to a prepared rural road surface:
crushed gravel layer (emulsifier-coated) with bitumen spay sealer coat **= \$7.50 per m^2**

In order to account for the variability in the costs for road rehabilitation works, the cost of the unpaved road scenarios were based on the rounded average of the three examples provided below (\$600 / m^2**)**.

The models assumed that the upgrade of the roads would result in an 80% reduction of loads off the improved areas.

While the models could not determine where exactly the rehabilitation would take place, it was assumed that high-risk areas – such as approaches to creek crossings and at creek crossings – would be sealed as a priority.

This scenario examines the impacts of remediating unpaved roads to reduce sediment and nutrient exports. It is assumed that 1.2 km of roads will be treated over a 30-year period at a cost of \$600 / m and a total cost of \$720,000. Costs per metre of road works were calculated for several past projects managed by Great Lakes Council. These projects ranged in cost \$300 to \$1000 per lineal metre of road. Projects differed in their scale and the types of actions that were undertaken. The figure of \$600 per lineal metre equated to the median value of unit costs in the data provided.

Unsealed road protection

Unsealed road protection assumes that the cost of best practice sediment and erosion control features such as mitre drains are included in the maintenance costs of road grading (and are therefore not costed in this Plan). The costs that are identified in the Plan cover identifying the priority areas for rehabilitation and building the capacity of staff undertaking the road grading to reduce sediment losses to the waterways. The costs of these actions are outlined in Section 3.3.3 of the WQIP and the costs have been attributed to each lake (Wallis, Smiths and Myall) according to the proportional size of their catchments.

Management of urban land including protection and remediation (water sensitive development of Greenfield sites)

These scenarios are based on modeling undertaken by Tony Weber (BMT WBM) using MUSIC – an urban stormwater model – for Smiths Lake. Generation rates for existing urban land were generated from model runs for urban land in the Smiths Lake catchment.

Existing urban areas and future release areas for the Smiths Lake catchment are summarised in Table A17.6.

Table A17.6. Existing and future urban areas for Smiths Lake catchment.

Sub-catchment	Area (ha)	
	Existing	Future
Smiths Lake	142.3	11

The future release areas (Greenfield sites) are non-urban lands, such as agriculture or native vegetation cover, which have been identified as sites for future urban development. The Great Lakes Council policy of 'no net increase' of pollutants for Greenfield sites means that future development of the land must not exceed the current level of nutrient and sediment export. Generation rates for Greenfield sites were obtained from AnnAGNPS model results.

Action-specific costs

The cost of acquisition of controls for this scenario has been estimated at $349,000 with annual maintenance costs estimated at $13,100. These costs have been distributed over years using an expected trajectory of Greenfield developments for the Smiths Lake catchment (Table A17.7).

Table A17.7. Urban development of Greenfield sites for the Smiths Lake catchment.

	Macwood Road	Tropic Gardens Road
Estimated area of land (ha)	5	6
Certainty of development	High	High
MUSIC modelling complete	Yes	No
Predicted development type / % of each	100% low-density residential	100% low-density residential
Certainty of predicted development type	High	Medium
Predicted dwelling	65	80
Estimated timing for first release	5 years	5 years
Estimated years for %	1–5 years for 50%	1–5 years for 20%

In addition, program costs were also accounted for as one-sixth of the cost of the 'general awareness WSUD' noted in the section on WSUD protection below. Finally, costs for developing heads of consideration for voluntary planning agreements (Section 3.4.2 of the WQIP) were also accounted as: one week of staff time; $5,000 for a consultant (Year 1); proportional costs according to the areas of release areas within each catchment.

The total cost of the controls on Greenfield developments is **$658,000** over 30 years.

Scenario implementation

A trajectory of impacts over 30 years is used to demonstrate the benefits of implementing the Plan compared with the current condition ('WQIP'), and the effects of development and redevelopment under current controls ('No Plan'). The scenario combinations for the 'No Plan' and 'WQIP' scenarios are shown in Table A17.8.

Table A17.8. Smiths Lake – Scenarios for Plan implementation for Greenfield developments.

Component scenario	No Plan		WQIP	
	Seven years	30 years	Seven years	30 years
Greenfield	Seven years of development	Full development	Seven years of development	Full development

WSUD implementation

Approximate locations of WSUD features were identified in the Smiths Lake existing urban area to identify likely areas available for WSUD measures and the relative area of the measures. From these analyses, Weber (2008) defined input parameters for MUSIC models and modelled the treatment train effectiveness. Outputs from these runs were averaged to get a percentage load reduction rate to be used for all existing urban areas.

Weber (2008) undertook analysis of the Smiths Lake catchment to determine where WSUD devices could be applied. A Maximum Practical Implementation scenario was established and involved assessment of those WSUD features considered most practical to implement.

For the WQIP scenario set, only the Maximum Practical Implementation of WSUD features is considered. For Smiths Lake, implementation of this scenarios traps 80% of TSS, 60% of TP and 36% of TN.

Action-specific costs

Costs specific to the implementation of WSUD devices are shown in Table A17.9.

Table A17.9. Smiths Lake – Costs of implementing Water Sensitive Urban Design devices.

Total acquisition cost	$591,430
Total maintenance cost per year	$38,074

In addition, several areas of program costs need to be accounted for:

- Development Assessment and compliance assessment (target audience – Council staff)
  - Development Assessment implementation / capacity-building (Council staff)
  - two months in the first year – train on new Development Assessment approach and mentor Development Assessment planners (Council staff) + one workshop with consultant (three days) + cost of workshop
  - two weeks per year every year thereafter for training and mentoring / advice
  - two weeks per year after the first year to audit the compliance practices (Council staff member) linked to staff reviews
  - starting in Year 2, a staff member would spend three weeks a year maintaining a database on the location and nature of the WSUD devices on properties (at the cost of a Catchment Officer salary)
- Complete development of WSUD DCP (Section 3.4.2 of the WQIP) – six weeks staff time, $20,000 on a consultant (Year 1), distribute costs proportional to the urban area

- [DG69]Develop further sources of funds for urban water quality management (Section 3.4.2 of the WQIP) – six weeks staff time to provide input, $7,000 additional costs for consultant time / advice (Year 2), distribute costs according to urban area
- Maintenance of WSUD and construction (target audience – Council staff)
    - one workshop every two years
    - two weeks to prepare and coordinate
    - consultant – three days
    - advice / assistance with construction of WSUD – two weeks for a consultant per year every year
    - coordination of consultant, advice on construction, auditing – two weeks staff time per year every year
    - develop maintenance plans / inspection plans – four weeks staff time in the first year (to cover the backlog of structures that already exist), then one week per year every year after that (as new structures are developed)
    - maintain a database of structures (staff member – three days a year, at the cost of a Catchment Officer)
    - *note* there may be some compliance assessment required. However, this is difficult to estimate at this stage.

The total cost of the WSUD implementation scenario is $1,661,000 over 30 years.

Scenario implementation

A trajectory of impacts over 30 years is used to demonstrate the benefits of implementing the Plan compared with the current condition ('WQIP'), and the effects of development and redevelopment under current controls ('No Plan'). The scenario combinations for the 'No Plan' and 'WQIP' scenarios are shown in Table A17.10.

Table A17.10. Smiths Lake – Scenarios for Plan implementation for Water Sensitive Urban Design management.

Component scenario	No Plan		WQIP	
	Seven years	30 years	Seven years	30 years
WSUD	None	None	Full implementation	Full implementation

This program contains several components that have been costed separately:

- include water quality management clause in LEP (Section 3.4.2 of the WQIP) – three weeks staff time (Year 1), $5,000 for additional consultant costs, proportional to urban area
- review Rural Living Strategy (Section 3.4.2 of the WQIP) – six weeks staff time, $15,000 for consultant assistance (Year 2), distribute costs across per area of catchment
- build WSUD into road standards (Section 3.4.2 of the WQIP) – six weeks staff time, $20,000 for consultant assistance (Year 2), distribute costs according to size of urban areas per catchment
- resource erosion and sediment control (Section 3.4.2 of the WQIP) – eight weeks staff time to explore options for regional or sub-regional programs, $8,000 to develop programs (Year 2 to Year 5), spread costs evenly over the time and distribute costs proportional to urban area
- sediment erosion control internal audits (Council staff) (Section 3.4.2 of the WQIP)

- two workshops every two years (start in Year 2)
- workshop costs
- consultant – $5,000 to design the audit program in Year 2
- internal audits every year (staff costs for two months; this also covers the cost of preparing for the workshops)
- audits every year – costs proportional to the size of the urban area

The program outlined in this section is to be applied across the Wallis, Smiths and Myall lakes. The costs of these programs have been included in the management action ‘WSUD protection’ and have been established for each lake proportional to the size of the urban area.

- urban stormwater management community education (Section 3.4.2 of the WQIP). Details are outlined below.
- sediment erosion control capacity-building (builders, contractors) (Section 3.4.2 of the WQIP)
    - two workshops every two years
    - two weeks to prepare and coordinate (staff member)
    - consultant – five days
    - workshop costs
- general awareness of WSUD (businesses, consultants, builders, real estate, Council staff) (Section 3.4.2 of the WQIP)
    - two workshops every two years for the first five years, then one workshop every two years after that (starting in Year 2); one advertisement per year for the first five years
    - two weeks to prepare and coordinate (staff member)
    - consultant – five days
    - workshop costs
    - Year 2 to Year 7 – bus required for field trip ($600 per day per workshop)
- general awareness of WSUD – general community (Section 3.4.2 of the WQIP)
    - demonstration WSUD sites field day with community
    - one every 2 years from Year 2 to Year 7, then one every four years after that
    - include workshop costs + bus costs + advertising
- water quality education program
- three ‘stormwater scampers’ with primary schools in the first year and then one every year after that. Each stormwater scamper would cost **$5,539** to run and include: 60 stormwater scamper booklets ($1,883), 10 stormwater scamper reports @ $28.47 each ($284), Stormwater Scamper calico bags x 60 ($212), coach hire ($400), staff contribution (four @ $45 per hour) = 60 hours ($2,700), 40 laminated certificates ($60)
- one Seagrass Education Workshop per year, which would cost $1,620 based on two staff members working 36 hours in total (@$45 per hour)
- integrating the WQIP findings into the school curriculum is a one-off project to be developed in Year 1. This would involve 14 weeks staff time to work integrate locally relevant examples of water

quality issues and solutions, as well as lake ecology, into subjects such as Geography, Marine and Aquaculture Technology, and Environmental Science in Year 1 ($34,149).

The cost of WSUD protection programs is $1,000,000 over 30 years. These costs are split by catchment according to area of urban land. The cost of WSUD protection programs in Smiths Lake is $4,000 over 30 years.

Foreshore and riparian management in urban areas

Costs associated with foreshore and riparian management in urban areas have been split proportional to the length of foreshore managed by Great Lakes Council around Wallis Lake (approximately 28 km) and Smiths Lake (approximately 9 km). Note that this action was added to the WQIP following the exhibition period and therefore has not been included in the economic analysis (Appendix 15), and the costs are shown over a seven-year period. Given the relatively low costs associated with this action, the overall results of the benefit-cost analysis will not be affected significantly.

Review of existing Foreshore Management Plans, Plans of Management and site-specific natural area work plans involves:

- one staff member half-time over two years ($98,750).

Enforcing legislation to protect foreshores involves:

- increased staff compliance effort in foreshore areas and follow-up on complaints. Identify impediments to compliance and inform the education program to reduce compliance issues. Costs are – four weeks in the first 2 years ($8,200) and 2 weeks every year after that ($1,900) = total of $22,100 over seven years.

Developing and implementing targeted education for residents of foreshore areas involves:

- three months to undertake needs assessment and establish education resources (signs, brochures, media materials). Develop an engagement strategy to be implemented over seven years ($24,600). Materials include signs, printing posters, pamphlets, etc. ($5,000). In Year 2 to Year 7, implement engagement strategy – four weeks every year ($7,600) plus materials ($2,000) = Total $39,200 over seven years.

Total cost of for the actions associated with foreshore and riparian management over seven years is $160,000

Proportional cost for Wallis Lake over seven years is $121,600.

Proportional cost for Smiths Lake over seven years is $38,400.

Improved pollution control systems / management systems

Recommendations are summarised from Section 3.7 of the WQIP.

- Undertake an internal audit of compliance with conditions of consent – four weeks staff time undertaking audit, four weeks staff time developing the management systems to support compliance with conditions of consent (total of two months in Year 1).
- Review the need for a pool of pollution control experts – 1.5 weeks for Council staff, four weeks for a state government staff member (Year 2).
- Review fee structure of On-site Sewage Management Strategy – 1.5 weeks Council staff (Year 1).
- Report on On-site Sewage Management Strategy – one month staff time, $25,000 to develop GIS-based data base for reporting (Year 2).
- Revise On-site Sewage Management Strategy – 1.5 weeks staff time (Year 2).
- Explore the possibility of increasing cross-delegations for compliance with conditions of consent and pollution control regulations – six weeks staff time (Year 2).
- Investigate alternative models for formalising responses to complex pollution cases – 1.5 weeks Council staff time and four weeks state government staff time (Year 2).
- Initiate options for strengthening cross-agency networks – 1.5 weeks staff time (Year 1).

The total cost of programs to improve pollution control systems in Smiths Lake is $2,000.

Ecological monitoring program

The ecological monitoring program is to be undertaken every year unless otherwise stated.

Table A17.11. Smiths Lake – Costs of implementing ecological monitoring program.

Monitoring program	Estimated frequency	Itemised expense (per sampling time)	Estimated cost per occasion	Estimate cost per annum
Monitoring of runoff from high-risk areas	Event monitoring, and hence frequency, depends on rainfall	24 water samples, analysed for nutrients and TSS	24 x $150 Approximately seven events a year	$25,200
		Officer time: Four hours per high-risk area. Assume five high-risk areas	Four x hourly cost of a field officer x five sites = 20 hours = 2.8 days x seven events a year = 20 days a year @ $300 / day	$6,000
		Equipment hire (car, autosamplers, water level sensors)	$150 / day $30,000 per annum each	
		Data analysis and reporting	One week @ $370/day	$1,850
Total				$33,050
Best management practice assessments / monitoring at six sites	Three-yearly	Fish sampling?	$3,000 per site x six (sites)	$18,000 ÷ three years = $6,000
	Three-yearly	Officer time: Riparian and in-stream habitat assessments	Two x one day = $600	$600 ÷ three years = $200
	Three-yearly	Vehicle costs: Riparian and in-stream habitat assessments	Four days @ $150 / day	$600 ÷ three years = $200
		Data analysis and reporting	One week @ $370 / day	$1,850 ÷ three years = $616
Subtotal				***$7,016***
Estuary condition targets				
Chlorophyll and turbidity	Six-weekly = nine samples per year plus three event samples	Two staff for two days (includes water quality meter calibration)	$1,200	$14,400
		Boat and vehicle use		
		Chlorophyll analyses (24 samples @ $30 each)	$720	$8,640
Seagrass / macrophytes	Quarterly	Community sampling	$150 four times a year [DG70]	$600 ~

~ Costs only include the cost of catering for sea grass monitoring volunteers as the program costs are coverd by implementing the Wallis Lake Monitoring Program. Note costs for seagrass monitoring have not been included in the total cost below.

The total cost of the ecological monitoring program for Smiths Lake is $19,000 over 30 years.

Future investigation relating to the Farm Scale Action Plan (Section 3.3.2 of the WQIP)

The majority of the costs identified in the Farm Scale Action Plan have been costed in the program costs (i.e. the cost of a catchment management practitioner's time to implement the actions identified – Sections 2.7, 2.11 and 2.15 of the WQIP). There are some cases where the Rural Management Practice Technical Group identified the need for additional specialised assistance such as researchers or other experts to assist with implementing the programs. These additional costs are summarised below. Details are outlined in Table 3.3.2 of the WQIP.

- Encouraging landholder uptake of improved management practices
  - future investigation – $60,000 (Year 1), $3,000 (Year 2), $7,000 (Year 3[DG71])
  - future extension – $10,000 (Year 2 to Year 3)
- Riparian management
  - future investigation – $32,000 (Year 2 to Year 4), $60,000 (Year 6 to Year 8)
- Wetland management
  - future investigation – 40,000 (Year 3 to Year 5), $20,000 (Year 2 to Year 4), $2,000 (Year 3)
- Groundcover management
  - future investigation – $5,000 (Year 1), $20,000 (Year 3 to Year 4), $5,000 (Year 2), $10,000 (Year 2 to Year 3)
- Farm infrastructure management
  - future extension – $20,000 (Year 2- to Year 3), $15,000 (Year 2) then $10,000 every year after that
- Nutrient management
  - future investigation – $25,000 (Year 2), $15,000 (Year 2), $10,000 (Year 2), $65,000 (Year 5 to Year 7).

These costs are split by lake based on area. The total cost of future investigation and extension actions to support the Farm Scale Action Plan for Smiths Lake is $19,000 over 30 years.

Adaptive management strategy

The costs of this program are four weeks of staff time each year to do reporting and collating, spread across all lakes. The Smiths Lake contribution to this cost is $4,000 over 30 years.

Appendix 18: Background information on Myall Lakes and catchment

This appendix has two purposes: to provide a background to the Myall Lakes system and catchment; and to provide the context and history to the catchment management actions and approach to catchment management. The first section on Myall Lakes and catchment includes descriptions of the key sub-catchments, catchment topography, history, land uses and ecology. The second section on catchment management includes discussion of land use planning, focussing on further expansion of urban and rural residential areas, and the development and implementation of catchment and estuary management plans.

1. Myall Lakes and its catchment

The Myall Lakes comprise a shallow coastal barrier lake system of four linearly interconnected brackish to freshwater basins: Myall Lake, Boolambayte Lake, Two Mile Lake and Bombah Broadwater (Figure A18.1) (DIPNR 2004[DG72]). The lakes are situated on the NSW Lower Mid North Coast, approximately 30 km north of Port Stephens; they have a total waterway area of 102 km^2 and total catchment area of 780 km^2. The average depth of the system is 2.7 m, although there is considerable variability in the lake depth, with several of the connecting channels and flow paths – such as at Violet Hill, Bombah Point and the Myall River mouth – reaching up to 13 m in depth. The catchment area includes the lake body and its immediate surrounds, and those catchment areas upstream of the Bombah Broadwater; this report does not include the tidal sections of the Lower Myall River and its immediately surrounding catchment.

The major water flows into the lake system come from the Myall and Crawford River sub-catchments, which together drain an area of approximately 439.32 km^2 to the west of the lakes. The Crawford River, being the smaller of the two river systems, joins the Myall River at the township of Bulahdelah; the combined flows then enter the lake network at the western extremity of the Bombah Broadwater. Boolambayte Creek, the third major source of freshwater surface flow, drains a catchment of some 77 km^2 and discharges into the lake system at the junction of Two Mile Lake and Boolambayte Lake. Additional surface flows into the lake are from rainfall on the lake surface and its immediate surrounds, an area of approximately 263 km^2. Subsurface waters from the extensive barrier dune system immediately east of the lakes also provide a significant flow into the lake system (DIPNR 2004; NPWS 2002).

Low flushing rates and long water residence times ensure that the lake system is essentially a sink for sediment and nutrient flows from the catchment, and therefore highly susceptible to human activity with the catchment (DIPNR 2004; NPWS 2002; Smith 2001). For information on the hydrodynamics and nutrients of the system, refer to Section 2.13.4 of the WQIP.

The Myall Lakes catchment falls wholly within the Great Lakes Council local government area.

2. Catchment topography

The Myall Lakes catchment can be sub-divided into three broad topographical units: sedimentary / metamorphic inland ridges and valleys; floodplain; and a coastal sand dune system.

The ridges and valleys in the western portions of the Myall Lakes catchment are defined by a series of narrow, linear valleys on a north-west / south-east axis separated by Carboniferous sedimentary and volcanic ridges (DIPNR 2004; NPWS 2002; Smith 2001). Ridges can reach a slope grade of >50%, but are generally between 20% and 50% (DIPNR 2004). The middle and upper valleys floors are undulating Permian sedimentary deposits; extensive erosion of these formations has given the undulating hills typical of the Markwell and Upper Myall landscapes. Slope grades in this area can be a little as 2%, but are generally between 10% and 20% (DIPNR 2004). Highest elevations within the catchment are found along the southern boundary of the catchment, with the Cabbage Tree Mountain / Euther peaks being approximately 660 m AHD. Elevations ranging between 300 m and 500 m are typical of the catchments bordering ridges.

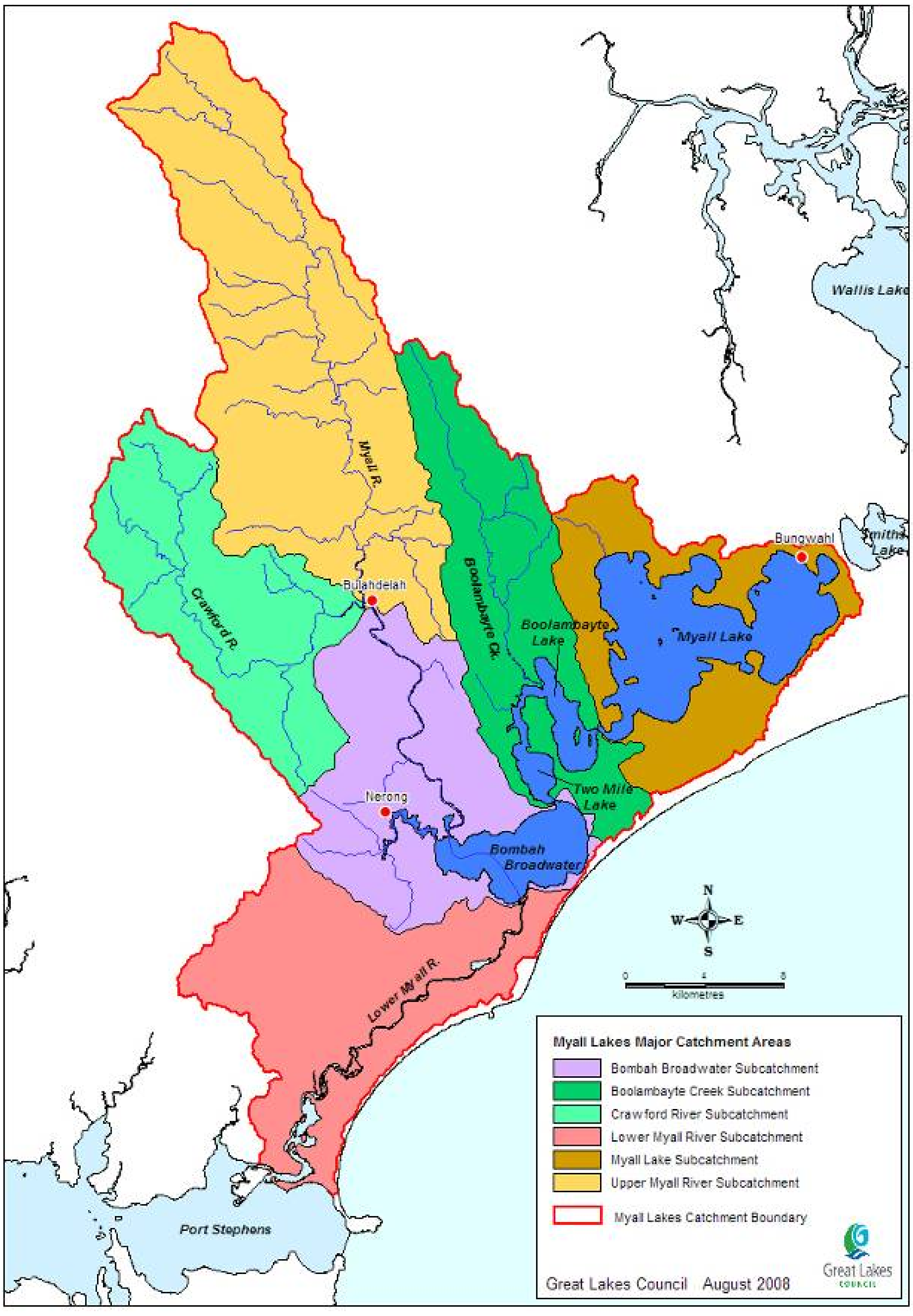


Figure A18.1. Location of the Myall Lakes and its catchment relative to Wallis Lake. Also shown are the three largest population centres with the catchment: Bulahdelah, and the villages of Nerong and Bungwahl.

The lower floodplain areas of the catchment basins consist of Quaternary alluvial deposits with a slope grade generally less than 5% (DIPNR 2004; NPWS 2002). Quaternary aeolian and wave-generated sand deposits have formed a substantial barrier dune system to the east of the lakes. Extensive networks of wetland and swamp have developed along the western edge of the barrier dune, much of which is underlain with potential acid sulfate soils (DIPNR 2004; NPWS 2002).

3. Catchment soils

Soils within the Myall catchment are sourced from sedimentary and volcanic parent material, and are generally of low fertility.

Colluvial soil landscapes are the dominant soil landscape type within the Myall catchment and are found across approximately 41% of the catchment (Table A18.1). Colluvial soils are a product of unconsolidated soil and rock, largely mobilised by gravitational forces. These soils are typical of the undulating to steep landscapes found on the mid to upper catchment ridges.

Erosional landscapes are found across 14% of the catchment and are the next largest component of the catchment soil landscape. Erosional soils are a product of the erosive action of water, and are typically found on undulating slopes and surrounding catchment drainage lines. Alluvial soils dominate the mid-catchment lowland areas surrounding the confluence of the Myall and Crawford rivers, as well as the lower reaches of the Myall River and Boolambayte Creek.

Table A18.1. Soil landscape types of the Myall Lakes catchment.

Soil landscape group	Area (ha)	Proportion of catchment (%)
Aeolian	5,230.71	6.70
Alluvial	7,182.37	9.20
Colluvial	32,264.55	41.30
Disturbed	1,145.86	1.43
Erosional	10,924.91	14.05
Estuarine	1,191.38	1.53
Residual	5,222.10	6.70
Swamp	2,088.16	2.64
Transferral	2,618.10	3.35
Water	10,177.70	13.10
Total	**78,045.84**	**100.00**

Aeolian landscapes develop via the deposition of wind-driven sand particles and are encountered in the eastern parts of the catchment. Wind-mobilised sand deposits have now formed a complex barrier dune system east of the lakes, as well as the less elevated sand sheets found on the Myall River floodplain downstream of Bulahdelah. In the eastern parts of the catchment swamp and estuarine landscapes are commonly associated with the aeolian dune complex.

4. Historical land use

The cultural heritage of Wallis Lake and its catchment includes a rich Aboriginal heritage and significant land use changes under European settlement. The extent of vegetation and ecosystem modification attributable to Aboriginal land use within the Wallis Lake Catchment is difficult to quantify. However, the arrival of European settlement defines a major alteration in catchment land use.

In late 1816, permission was granted for cedar harvesting from the Myall valley, and from this point, land use within the catchment began to undergo rapid changes. The initial attempts at agriculture in the Myall catchment were undertaken by the Australian Agricultural Company, as was the case in the adjacent Wallis Lake catchment. These early attempts were unsuccessful and the company handed back their lands to the Crown in exchange for more favourable grazing lands west of the Great Dividing Range (Garland & Wheeler 1982; Smith 2001).

By the 1830s, timber grants were awarded in the catchment. The harvested timber was transported down the Myall River for use in shipbuilding enterprises established in the Port Stephens and Newcastle area (Smith 2001). The first land grants in the catchment were applied for in 1840, and by 1857 the township of Bulahdelah had been established at the junction of the Crawford and Myall rivers (Smith 2001). Freehold title land became available for purchase in 1895 and the first attempts at cattle grazing began (Smith 2001). However, timber harvesting maintained its importance into the new century as new catchment landholders worked towards clearing their lands for cattle grazing (Garland & Wheeler 1982; Smith 2001). By the early 1940s, advancement in timber harvesting and transport machinery led to a substantial expansion in the catchment's timber harvesting activities to support Australia's involvement in World War II.

Stock grazing in the early years of settlement was limited to beef cattle, due to the dominance of native grasses and the difficulty of improving land productivity with limited mechanical assistance (DIPNR 2004; Smith 2001). As with the improvement in timber harvesting machinery, the war effort led to significant improvements in the mechanisation of farm machinery. The advent of the diesel-powered farm tractor allowed the catchment's graziers to sow and cultivate improved pasture species such as rye and clover. Thus, by the late 1940s, every property along the Myall River had converted from beef grazing to dairy operations (DIPNR 2004; Smith 2001). The bulk of properties were small, family-controlled operations carrying around 30 head of milking stock. Most farms produced corn crops and, to a lesser extent, wheat and oats to supplement their winter stock food supplies (Smith 2001).

Landscape clearing and modification to facilitate timber harvesting and agricultural production was the dominant catchment management regime well into the 20th century. Such landscape modification removed the indigenous tree cover from approximately 116 km^2 (14.9%) of the catchment, including a significant amount of riparian vegetation, with subsequent impacts on water quality.

In 1972, 150 km^2 on the eastern side of Boolambayte Lake and the Bombah Broadwater, including the entire bed of the Myall Lakes, was gazetted as the Myall Lakes National Park (NPWS 2002). Since that time, additional lands – including acquired landholdings, and former state forest estate to the north and south of Bulahdelah – have been added to the park. Today, the park covers a total of 479.69 km^2, 328 km^2 of which lies within the Myall Lakes catchment.

5. Land use today

Conservation land use, in the form of national parks and reserves, is the dominant land use for the Myall Lakes system, covering approximately 351 km^2 (45.0%), including the surface area of the Myall Lakes themselves (see Figure A18.2 and Table A18.2). Together, state forest and private native forest (multiple land uses) cover a further 323.4 km^2 (37.8 %) of the catchment, making these two activities the dominant land uses after conservation. Grazing lands cover 109 km^2 (14.0 %) of the catchment, with beef grazing now replacing dairy as the primary agricultural land use within the Myall Lakes catchment.

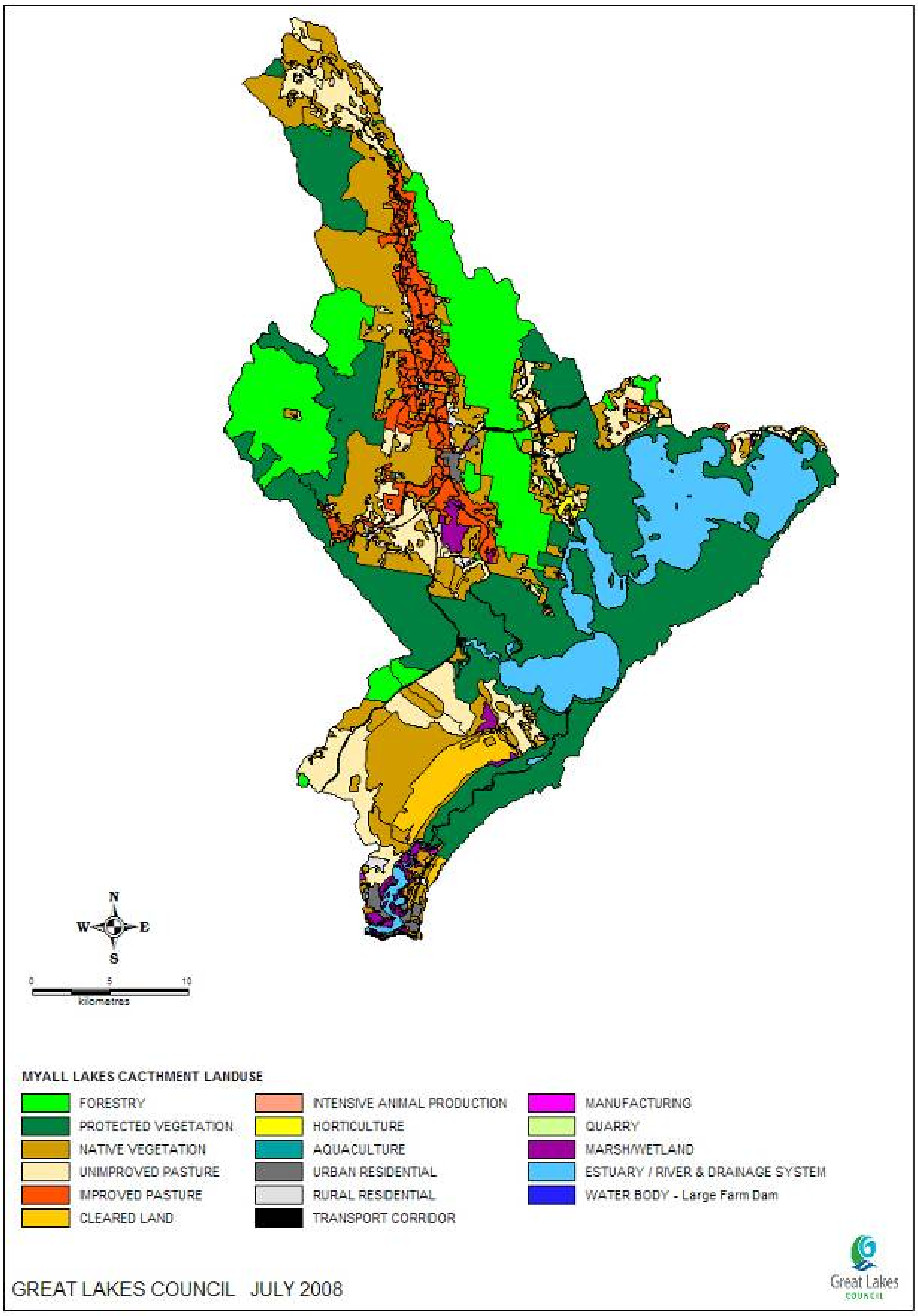


Figure A18.2. Distribution and extent of land use activities within the Myall Lakes catchment.

Table A18.2. Land use summary for the Myall Lakes catchment.

Myall Lakes catchment land use – Mapped classes		**Area (ha)**	**% Area**
AQUACULTURE	Oyster, fish, prawn, yabbie or beach worm farm infrastructure	35.76	0.05
CONSERVATION AREA	National park or nature reserve	24,987.78	32.09
GRAZING	Improved perennial pastures	4,756.40	6.11
GRAZING	Volunteer, naturalised, native or improved pastures	6,259.90	8.04
HORTICULTURE	Tea-tree oil / cut flower production	208.66	0.27
INTENSIVE ANIMAL PRODUCTION	Poultry	13.23	0.02
	Dairy shed	4.02	0.01
MINING & QUARRYING	Construction sand or gravel quarry	6.89	0.01
	Restored sand mining area	55.02	0.07
RIVER & DRAINAGE SYSTEM	Major river, creek or other incised drainage feature	150.40	0.19
STATE FOREST		13,818.57	17.75
TRANSPORT & OTHER CORRIDORS	Road or road reserve	350.57	0.45
TREE COVER	On private landholdings and unreserved lands	15,696.79	20.16
URBAN	Residential and urban infrastructure	277.20	0.36
	Rural residential / Small rural landholdings	407.81	0.52
WATER BODY	Coastal lake, sand spit or estuarine feature	10,293.10	13.22
	Large farm dam	2.61	0.00
WETLAND	Coastal marsh, mangrove, mudflat or swamp	545.17	0.70
Total mapped area		77,869.88	100.00[DG73]

Agriculture

Beef grazing, dairy production and poultry production are the main agricultural activities within the catchment. Agricultural activities utilise 112.4 km^2 (14.2%) of the catchment, and are predominantly found on the lower hillslopes and valley floors of the Myall and Crawford rivers and, to a lesser extent, the Boolambayte Creek valley. The trend of reduced dairy activity seen in the adjacent Wallis Lake catchment is also evident in the Myall Lakes catchment. In their assessment of the blue-green algal blooms in the Myall Lakes, DIPNR (2004) noted that by the late 1940s most, if not all, of the properties along the Myall River were dairy. By 2001, the number of operational dairies had reduced to seven (Smith 2001), and by late 2007, field surveys and personal communication suggest only three dairies remain operational within the catchment. Estimates undertaken for the Coastal Catchment Initiative project indicate that 11.9 km^2 (1.9%) of the catchment's grazing lands currently supports dairy production. It is likely that arrangements between neighbouring landholders provide additional grazing pasture for dairy herds, allowing an increase in carrying capacity and productivity of the remaining dairy operations. The majority of landholders leaving dairying have converted their operations to beef grazing.

Several intensive poultry production sites have been established upstream of the Myall and Crawford rivers junction. While not covering a large land area, in late 1997, 21 individual poultry sheds were in operation ranging between 75 m and 150 m in length.

More detailed information on the agricultural land uses that occur in the Great Lakes can be found in Appendix 9.

Horticultural activity within the catchment occupies 2.0 km^2 (0.26%), and is largely restricted to the production of melaleuca shrub for tea-tree oil and brush fencing material.

Commercial fishing / aquaculture

Commercial fishing activities are carried out on the waters of the Myall Lakes, the Lower Myall River and on the eastern beaches of the barrier dune complex (NPWS 2002). Commercially harvested species from the lakes include bream, sea mullet, luderick and whiting. School prawns, blue swimmer crabs and mud crabs are also harvested in commercial quantities. Mullet, bream and luderick, along with beachworms and pipis, are harvested from the catchment's ocean beaches (NPWS 2002).

Oyster production does not occur within the waters of the Myall Lakes. The brackish to fresh nature of the water is not a favourable oyster habitat. Aquaculture ponds have been identified on several landholdings in the area surrounding the Myall and Crawford rivers junctions, and in the Boolambayte Creek valley. The total area covered by ponds is approximately 36 ha and although the exact nature of what is being produced is unknown, interpretation of recent aerial imagery of the Myall catchment suggests the ponds are being actively maintained and are in use.

Forested land

Together, privately-owned native forest and state forest estate covers approximately 292.5 km^2 (37.5%) of the catchment. The larger proportion of this, some 154.3 km^2, is on private landholdings. Privately-owned forests can support a range of concurrent land uses such as grazing cattle in the understorey, low-volume timber harvesting, firewood collection, seed and flower collection, private conservation, as well as numerous recreational activities.

The topographical characteristics of the Myall Lakes catchment (narrow, linear valleys with steep adjacent ridge slopes) has seen the limited flat land largely cleared of its tree cover for dairy pasture and beef grazing. Hence, most of the forested land is found on the steeper hillslopes and ridgetops of the catchment perimeter.

Conservation

Approximately 249.8 km^2 (32 %) of the catchment land is utilised for conservation purposes. This land is under the ownership and management of the NSW National Parks and Wildlife Service, and includes the Myall Lakes National Park, Ghin-Doo-Ee National Park and The Glen Nature Reserve. At the time of writing this report, only the Myall Lakes National Park is managed under a formally adopted plan of management. All three conservation areas have formally adopted fire management plans.

The largest proportion of the conservation land within the catchment is located on and around the Myall Lakes and the adjacent barrier dune system. Significant areas along the southern catchment boundary ridgeline are also dedicated as conservation lands. While these areas are primarily managed for conservation purposes, they also provide substantial recreational and tourism opportunities. The current conservation estate within the Myall Lakes catchment provides excellent representative examples of brackish coastal lakes and associated dune complexes, and well as steeper forested hillslope and ridgetop landscapes. Freshwater riverine and riparian rainforest, and valley lowland habitats, are poorly represented within the current Myall Lakes catchment conservation estate.

The Myall Lakes are contained within the Port Stephens–Great Lakes Marine Park; refer to Figure A18.3. The inclusion of the lakes into the Port Stephens–Great Lakes Marine Park ensures the lake is managed to conserve biodiversity while still allowing for recreational and commercial activity. The Myall Lakes are dominated by the marine park zones of management for sanctuary or general use (refer to zoning maps in Marine Parks Authority NSW 2008). A sanctuary zone provides the highest level of protection, with management towards activities that do no harm the marine habitat or animals, e.g. boating, snorkelling. A general use zone is managed for a wide range of commercial and recreational activities including fishing. An area of habitat protection and seasonal general use exists in the Bombah Broadwater. The Port Stephens–Great Lakes Marine Park Authority is in the process of preparing an operational plan as required under the *Marine Parks Act 1997*. The operational plan will formally set out the operations the Authority will undertake or permit within the park's boundaries.

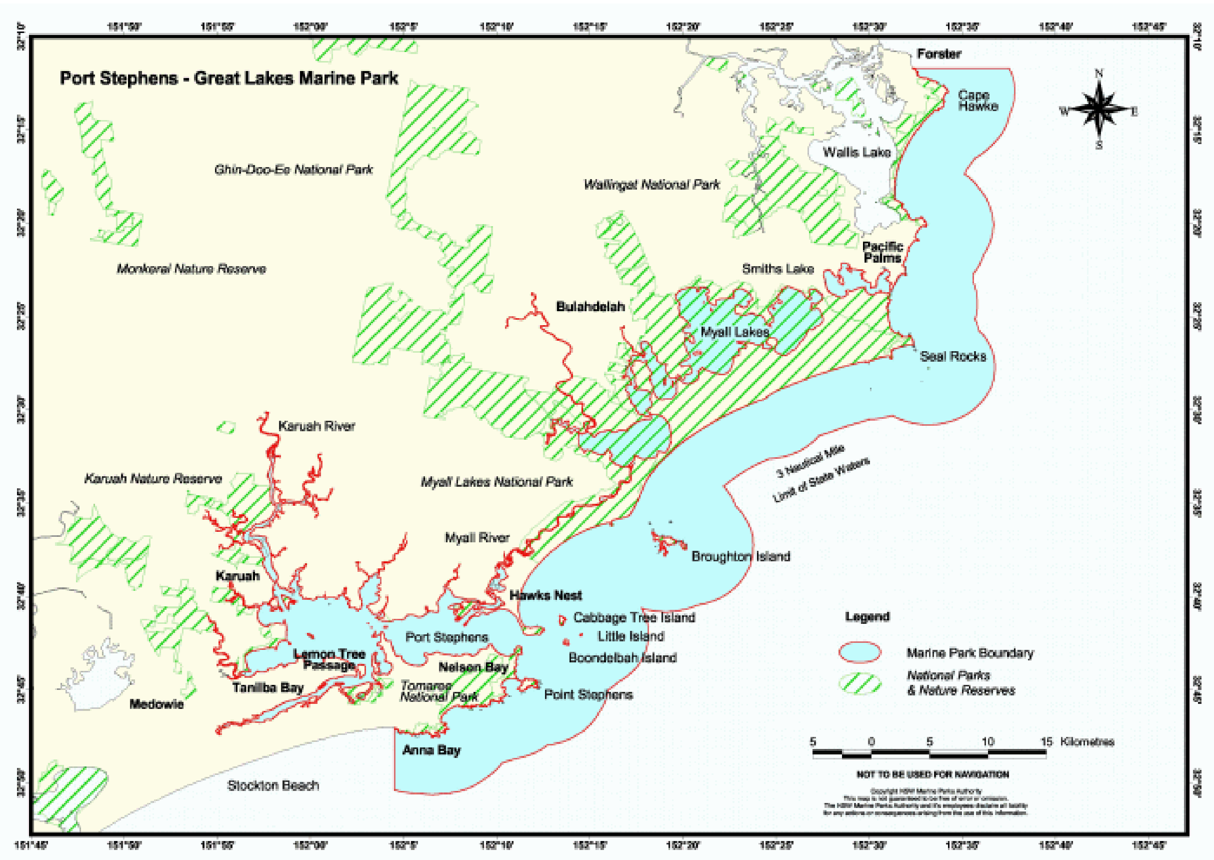


Figure A18.3. The water bodies of Myall Lakes, Myall River and Crawford River are contained within the Port Stephens–Great Lakes Marine Park. This map also shows the area of land conservation (national parks and nature reserves).

Urban development

Urban and rural residential development and its associated infrastructure cover approximately 10.35 km^2 (1.3%) of the Myall Lakes catchment. It is difficult to provide accurate population figures related specifically to the Myall Lakes catchment. However, Australian Bureau of Statistics data covering the Bulahdelah–Central Rural census district put the district's population at 1,771 in 2006 (Great Lakes Council 2007[DG74]c). This represents an 11.9% decline in the district's population since the 1996 census when the Australian Bureau of Statistics recorded 2,010 people as residents of the district (Great Lakes Council 2007[DG75]c). The Bulahdelah–Central Rural census district approximately covers the Myall Lakes catchment but excludes the small population centre surrounding Bungwahl. However, these figures do provide a reasonable representation of the general population trends within the Myall Lakes catchment.

The township of Bulahdelah (population 1,161), located on the Myall River, is the largest township within the catchment (Great Lakes Council 2007[DG76]c). The Bulahdelah urban area and its associated industrial and recreation areas cover approximately 2.3 km^2 (0.3%) of the catchment. Additional village centres include Nerong (150 houses) located on Nerong Inlet, an arm of the Bombah Broadwater; and parts of Bungwahl village on the northern shore of Myall Lake. Several rural residential subdivisions have been established in the Myall River and Boolambayte Creek catchments. Rural residential development occupies approximately 2.7 km^2 (0.34%) of the catchment.

Bulahdelah is the only urbanised area within the catchment to be serviced by a reticulated effluent treatment system. Effluent is treated to tertiary level and discharged into Frys Creek, which then flows into the Myall River upstream of Bulahdelah. The remainder of the catchments residential developments and rural landholdings are serviced by on-site effluent disposal systems. Bulahdelah and Nerong village are the only residential areas with formalised stormwater collection systems. The Nerong village stormwater system consists of roadside kerb and guttering, and a limited piped network discharging directly into Nerong Inlet or as surface discharge into the surrounding bushland. A mixture of formal roadside kerb and guttering, grassed swales, bare earth swales and modified natural watercourses are used to manage stormwater within the Bulahdelah urban area.

6. Ecological significance

The Myall Lakes system and catchment is an important ecological system, with approximately one-third of the catchment managed as conservation estate, and the lakes sectioned as part of the Myall Lakes National Park and the Port Stephens–Great Lakes Marine Park.

The lake margins contain a number of gazetted SEPP 14 coastal wetlands. The lake and its margins provide suitable habitat for an estimated 25 JAMBA and CAMBA-listed international migratory bird species (NPWS 2002), as well as a range of threatened species listed on the *Threatened Species Conservation Act 1995*.

In 1999, the Myall Lakes National Park was formerly listed as a Ramsar Wetland of International Importance. As a signatory to the Ramsar Convention, Australia has an obligation to manage Ramsar sites to protect ‘ecological character’. Actions that result in the deterioration of those characteristics should be seen as contravening the terms of the agreement (NPWS 2002).

Vegetation communities

Aquatic vegetation

The former Department of Infrastructure Planning and Natural Resources (DIPNR – now part of DECC) conducted surveys in 2001 and 2002 to collect and identify species and distribution of macrophytes, ephemerals and algae in the Myall Lakes (Dasey *et al*. 2004). The study identified that:

- charophytes were present all year in all three lakes, but were in far greater abundance in summer in Myall Lake
- a number of perennial angiosperms exist in the system, although their distribution in time and space varied. For example, *Ruppia megacarpa* was mainly confined to the shallow areas of Bombah Broadwater, bottom part of Boolambayte Lake and fringes of the other areas. However, it was noted to be undergoing recruitment in deeper areas of the Bombah Broadwater during the study period. In contrast, *Myriophyllum salsugineum* was present in all lakes except for Bombah Broadwater and did not appear to change in distribution over the study period
- over the study period, the annual angiosperm *Najas marina* increased in biomass and distribution in all lakes except for Bombah Broadwater, and suffered extensive dieback over winter.

There was a clear distinction between the character of Bombah Broadwater and the lower part of Boolambayte Lake, and that of Myall Lake and the upper Boolambayte Lake (Dasey *et al*. 2004). The downstream lakes contain large areas of perennial angiosperm macrophyte beds, which persist throughout the year. The upstream lakes are dominated mainly by annual / ephemeral plants and macroalgae, which demonstrate a more seasonal cycle.

The extent of aquatic flora distribution and diversity throughout the lake system is not well known. In the muddy sand substrates of Bombah Broadwater, Boolambayte Lake and Myall Lake, there is a mosaic of vegetation communities. These range from areas of sand, which contain little or no aquatic vegetation; and areas that contain dense vegetation in which the emergent seagrass *Ruppia* and aquatic species of *Myriophyllum* and *Vallisneria*, as well as saltmarsh (*Triglochin* spp.) dominate, depending on salinity levels (Atkinson, Hutchings, Johnson, Johnson & Melville 1981).

Shoreline vegetation is extremely important to the ecology of the lakes, providing food and shelter for many fish and other organisms, as well as stabilising the banks, stopping erosion and subsequent siltation, and contributing organic matter to the system. Along the shoreline of the lakes is a rich diversity of plants that respond to the wetting and drying cycles of the lakes and subsequent salinity fluctuations. The shoreline of the wetlands is dominated by the emergent vegetation Broad-leaved cumbungi (*Typha* spp.), Common reedgrass (*Phragmites australis*), Sedge (*Cladium procerum*), Leptocarpus (*Leptocarpus tenax*) and Scirpus (*Scirpus litoralis*) (Timms 1982[DG77]).

Gyttja

Gyttja, a thick layer of organic mud, has been observed over much of Myall Lake. Gyttja is a common feature of North American and Scandinavian lakes, although is not very common in Australia. In Myall Lake, the gyttja is thought to consist of decaying macrophytes and microalgae, and it contains high levels of ammonia ($NH4+$). With disturbance of the layer, there is potential for changes in phytoplankton abundance and assemblages (DECC 2008).

Terrestrial vegetation

The Myall Lakes catchment contains a diverse assemblage of native terrestrial vegetation community types. This is a result of the location of the catchment near a region where two botanical biogeographic regions converge (the NSW North Coast and Sydney Basin biogeographic regions), and due to the variety of landscapes and soil types present. The landscapes include coasts, estuaries, river floodplains and coastal ranges.

Plant communities within the catchment and national park include subtropical rainforest, mixed *Eucalyptus* spp. forest, woodland, coastal dry and wet heath, grassland, and wetlands (i.e. swamp, swamp forest, wet heath, and fringe forest). Indicative of the biologically diverse region, the Myall Lakes National Park has over 549 reported species of plants.

Great Lakes Council (2003[DG78]b) provided a survey and description of the privately-held and unreserved public lands (excluding state forest and national park / nature reserve) of the catchment. This was based on aerial photograph interpretation and some ground-truthing. The information available on terrestrial native vegetation confirms that the Myall Lakes catchment is diverse and significant. The major vegetation classes (Keith 2004) of the Myall Lakes catchment contains are shown in Table A18.3.

Table A18.3. Broad vegetation classes of the Myall Lakes catchment.

Subtropical rainforests	Northern warm temperate rainforests
Dry rainforests	Littoral rainforests
North coast wet sclerophyll forests	Northern hinterland wet sclerophyll forests
Coastal valley grassy woodlands	Hunter–Macleay dry sclerophyll forests
Coastal dune dry sclerophyll forests	Coastal headland heaths
Wallum sand heaths	Coastal heath swamps
Coastal freshwater lagoons	Coastal swamp forests
Coastal floodplain wetlands	Mangrove swamps

Within these broad vegetation classes, there is a wide range of specific vegetation communities that are known to occur. The Myall Lakes catchment contains vegetation communities of state, regional and local conservation significance. Table A18.4 ists the endangered ecological communities that occur in the Myall Lakes catchment.

Table A18.4. Endangered ecological communities of the Myall Lakes catchment.

Freshwater wetlands on coastal floodplain	Littoral rainforest
Lowland rainforest on floodplain	Lowland rainforest
Subtropical coastal floodplain forest	Swamp oak floodplain forest
Swamp sclerophyll forest on coastal floodplain	

The regional significance of native vegetation communities has been determined by the Comprehensive Regional Assessment for the NSW North Coast. Great Lakes Council (2003[DG79]b) listed the native terrestrial vegetation communities that are considered to be regionally significance, due to the rarity, vulnerability, levels of depletion through clearing since European settlement and degree of representation in conservation reserves. The Myall Lakes catchment also contains a number of locally significant vegetation communities, i.e. represented by currently less than 100 ha extent in the Great Lakes local government area. Examples of regionally and locally significant native vegetation communities in the Myall Lakes catchment are provided in Table A18.5.

Table A18.5. Regionally and locally significant vegetation communities of the Myall Lakes catchment.

Brown myrtle dry rainforest	Cabbage tree palm rainforest
Tallowwood wet sclerophyll forest	Forest red gum dry sclerophyll forest
Coastal banksia low open forest / woodland	Spotted gum / ironbark / mahogany dry sclerophyll forest
Brushbox wet sclerophyll forest	Swamp mahogany swamp sclerophyll forest
Wallum banksia / *Allocasuarina* dry heathland	*Baumea* sedgeland

Fauna communities

Aquatic fauna

The Myall Lakes system is an important breeding area for many fish and crustaceans, many of which are or have been commercially fished (including sea mullet, eel, bream, luderick, silver biddy, whiting, school prawns, blue swimmer crabs and mudcrabs).

The system also supports several frog species, with the swamp edge habitat providing a moist habitat and suitable shelter and / or refuges and food (NPWS 2002). Frog surveys in 1986 (Broadwater) and 1999 (near Neranie) showed a diversity of 11 frog species from two families and five genera (Llewellyn & Courtice 1999; Markwell & Knight 1986).

Many waterbirds feed on aquatic invertebrates at lake margins or in intertidal areas, and the system is a refuge for birds during drought years. Further discussion on migratory bird species' usage of the Myall Lakes catchment is found below.

Both NSW Fisheries and the NPWS have responsibilities for managing aquatic vegetation and fauna. The NPWS manages the lake beds, which are gazetted as part of Myall Lakes National Park. Under the *National Parks and Wildlife Act*, the NPWS is responsible for managing protected native plants and animals within the lake and surrounding area. NSW Fisheries administers the *Fisheries Management Act 1994*, including sustainable commercial catch.

Terrestrial fauna

The Myall Lakes catchment (and the Great Lakes local government area generally) is a region of significant and characteristically high faunal species diversity. This is due to the diversity of vegetation community types (coastal, estuarine, rainforest, forest, woodland, heath and wetland habitats), the relative intactness of habitat units (when compared to other regions), and the location of the region in a zone where it receives influences from both tropical and temperate faunal groups. Due to this zone of overlap of major faunal assemblages, the region contains a number of species at or near the limit of their natural distribution, such as the eastern blossom-bat (*Syconycteris australis*).

There has never been a systematic and representative inventory of the faunal species of the Myall Lakes catchment. Nor have the results of specific fauna studies on lands within the catchment, particularly for environmental assessments of development proposals, been collated. A current program to catalogue the faunal species diversity of the wider Great Lakes local Governmentgauthority has identified that 67 native mammal species, 38 frog species, 59 reptile species and 303 native bird species have been recorded in the region. Within these faunal groups, the local government area in which the Myall Lakes catchment occurs contains habitats for 26 threatened mammal species, 6 threatened frogs species, 1 threatened reptile species and 39 threatened bird species (as listed on the *Threatened Species Conservation Act 1995*). A total of 352 species of animals have been recorded in the Myall Lakes National Park, including 280 bird species, 41 mammal species, 15 amphibian species and 16 reptile species (NPWS 2002). Characteristic threatened species in the Myall Lakes catchment are listed in Table A18.6.

Table A18.6. Examples of threatened terrestrial faunal species within the Myall Lakes catchment.

Common name	Conservation status	Scientific name
Koala	Vulnerable	*Phascolarctos cinereus*
Yellow-bellied glider	Vulnerable	*Petaurus australis*
Brush-tailed phascogale	Vulnerable	*Phascogale tapoatafa*
Regent honeyeater	Endangered	*Xanthomyza phrygia*
Wallum froglet	Vulnerable	*Crinia tinnula*
Green and golden bell frog	Endangered	*Litoria urea*
Stephen's banded snake	Vulnerable	*Hoplocephalus stephensii*
Osprey	Vulnerable	*Pandion haliaetus*
Pied oystercatcher	Vulnerable	*Haematopus longirostris*
Little tern	Endangered	*Sterna albifrons*
Glossy black cockatoo	Vulnerable	*Calyptorhynchus lathami*
Masked owl	Vulnerable	*Tyto novaehollandiae*

The terrestrial faunal assemblages of the Myall Lakes catchment are under significant pressure from a range of threats. Such threats include, but are not limited to, clearing, modification or fragmentation of habitat, pollution, inappropriate fire regimes, effects of exotic fauna and flora, altered drainage patterns, disease, road kills, and effects of climate change. Such threats must be recognised, managed and reversed in order to protect and enhance the biodiversity of the Myall Lakes catchment.

International conservation agreements

RAMSAR wetland of international importance (Site 5AU052)

The Myall Lakes is one of the few coastal brackish lake systems in New South Wales that has not been greatly modified by human activities, and is a good example of the barrier lagoon systems that occur within the North Coast biogeographic region (http://www.environment.gov.au/cgi-bin/wetlands/report.pl, accessed August 2007). It provides habitat for a large number of native flora and fauna species, including a number of endangered and vulnerable species of amphibians and reptiles.

The Ramsar Sites Information Service website identifies the key biological values (fauna and flora) associated with Myall Lakes as (http://www.wetlands.org/RSDB/Default.htm, accessed June 2007):

- being a waterbird wintering / non-breeding / dry season area
- being a staging area for migratory waterbird species
- supporting rare / endangered species
- being a breeding area for waterbirds
- having an outstanding variety of flora and fauna species present
- being important for reproduction (all fauna groups except waterbirds)
- having an outstanding example of a particular plant community.

The scope of the Ramsar Convention covers "**all aspects** of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well-being of human communities" (http://www.ramsar.org/about/about_infopack_2e.htm).

More details on the ecological significance and details on the Myall Lakes Ramsar site are outlined in the Myall Lakes Ecological Character Description (DECC 2008a).

JAMBA and CAMBA

Australia has two international agreements for the protection of migratory birds that have implications for the management of the Wallis Lakes system:

- JAMBA: Australian Treaty Series 1981, No. 6 – The agreement between the government of Australia and the government of Japan for the protection of migratory birds and birds in danger of extinction and their environment
- CAMBA: Australian Treaty Series 1988, No. 22 – The agreement between the government of Australia and the government of the People's Republic of China for the protection of migratory birds and their environment.

These agreements list terrestrial, water and shore bird species that migrate between Australia and the respective countries, of which the majority are shorebirds. They require both parties to "protect migratory birds from take or trade except under limited circumstances, protect and conserve habitats, exchange information, and build cooperative relationships" (http://www.environment.gov.au/biodiversity/migratory/waterbirds/bilateral.html, accessed 22 August 2007). The JAMBA agreement also includes specific provisions for cooperation on conservation of threatened birds.

The extensive shallow water of the Myall Lakes National Park provides prime waterbird habitat and an important drought refuge for migratory birds. Migratory bird species protected under JAMBA and CAMBA agreements regularly visit and utilise a variety of habitats across Myall Lakes National Park. An estimated 25 JAMBA and CAMBA species have been recorded or have a high probability of occurrence within the national park based on the presence of suitable habitat (NPWS 2002).

7. Planning and management

Planning and management strategies developed for the Myall Lakes catchment can be considered in terms of land use planning (strategic planning), and also catchment and estuary planning.

Land use planning

A key issue facing the Great Lakes City Council is that of future expansion of urban and rural residential land use, and the design of suitable planning instruments for future development strategies.

Myall Lakes and surrounds have been the subject of several planning and environmental studies examining the constraints on further development in the area, and the suitability of the area for further urban and / or less intense forms of development (Great Lakes Council 2004[DG80]).

A total of 99 existing vacant blocks within the town precinct have been identified for future urban development, although it is noted that 37 of the vacant blocks are potentially flood-affected (Great Lakes Council 2004). A further 0.3 km^2 of land on the northern edge of the Bulahdelah urban area is considered suitable for future village expansion. Approximately 4.8 km^2 of land near the intersection of Booral Road and the Pacific Highway are suitable for rural residential subdivision. This figure does not include the Bulahdelah beer and golf resort and subdivision, as at the time of writing it was still under negotiation between Great Lakes Council and the Department of Planning (Great Lakes Council 2004).

Strategies have been prepared by Great Lakes Council with the aim of ensuring a long-term sustainable future for those lands impacted by urban expansion within the Great Lakes local government area. The strategies consider the social, environmental and economic needs of the region’s communities. Whilst outlining a template for growth into the future, the strategies also outline an appropriate framework that will ensure the critical elements of water quality and ecological integrity remain intact, and continue to serve as assets to the catchment community. Of particular relevance to the maintenance and enhancement of water quality within the Myall Lakes catchment is Great Lakes Council’s Rural Living Strategy (Great Lakes Council 2004).

Strategies and plans are discussed in more detail in Appendix 29.

Catchment and estuary planning

Catchment management priorities within the Wallis Lake catchment are a product of past catchment management approaches. Smith (2001) noted in his assessment of Myall Catchment land use that past intensive logging and crop production activities might have accelerated erosion on steeper hillslopes and cultivated river flats. Evidence exists that gully erosion was more of a problem in the past than it is today. However, localised gully erosion and stream bank erosion, along with eutrophication of creeks and standing water bodies, remain significant catchment management issues today (Smith 2001).

The recent catchment management approaches that have taken place in the Myall Lakes catchment are summarised in Table A18.7. Some of these approaches have ongoing associated plans, strategies or programs, which are discussed in Appendix 29.

Table A18.7. Myall Lakes catchment management to date[pt81].

Program	History	Current operation
Landcare	The landcare concept was introduced to the Myall Lakes catchment in the early 1990s as a means of halting or reversing the effect of nearly two centuries of landscape clearing and modification (D Smith & K Smith 2007, pers. comm., 27 November). The Karuah Great Lakes Landcare Management Committee oversees the strategy, activities and funding of the landcare groups in the region. The committee is comprised of members of each landcare group within its management area (the Karuah River catchment, Myall Lakes catchment, Smiths Lake catchment and Wallis Lake catchment). The committee is voluntary and meets regularly. It oversees the activities of the various groups, attracts / sources project funding for their area of responsibility, and liaises with federal and state government departments associated with land and environmental management. The committee also engages a landcare officer to work with and offer advice to local landholders to assist them in improving the sustainability of their farming operations. This officer also organises field days at various local properties to demonstrate property management techniques such as rotational grazing, dung beetle release, and off-stream watering systems.	No active landcare groups or projects in the catchment. Landcare across the Great Lakes catchments is coordinated through Karuah Great Lakes Landcare Management Committee
Rivercare	In July 2000, the former Myall Catchment Landcare Group Inc. – in partnership with the NSW Department of Land and Water Conservation, Rivercare and Landcare NSW – released a Rivercare Plan. The plan set out a range of recommendations for actions designed to address existing problems affecting the Myall River; the companion booklet provides important support information related to stream process, problems and management principles. Several landcare projects, primarily focussed on rectifying streambank erosion and dairy effluent management issues, have been completed since the release of the Rivercare Plan. There are not known to be any current activities in response to this plan.	Rivercare Plan and companion booklet for the Myall River (Schneider 2000).
Rural programs	Several rural programs that operate within the Myall Lakes Catchment designed to improve catchment condition and water quality. These generally involved dairy effluent management.	Ongoing participation within federal, state and regional programs to improve on-farm management
	Dairy Effluent Management Project: a National Heritage Trust (NHT) funded project running from 1998 to 2002, which involved auditing dairy effluent systems, preparing action plans to manage effluent and souring funding to carry out on-ground works. This involved 415 dairy farms, of which approximately 40 farms were in the Great Lakes CCI area.	Completed program

	Cleaner Production on Dairy Farms project (2004): funded by the NSW Environment Protection Agency (now part of DECC), this project identified, documented and demonstrated solutions to NRM and production issues on dairy farms. Farmers put in stock water, effluent management systems, and improved feed pads and laneways. It featured workshops, field days and the development of various resources, such as fact sheets and a CD photo library. The program was commended by the Industry Partnership Program in the Best Cleaner Production Cluster Category.	Completed program
	Setting Targets for Change project (2003/04) / Farmers Targets for Change: Mid Coast Dairy Advancement Group (MCDAG) piloted program on behalf of Dairy Australia. It was promoted under the national 'Dairying for Tomorrow' banner. Farmers on one river sub-catchment (Landsdown) participated and worked as a group to prioritise local issues and provide solutions to pilot the program. Projects were linked to external funding from the Hunter-Central Rivers Catchment Management Authority (CMA). Since that time, Setting Targets for Change has expanded (Farmers Targets for Change) and has involved approximately 11 farms (including non-dairy) in the Stroud / Bulahdelah area.	Completed program
	PROfarm including courses such as Prograze and LANDSCAN	Ongoing program
	Advancing for nutrients	Ongoing program
	Real farm planning	Ongoing program
	Milk Biz	Ongoing program
	Dairying for Tomorrow	Ongoing program
Myall Catchment Planning Group	The Myall Catchment Planning Group was convened by the then NSW Department of Land and Water Conservation to develop The Myall Catchment: Community Catchment Management Plan (Smith 2001). The group was formed in response to toxic blue-green algal blooms in 1999 – an indicator that whole-of-catchment management strategies were required to improve water quality. The group, in conjunction with the Department of Land and Water Conservation, undertook the preparation of a catchment management plan.	The Myall Catchment: Community Catchment Management Plan (Smith 2001).

Port Stephens and Myall Lakes Estuary Management Committee (EMC)	The Port Stephens and Myall Lakes EMC is jointly run by Port Stephens and Great Lakes councils. The EMC was established to develop plans for the sustainable use of the estuary and its immediate catchment, bringing together representatives of local and state government authorities, estuary user groups, and community to ensure inclusion of a broad array of interests and values in the planning process. The EMC has representatives from Port Stephens Council and Great Lakes Council, state government agencies (DPI – Fisheries, Maritime, DECC, NPWS, DLWC), Karuah Great Lakes Landcare Management Committee, Industry (NSW Oyster Quality Assurance Program, Newcastle Fisherman's Co-op Limited), recreational users (Myall Lakes Yacht Club, Marina Owners, Regional Recreational Fishing Advisory Council), Hunter Water Corporation, Myall Waterways Chamber of Commerce, ECO Network (an environmental action network) and community members.	Port Stephens and Myall Lakes Estuary Management Plan 2000

Catchment management achievements to date

While there has been limited landcare or specific catchment management activity within the Myall Lakes catchment, valuable land management projects have been completed on 11 sites. The Great Lakes Council's Management Tracking System contains information on these formally funded projects (that is, by Council or the Hunter Rivers Central CMA), include fencing, erosion control works, revegetation and dairy effluent management system repairs. The works have been put in place as part of the Hunter-Central Rivers Catchment Management Authority's programs aimed at identifying and rectifying catchment management issues.

Protective fencing

Currently a total of 3.81 km of protective fencing has been put in place to control stock access to the catchments waterways and vegetation management areas. These fences have been mapped and fall into the following categories:

- riparian protection
  - Myall River catchment – 0.86 km
  - Crawford River catchment – 2.67 km
- vegetation protection
  - Boolambayte Creek catchment – 0.28 km.

In all cases, fencing has been used as a means of controlling or preventing stock access to riparian margins, water storage dams, ephemeral gullies or native vegetation management areas. State forest and conservation estate has been excluded from this figure, as grazing stock is generally excluded from forestry and conservation lands.

Restricting direct stock access to the catchment's waterways has been given a high priority in efforts to improve water quality. Therefore, where protective riparian fencing is employed, it is considered more beneficial to restrict stock access from both sides of the watercourse. Where possible, riparian fencing projects have attempted to restrict stock access to both sides of a watercourse; achieving this can be a complex process, as it is common for a given length stream bank to be bordered by several landholders. Table A18.8 provides a comparison of the ratio of watercourse fenced on both sides or on one side only, as compared the total length of water course that potentially could be fenced within the Myall Lakes three main sub-catchments.

Table A18.8. Riparian fencing ratio summary for the watercourses within the Myall River, Crawford River and Boolambayte Creek catchments (excluding watercourses within state forest and national park estate).

Watercourse	Length (km)	Length fenced both sides (km)	% fenced both sides	Length fenced single side (km)	% fenced single side
Myall River	62.070	0.000	0.00	0.86	1.39
Named creeks within the Myall River catchment	57.320	0.000	0.00	0.00	0.00
Unnamed creeks and gullies within the Myall River catchment	514.800	0.000	0.00	0.00	0.00
Crawford River	13.900	0.767	5.50	1.14	8.20
Named creeks within the Crawford River catchment	10.830	0.000	0.00	0.00	0.00
Unnamed creeks and gullies within the Crawford River catchment	137.600	0.000	0.00	0.00	0.00
Boolambayte Creek	16.910	0.000	0.00	0.28	1.65
Named creeks within the Boolambayte Creek catchment	5.360	0.000	0.00	0.00	0.00
Unnamed creeks and gullies within the Boolambayte Creek catchment	57.270	0.000	0.00	0.00	0.00
Total watercourse comparison	**876.060**	**0.767**	**0.09**	**2.28**	**0.26**

The above figures refer only to those fences put in place as part of catchment management incentive schemes and formally mapped in the Great Lakes Catchment Management Tracking System. The potential does exist for considerably more fencing, put in place by landholders, to act as barriers to stock access to the catchment waterways. However, logistical difficulties and time constraints preclude the collation of such detailed data.

Off-stream stock watering systems

Off-stream stock watering systems utilise pump extraction of water from streams or storage dams to supply off-stream storage tanks and further distribution to outlying stock water troughs. This allows landholders to restrict direct stock access to the catchment's waterways. Currently the Crawford River and Myall River sub-catchments each have one known off-stream watering system to enhance the effectiveness of riparian stock exclusion fencing.

Vegetation management

Approximately 6.5 ha of native vegetation or revegetation plantings have been placed under protective management. The distribution of these management areas is:

- Myall River Catchment – 0.57 ha
- Crawford River Catchment – 5.643 ha
- Boolambayte Creek Catchment – 0.29 ha.

Erosion control

Approximately 29,960 m^2 of erosion control measures are in place across the catchment. These measures are predominantly in place to control stream bank erosion within the Myall and Crawford rivers. The distribution of erosion control works is:

- Myall River Catchment – 22,885.99 m^2
- Crawford River Catchment – 7,074.5 m^2.

Dairy effluent management

Three dairy sheds within the Myall River catchment have had repairs or modifications to their effluent management systems to ensure better management of nutrients and surface runoff from cattle handling areas.

Urban stormwater management

Great Lakes Council has constructed a number of structural solutions aimed at decreasing the amount of pollutants reaching local waterways in the local government area, including Myall Lakes, Smiths Lake and Wallis Lake, and their respective tributaries.

All stormwater flows from Bulahdelah discharge into Myall Lakes. The Council has installed two stormwater litter baskets, designed to intercept urban street litter, in Stroud Street, the main shopping / commercial centre of Bulahdelah.

Maintenance and cleaning of all stormwater treatment equipment is carried out on a periodic basis as resources permit. Litter baskets are cleaned out on a monthly basis. During the cleaning operation, Council staff records the composition of the captured material and its weight. The types of pollutants captured in each of the structural solutions are divided into three categories: litter, sediment and organics (leaf litter / grass, etc.). Analysis of these pollutant categories is an important monitoring and assessment tool for stormwater management, and can help identify and address locally unique stormwater issues.

Appendix 19: Contributions of pollutants by land use in individual sub-catchments, Myall Lakes

All land areas contribute some sediment and nutrients to the lake, even protected vegetation. In a management sense, we are most interested in where human activities have caused elevated pollutant loads to the lake, as these are areas where intervention may act to decrease loads. This means, for example, that while protected vegetation may contribute pollutants to the lake, if no human activities (such as changes to the fire regime or provision of tracks) have caused this to be higher than what would be expected to naturally occur, then these pollutants are not of management concern. Descriptions below of sources of pollutants by land use should be read with this in mind. Note that in undertaking analysis for this Plan, detailed land uses have been grouped into several broader classifications. These classes are based on similar generation rates. Groupings used in the analysis are shown in Table A19.1.

Table A19.1. Myall Lakes land use classes represented in the Great Lakes CCI DSS.

Simplified DSS land use class	Land use description	AnnAGNPS model classes	Australian Land Use and Management (ALUM) classification [a]
Protected Vegetation	• Protected Vegetation: This group is comprised of: (1) National parks, which are protected areas managed mainly for ecosystem conservation and recreation; and (2) Strict nature reserves, which are protected areas managed mainly for science.	• National park • Strict nature reserves	• ALUM 1.1.3 • ALUM 1.1.1
Forestry	• Forestry: This group is comprised of: (1) Hardwood production, which is land managed for hardwood sawlogs or pulpwood; (2) Production forestry, which involves commercial production from native forests, and related activities on public and private land; and (3) State forest.	• Hardwood production • Production forestry • State forest	• ALUM 3.1.1 • ALUM 2.2.0 • n/a
Native Vegetation	• Native Vegetation: This group is comprised of: (1) Remnant native cover, which is land under native cover that is mainly unused (no prime use), or used for non-production or environmental purposes; and (2) Riparian vegetation.	• Remnant native cover • Riparian vegetation	• ALUM 1.3.3 • n/a
Unimproved Pasture	• Unimproved Pasture: This land use type is native / exotic pasture mosaic, which is pasture with a substantial native species component despite extensive active modification or replacement of native vegetation (BRS 2006).	• Native / exotic pasture mosaic	• ALUM 3.2.1

Simplified DSS land use class	Land use description	AnnAGNPS model classes	Australian Land Use and Management (ALUM) classification [a]
Improved Pasture	• Improved Pasture: This group is comprised of: (1) Pasture legume / grass mixture; (2) Irrigated sown grasses; and (3) Irrigated legume / grass mixture.	• Pasture legume / grass mixture • Irrigated sown grasses • Irrigated legume / grass mixture	• ALUM 3.2.4 • ALUM 4.2.4 • ALUM 4.2.3
Roads	• Unpaved Roads: All unpaved roads mapped for the Great Lakes catchments.	• Roads	• ALUM 5.7.2
Rural Residential	• Rural Residential: This land use is "characterised by agriculture in a peri-urban setting, where agriculture does not provide the primary source of income" (BRS 2006).	• Rural residential	• ALUM 5.4.2
Urban Residential [b]	• Urban Residential: This group is comprised of: (1) Urban residential (e.g. houses, flats, hotels); and (2) Recreation, which include parks, sports grounds, camping grounds, swimming pools, museums and places of worship (BRS 2006).	• Urban residential • Recreation	• ALUM 5.4.1 • ALUM 5.5.3
Manufacturing		• Manufacturing	• ALUM 5.3.0
Quarries		• Quarries	• ALUM 5.8.2
Cleared Land	• Cleared land	• Cleared land	• n/a

a: BRS (2006).
b: Export rates for urban residential land were determined from MUSIC model results for urban sub-catchments in the Great Lakes.
The groups and their Australian Land Use and Management (ALUM) classification (BRS 2006) are listed above. More details on features of these land uses can be accessed from http://adl.brs.gov.au/mapserv/landuse/alum_classification.html (accessed 24 July 2008).

1. Myall Lakes sub-catchment pollutant contributions

All land areas contribute some sediment and nutrients to the lake, even protected vegetation. In a management sense, we are most interested in where human activities have caused elevated pollutant loads to the lake, as these are areas where intervention may act to decrease loads. This means, for example, that while protected vegetation may contribute pollutants to the lake, if no human activities (such as changes to the fire regime or provision of tracks) have caused this to be higher than what would be expected to naturally occur then these pollutants are not of management concern. Descriptions below of sources of pollutants by land use should be read with this in mind. The contribution of pollutants in each sub-catchment is outlined in the following section and the locations of the sub-catchment are shown in Figure A19.1.

The land use classes that are targeted in modelling presented in Section 2.15 are: agriculture and (only in the Crawford River sub-catchment) unpaved roads. The modelled actions in this Plan do not address the management of forestry, protected vegetation, native vegetation, urban residential or rural residential lands, although are considered by some of the non-modelled actions in this Plan. The management of forestry and protected vegetation areas should be accounted for by other planning and legislative processes (e.g. DECC licensing agreements).

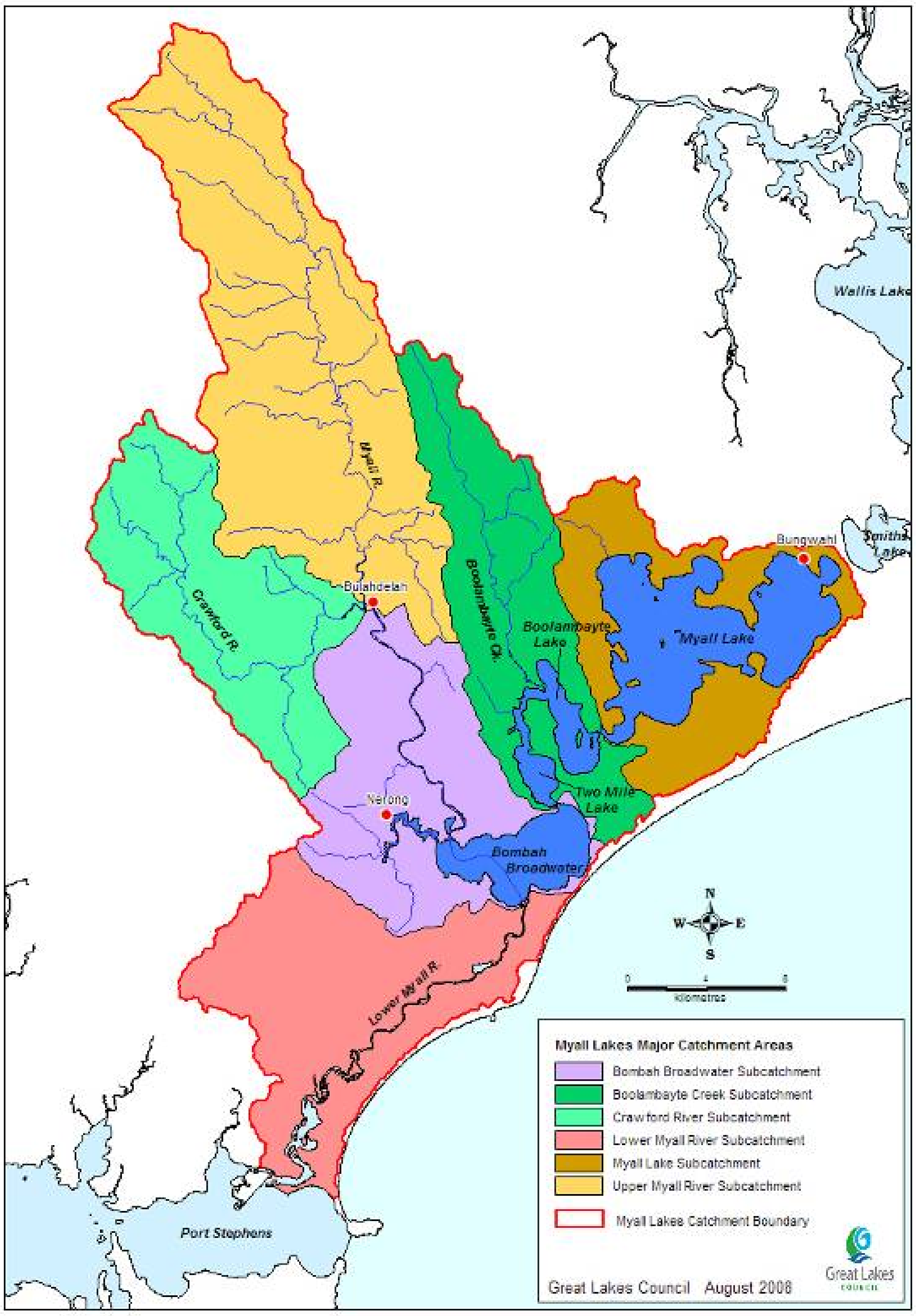


Figure A19.1. Sub-catchments in the Myall Lakes catchment.

This sub-catchment is the only catchment that directly affects Myall Lake, although the other sub-catchments indirectly influence the lake through interactions with Boolambayte Lake. The sub-catchment loads and contributions as a percentage of the total catchment loads are shown in Table A19.2.

Table A19.2. Area and pollutant exports from the Myall Lakes sub-catchment. The table shows absolute values as well as the percentage contribution of the sub-catchment to the catchment total.

Sub-catchment	Area		TSS		TN		TP	
	ha	%	tonnes	%	kg	%	kg	%
Myall Lake	7,771	10	740	11	4,546	10	545	10

The relative contribution of different land use activities and sources of pollutants compared to the area they cover in the Myall Lake sub-catchment is shown in Figure A19.2. Table A19.3 lists the percentage area of target (agricultural lands) and non-target land (forestry, protected vegetation or native vegetation, unpaved roads, and rural and urban residential), and the amount of total loads sourced from these lands. While much of the land (~90%) is not targeted by the actions modelled in Section 2.15 of the WQIP, the remaining 10% of land contributes about 20% of the nutrient exports and about 90% of the sediment exports modelled for the Myall Lake sub-catchment.

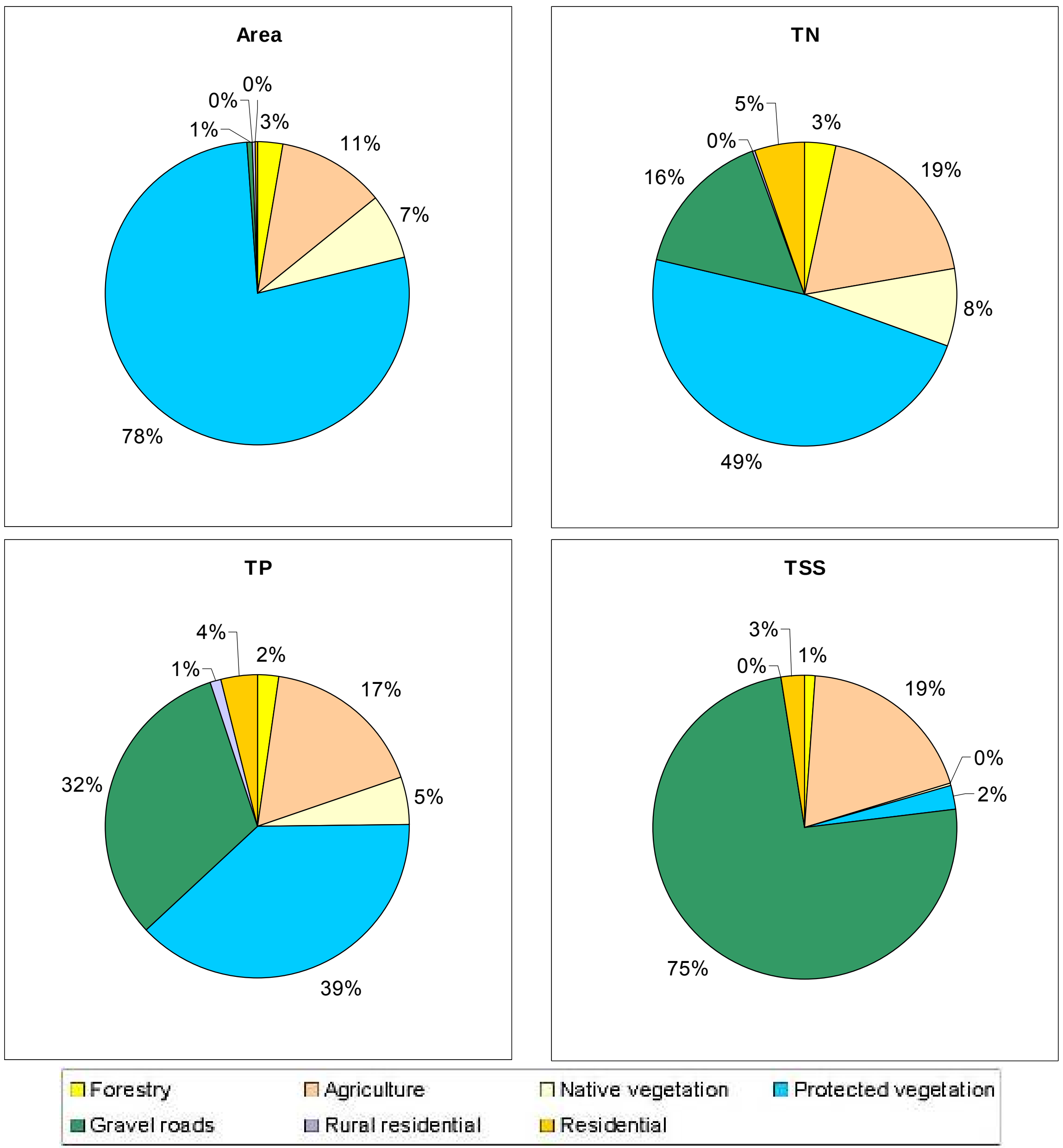


Figure A19.2. Relative contribution of land use activities to pollutants and area in Myall Lake sub-catchment.

Table A19.3. Percentage area of target (agriculture, rural residential and urban residential lands) and non-target land (forestry, protected vegetation or native vegetation) in the Myall Lake sub-catchment, and the amount of total loads sourced from these lands.

	Area	TN	TP	TSS
Target land	11	19	17	19
Non-target land	89	81	83	81

This shows that the contribution of sediments and nutrients varies by land use, such as the primary sources of TSS (unpaved roads) differ from those of TN or or TP (protected vegetation). In this sub-catchment, the large area of protected vegetation contributes a reasonable proportion of TN and TP (but less than the equivalent proportion of area) but very little TSS. Unpaved roads are shown to be a land use with a very small area (1%) in the catchment, but produce a substantial amount of the nutrients (16% of TN, 32% of TP) and sediments (75%) generated in this sub-catchment. Agricultural lands also produce a reasonably large proportion of nutrients (19% of TN, 17% of TP) and sediments (19%), and are contributing more than would be expected based on the area of this land in the sub-catchment (11%). Rural residential and residential areas contribute relatively high loads, considering the small contribution these land uses make to total area, but overall pollutants from these sources are swamped by other sources.

2. Boolambayte Creek sub-catchment

Boolambayte Lake is the receiving waters for the Boolambayte Creek sub-catchment, although it is also influenced by conditions in both Myall Lake and Bombah Broadwater. The sub-catchment loads and contributions as a percentage of the total catchment loads are shown in Table A19.4.

Table A19.4. Area and pollutant exports from the Boolambayte Creek sub-catchment. The table shows absolute values as well as the percentage contribution of the sub-catchment to the catchment total.

Sub-catchment	Area		TSS		TN		TP	
	ha	%	tonnes	%	kg	%	kg	%
Boolambayte Creek	11,131	14	451	7	5,140	11	300	6

The relative contribution of different land use activities and sources of pollutants compared to the area they cover in the Boolambayte Creek sub-catchment is shown in Figure A19.3.

Table A19.5 lists the percentage area of target (agricultural lands) and non-target land (forestry, protected vegetation or native vegetation, unpaved roads, and rural and urban residential), and the amount of total loads sourced from these lands. While much of the land (~90%) is not targeted by the actions modelled in Section 2.15 of the WQIP, the remaining 10% of land contributes about 15% of the nutrient and sediment modelled for the Boolambayte Creek sub-catchment.

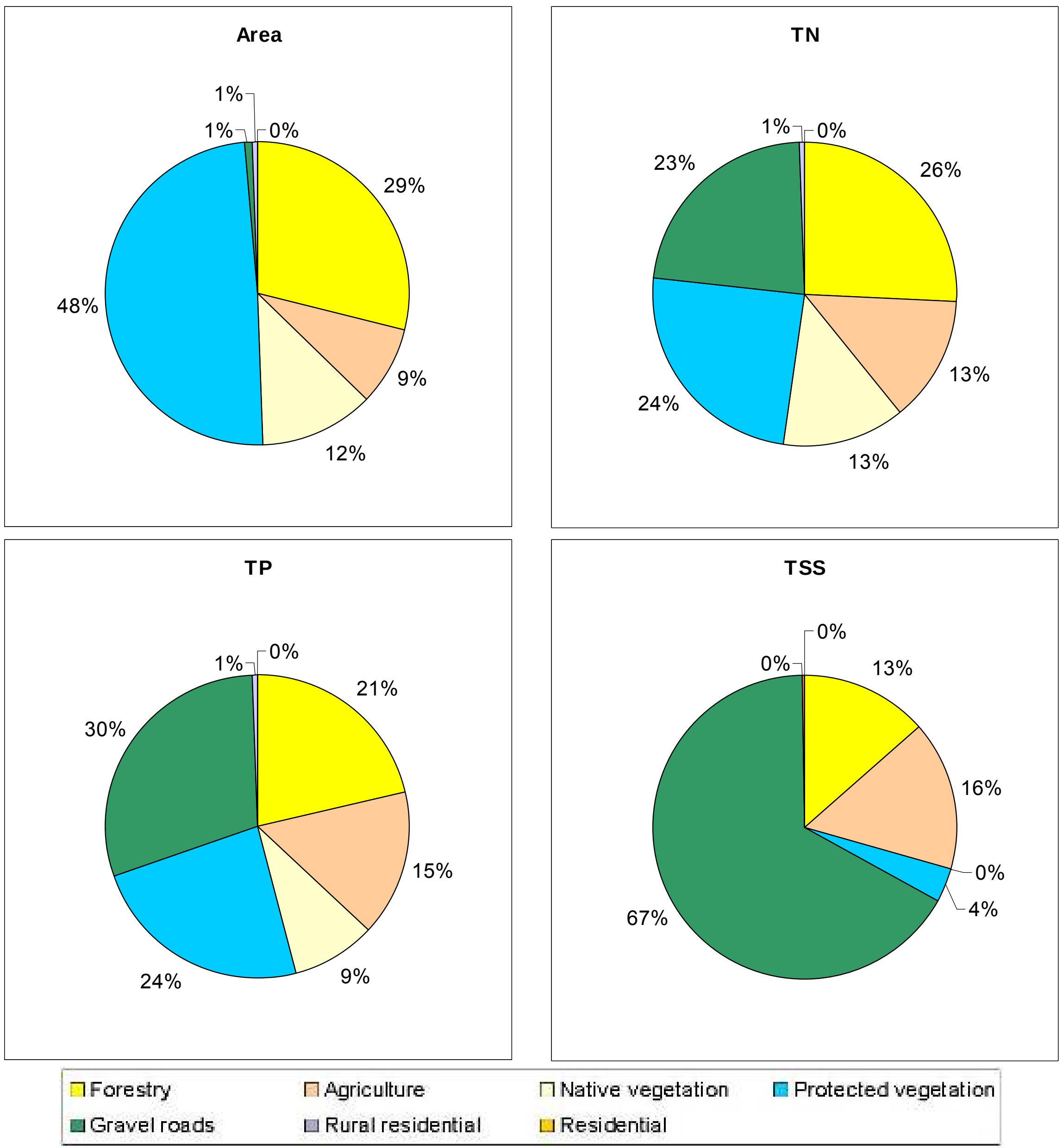


Figure A19.3. Relative contribution of land use activities to pollutants and area in Boolambayte Creek sub-catchment.

Table A19.5. Percentage area of target (agriculture, rural residential and urban residential lands) and non-target land (forestry, protected vegetation or native vegetation) in the Boolambayte Creek sub-catchment, and the amount of total loads sourced from these lands.

	Area	TN	TP	TSS
Target land	9	13	15	16
Non-target land	91	87	85	83

Figure A19.3 shows that in a similar way to the Myall Lake sub-catchment, unpaved roads are the major contributor of TSS (67%) in this sub-catchment but contribute much less TN (23%) and TP (30%). Forestry contributes a substantial amount of nutrients (26% of TN, 21% of TP) and sediments (13%), but this amount is less than what could be justified based on area alone (29%). Agricultural lands contribute more nutrients (13% of TN, 15% of TP) and sediments (16%) than can be justified by their area (9%), but given the smaller agricultural area in this catchment, these areas contribute relatively small amounts of the total nutrient and sediment loads. Protected vegetation also produces a reasonably large proportion of TN and TP (24%), but much less than the proportion of the catchment under this land use (48%).

3. Upper Myall River sub-catchment

The Upper Myall River sub-catchment loads and contributions as a percentage of the total catchment loads are shown in Table A19.6.

Table A19.6. Area and pollutant exports from the Upper Myall River sub-catchment. The table shows absolute values as well as the percentage contribution of the sub-catchment to the catchment total.

Sub-catchment	Area		TSS		TN		TP	
	ha	%	tonnes	%	kg	%	kg	%
Upper Myall River	23,956	31	3,385	52	20,947	45	1,548	29

The relative contribution of different land use activities and sources of pollutants compared to the area they cover in the Upper Myall River sub-catchment is shown in Figure A19.4. Table A19.7 lists the percentage area of target (agricultural lands) and non-target land (forestry, protected vegetation or native vegetation, unpaved roads, and rural and urban residential), and the amount of total loads sourced from these lands. While much of the land (~75%) is not targeted by the actions modelled in Section 2.15 of the WQIP, the remaining land contributes about 40% of the nutrient exports and 62% of the sediment exports modelled for the Upper Myall River sub-catchment.

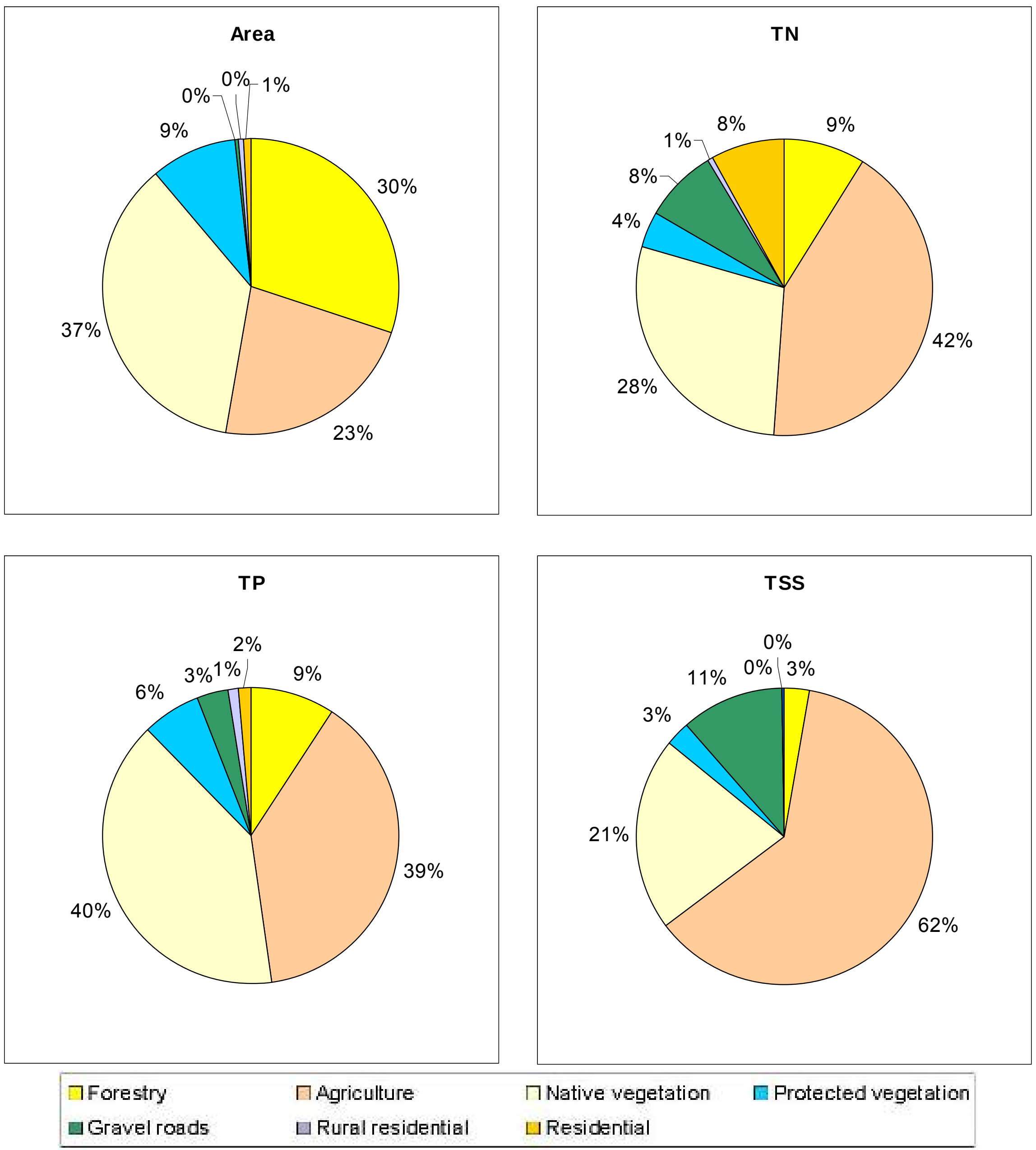


Figure A19.4. Relative contribution of land use activities to pollutants and area in Upper Myall River sub-catchment.

Table A19.7. Percentage area of target (agriculture, rural residential, and urban residential lands) and non-target land (forestry, protected vegetation or native vegetation) in the Upper Myall River sub-catchment, and the amount of total loads sourced from these lands.

	Area	TN	TP	TSS
Target land	23	42	39	62
Non-target land	77	58	61	38

The main contributor of sediments and nutrients in the Upper Myall River is agricultural lands. These lands contribute proportionally more pollutants than their area (23%), and contribute a much higher proportion of TSS (62%) than TN (42%) or TP (39%). Native vegetation also produces a relatively large proportion of TSS (21%), TN (28%) and TP (40%). Its contribution of TSS and TN are less than the proportion of area of this land use (37%), but for TP the proportion is slightly higher than the land area proportion. Residential areas contribute substantially more TN (8%) than their contribution to total area (1%), but overall pollutant loads from these areas are still small compared to loads from other land uses, given the relatively small area of land devoted to this land use in the catchment.

4. Crawford River sub-catchment

The Crawford River sub-catchment loads and contributions as a percentage of the total catchment loads are shown in Table A19.8.

Table A19.8. Area and pollutant exports from the Crawford River sub-catchment. The table shows absolute values as well as the percentage contribution of the sub-catchment to the catchment total.

Sub-catchment	Area		TSS		TN		TP	
	ha	%	tonnes	%	kg	%	kg	%
Crawford River	11,926	15	271	4	6,394	14	991	18

The relative contribution of different land use activities and sources of pollutants compared to the area they cover in the Crawford River sub-catchment is shown in Figure A19.5. Table A19.9 lists the percentage area of target (agricultural lands and unpaved roads) and non-target land (forestry, protected vegetation or native vegetation, and rural and urban residential), and the amount of total loads sourced from these lands. While much of the land (~90%) is not targeted by the actions modelled in Section 2.15 of the WQIP, the remaining land contributes 25% or more of the nutrient exports and about 70% of the sediment exports modelled for the Crawford River sub-catchment.

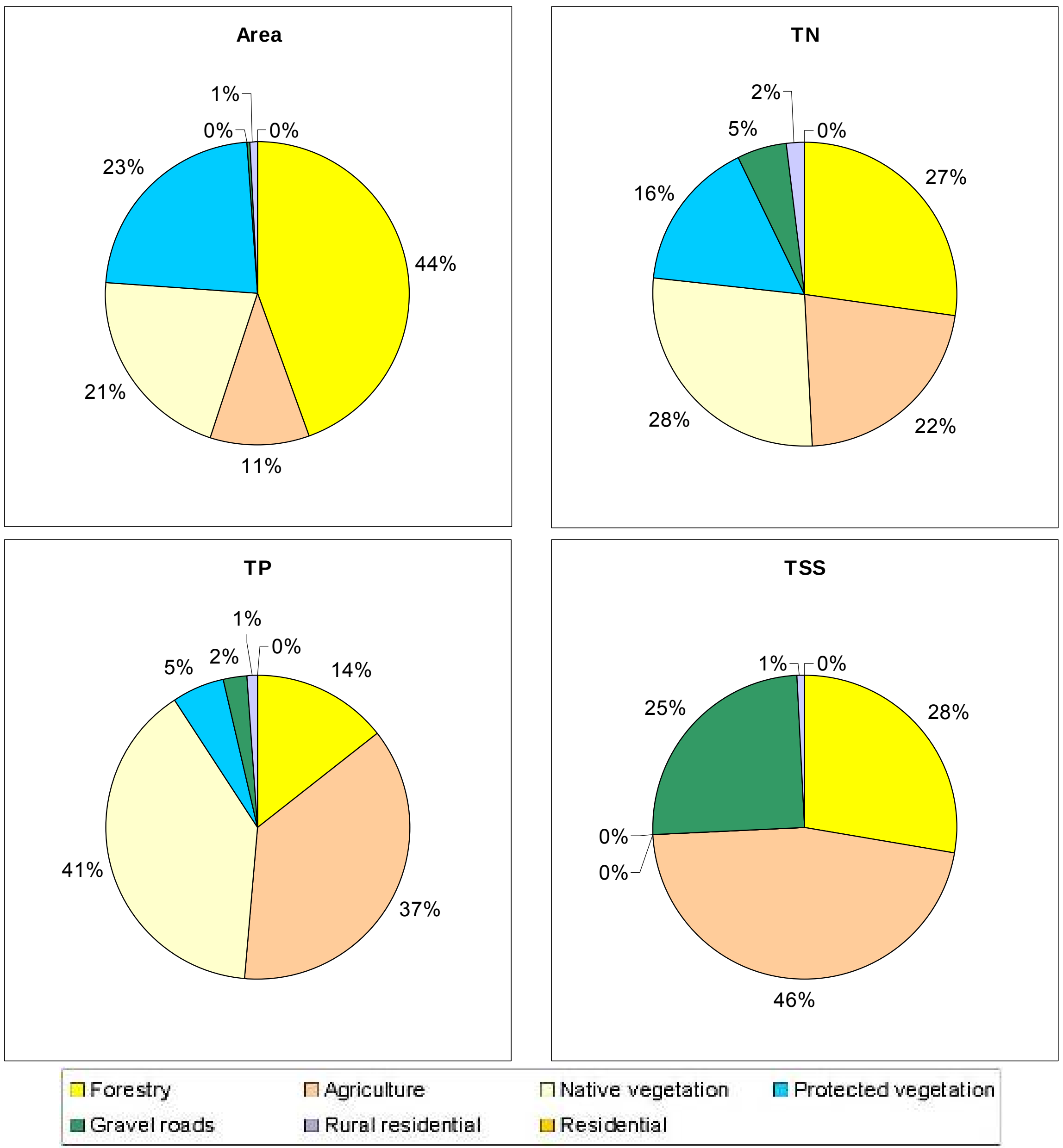


Figure A19.5. Relative contribution of land use activities to pollutants and area in Crawford River sub-catchment.

Table A19.9. Percentage area of target (agriculture, rural residential and urban residential lands) and non-target land (forestry, protected vegetation or native vegetation) in the Crawford River sub-catchment, and the amount of total loads sourced from these lands.

	Area	TN	TP	TSS
Target land	11	27	39	71
Non-target land	89	73	61	29

This figure shows that agricultural lands dominate the production of TSS (46%) in the Crawford River, and produce substantial amounts of TP (37%) and TN (22%). These lands account for a relatively small area of the catchment (11%). Forestry lands also produce a relatively large proportion of nutrients (27% of TN, 14% of TP) and sediments (28%) in the Crawford River, but still produce significantly less than would be expected based on the proportion of area under forestry (44%). Unpaved roads produce a very high proportion of sediments (25%) and, to a lesser extent, nutrients (5% of TN, 2% of TP), given that they account for such a small area of the catchment. Native vegetation is also a significant contributor of TN (28%) and TP (41%), but contributes very little TSS (<1%).

5. Bombah Broadwater sub-catchment

The Bombah Broadwater sub-catchment loads and contributions as a percentage of the total catchment loads are shown in Table A19.10.

Table A19.10. Area and pollutant exports from the Bombah Broadwater sub-catchment. The table shows absolute values as well as the percentage contribution of the sub-catchment to the catchment total.

Sub-catchment	Area		TSS		TN		TP	
	ha	%	tonnes	%	kg	%	kg	%
Bombah Broadwater	12,095	15	617	9	5,467	12	870	16

The relative contribution of different land use activities and sources of pollutants compared to the area they cover in the Bombah Broadwater sub-catchment is shown in Figure A19.6. Table A19.11 lists the percentage area of target (agricultural lands) and non-target land (forestry, protected vegetation or native vegetation, unpaved roads, and rural and urban residential), and the amount of total loads sourced from these lands. While much of the land (75%) is not targeted by the actions modelled in Section 2.15 of the WQIP, the remaining land contributes 32% of the nutrient exports and 20% of the sediment exports modelled for the Bombah Broadwater sub-catchment.

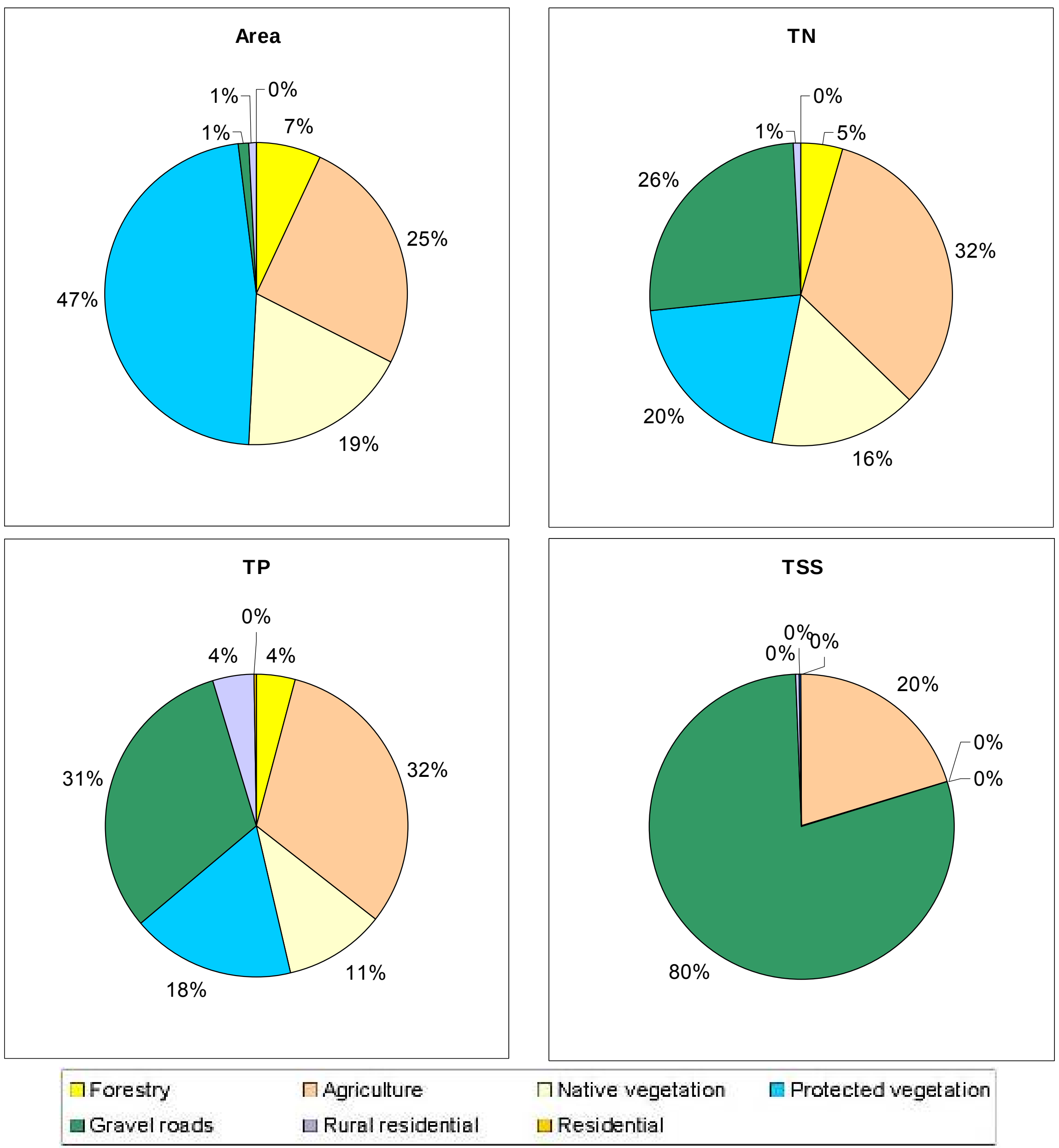


Figure A19.6. Relative contribution of land use activities to pollutants and area in Bombah Broadwater sub-catchment.

Figure A19.6 shows that as for the Myall Lake and Boolambayte Creek sub-catchments, Unpaved roads dominate the production of sediments (80%) in the Bombah Broadwater sub-catchment, and make substantial but much smaller contributions to nutrients (26% of TN, 31% of TP). Agricultural lands dominate nutrient generation (32%) and also contribute substantial loads of TSS (20%). Protected vegetation and native vegetation also generate sizable loads of TN (20% and 16%, respectively) and TP (18% and 11%, respectively), although in both cases this is less than the proportion of area devoted to these land uses (47% and 19%, respectively).

Table A19.11. Percentage area of target (agriculture, rural residential and urban residential lands) and non-target land (forestry, protected vegetation or native vegetation) in the Bombah Broadwater sub-catchment, and the amount of total loads sourced from these lands.

	Area	TN	TP	TSS
Target land	25	32	32	20
Non-target land	75	68	68	80

6. Lower Myall River sub-catchment

The Lower Myall River sub-catchment loads and contributions as a percentage of the total catchment loads are shown in Table A19.12.

Table A19.12. Area and pollutant exports from the Lower Myall River sub-catchment. The table shows absolute values as well as the percentage contribution of the sub-catchment to the catchment total.

Sub-catchment	Area		TSS		TN		TP	
	ha	%	tonnes	%	kg	%	kg	%
Lower Myall River	11,615	15	1,040	16	3,667	8	1,106	21

The relative contribution of different land use activities and sources of pollutants compared to the area they cover in the Lower Myall river sub-catchment is shown in Figure A19.7. Table A19.13 lists the percentage area of target (agricultural lands) and non-target land (forestry, protected vegetation or native vegetation, unpaved roads, and rural and urban residential), and the amount of total loads sourced from these lands. While about 70% is not targeted by the actions modelled in Section 2.15 of the WQIP, the remaining land contributes ~30% of the TN exports, ~40% of the TP exports and ~50% of the sediment exports modelled for the Lower Myall River sub-catchment.

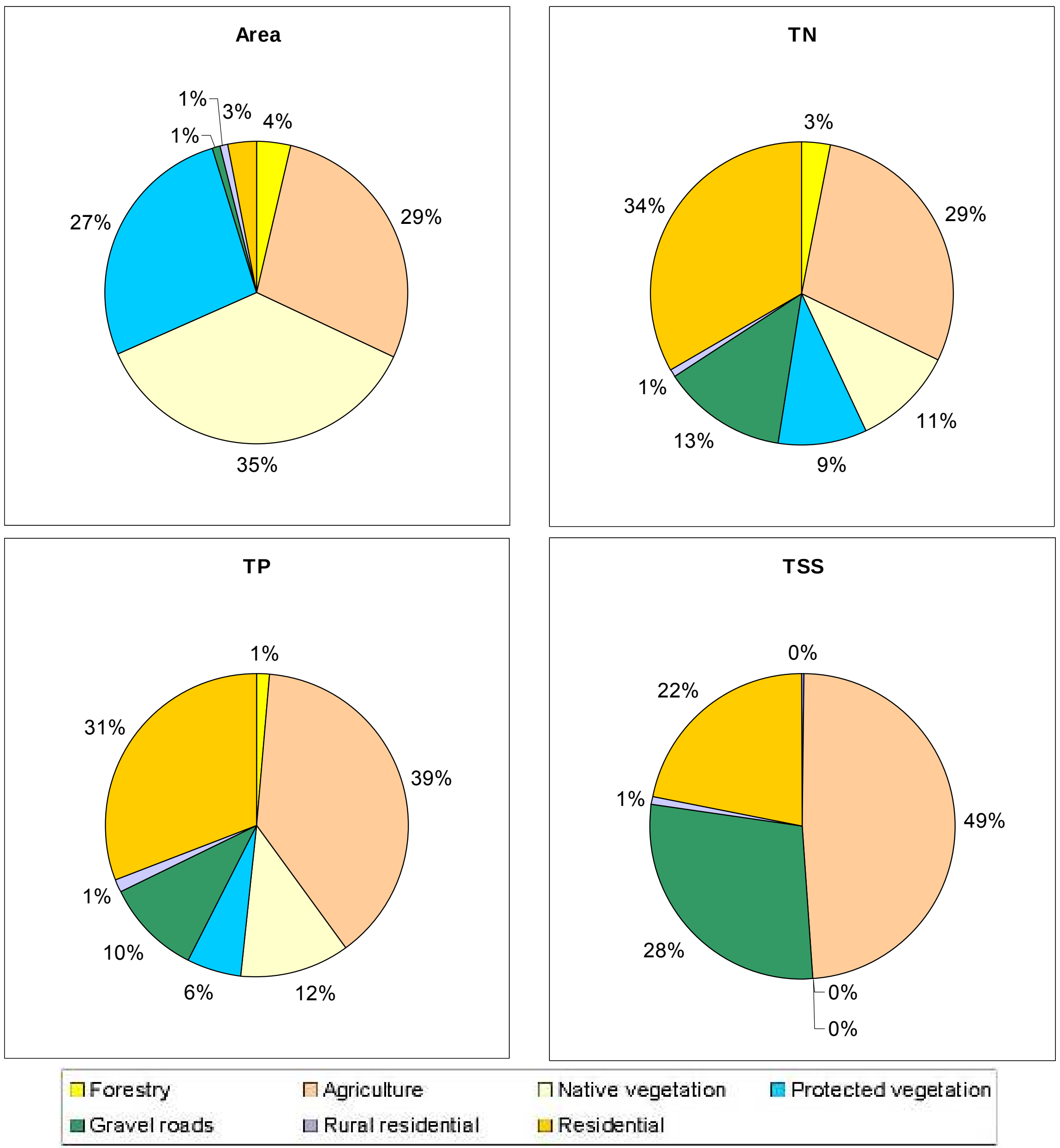


Figure A19.7. Relative contribution of land use activities to pollutants and area in Lower Myall River sub-catchment.

Table A19.13. Percentage area of target (agriculture, rural residential and urban residential lands) and non-target land (forestry, protected vegetation or native vegetation) in the Lower Myall River sub-catchment, and the amount of total loads sourced from these lands.

	Area	TN	TP	TSS
Target land	29	29	39	49
Non-target land	71	71	61	51

Figure A19.7 shows that agricultural lands, unpaved roads and residential areas are the three biggest contributors of sediments (49%, 28% and 22%, respectively). Unpaved roads, while still large contributors, produce relatively less nutrients (13% of TN, 10% of TP), although these contributions are still much higher than could be expected based on the area of roads in the sub-catchment. Agricultural lands and residential areas produce the most nutrients of any land uses in the Lower Myall River sub-catchment (TN – 29% and 34%, TP – 39% and 31%, respectively). The contribution of residential areas is very large, given the relatively small area this land use covers in the sub-catchment (3%). Agricultural areas also produce more pollutants than would be expected based solely on the area this land covers in the catchment (29%), but the differences are less than is the case for residential land. Other lands uses, such as native vegetation and protected vegetation, also contribute some nutrients, although less than would be expected given the large role these land uses play in the sub-catchment. These land uses do not have problematic elevated pollutant loads unlike agricultural lands, unpaved roads and residential areas.

Appendix 20: WQIP scenario sescriptions for Myall Lakes

This appendix describes scenarios for the WQIP that developed and modelled using the DSS developed as part of the Great Lakes CCI. Rural scenarios were developed by iCAM, GLC and the CCI Rural Management Practices Technical Group. Urban scenarios were based on urban stormwater modelling undertaken as part of the CCI project by BMT WBM and discussions with key staff on engaging the urban community.

This plan presents water quality improvement actions required to achieve the 'feasible reduction in chlorophyll-a' over a seven-year time frame. Some of the actions identified in the plan cannot be completed during this time frame. For example, wetland protection and water-sensitive design of Greenfield sites will occur over a much longer period. For the purposes of benefit-cost analysis (Appendix 15), the costs and benefits of these programs were estimated over a 30-year period.

Most rural actions developed in this plan were designed as seven-year programs. Costs of maintaining these levels of change past Year 7 were estimated, but no option for ramping-up programs after Year 7 was considered. It is likely that additional benefits would have been achieved if the rural programs were increased between Year 8 and Year 30. However, in recognition of the inherent difficulties associated with making predictions about the implementation of actions in the first seven years, the Rural Management Practices Technical Group was not confident estimating what program actions would be implemented beyond the seven-year time frame. Two of the rural actions – unpaved road remediation and riparian remediation – were developed as 30-year ongoing programs. Urban management options were typically run over 30 years because they depend on redevelopment rates that are likely to occur over the coming decades. Protection and management actions were costed over 30 years as this time period is appropriate for the benefit-cost analysis presented in Appendix 15.

For summary purposes, the time frames that apply to the proposed remediation, protection and management support actions developed for this Plan are summarised in Table A20.1

Table A20.1. Myall Lakes – Proposed remediation, protection and management support actions for this Plan, and the time frame for their implementation.

Actions	Time frame for implementation
Remediation actions – modelled using the DSS	
Groundcover management	Seven years to implement and 30 years for maintenance of the program
Nutrient management (Fertiliser)	Seven years to implement and 30 years for maintenance of the program
Infrastructure (Dam) management	Seven years to implement and 30 years for maintenance of the program
Riparian remediation	Implement over 30 years
Unpaved road remediation	Implement over 30 years
Protection actions – not modelled with the DSS	
Wetland protection	Implement over 10 years
Riparian protection	Implement over 30 years
Water Sensitive Development of Greenfield sites	Implement over 30 years
Water Sensitive Urban Design protection	Implement over 30 years
Best management of unpaved roads	Implement over seven years
Improved pollution sontrol systems / management systems	Implement over seven years
Improved management of lake use activities	On-going
Management support actions – not modelled with the DSS	
Adaptive Management Strategy / Ecological monitoring program	Undertake over 30 years
Future investigation relating to the Farm Scale Action Plan	Undertake over 30 years

General cost assumptions

Table A20.2 summarises the general assumptions made in the costing of the WQIP and its component actions. These assumptions cover the range of workshop types as well as all of the general expenses that might occur in implementing the WQIP. It should be noted that:

- the time lag between holding the education programs and the changing of practice will depend on the program being run, and could range from months to years
- there is crossover between programs, particularly in relation to the Catchment Officer role (the Catchment Officer would need to be assessing the whole farm and all of the farm features at the same time). The proportion of the person's job that relate to the specific action is described in this appendix
- expanded dam, groundcover and nutrient management programs are assumed to be fully implemented by Year 7. Annual plan costs to Year 30 are assumed the same as Year 0 to Year 7 to reflect increasing turnover rates in rural areas, subdivisions of farm land to smaller rural residential properties, and increases in costs and the consequent need for programs to be ongoing to maintain levels
- the healthy lakes program (current program) for urban education and capacity-building covers the cost of general community awareness-raising in relation to stormwater management, so the additional costs of showcasing the WSUD devices is the only additional cost outlined here in relation to engaging with the general community

- MidCoast Water already has a rebate program for the rainwater tanks, so it is only the cost of the tanks, not the program costs that should be costed here
- Council staff member time should be costed at $108,465 / year (this includes on-costs) = $417.17 / day
- consultant costs are $1,120 per day
- additional costs for workshops include a cost for catering, at $250 per workshop
- advertising = $250
- bus for field trips = $600 / day
- WSUD remediation and protection should be costed per plan according to the proportion of urban area
- total costs for each program have been rounded to the nearest $5,000 to reflect the level of uncertainty in these estimates.

Table A20.2. Myall Lakes – Assumptions in costing the Water Quality Improvement Plan and its actions.

Description	Assumptions
Catchment Officer	• One full-time person would cost $80,000 per year to operate (including on-costs) • Each full-time person would have a mobile phone with a one-off cost of $450 plus $550 worth of line rental and calls per year • Each full-time person would need a car costing $18,200 per year (including petrol and hire) ($350 / week) **Total** to operate the person = $99,200 in the first year and $98,750 per year in the years that follow, given additional costs of mobile phone purchase in the first year
Technical Officer	As above **Total** to operate the person = $99,200 in the first year and $98,750 per year in the years that follow
Formal workshop	• 30 people attending at $15 / head catering = $450 • Hall or toilet hire of $100 • Materials $450 (photocopying $150, advertising $200, mail-out $100) • $3,000 per person per day (guest speaker) • Average of 1.5 persons per workshop = $4,500 for guest speaker **Total** to run a formal workshop = $5,500 / day
Basic field days	• Demonstration / Field day on a landholder's property similar to those run through the Sustainable Grazing program • **Total** to run basic field day = $500 / day • Morning tea $100 • Toilet or hall hire $100 • Materials / Consumables $300 This includes demonstration sites that could be returned to each year; the funding for the actions that are being demonstrated would come from the other actions (e.g. if it is a riparian management trial then the funding for that work would come from the riparian management section)

Dam refurbishment and removal

This scenario group is based on assumptions defined by the Rural Management Practices Technical Group, survey data collected as part of the Great Lakes CCI and literature. It examines:

- current dam management
- the expected impact of fully implemented **existing** programs for refurbishing or removing dams over a seven-year time frame
- the expected impact of fully implemented **expanded** programs for refurbishing or removing dams over a seven-year time frame.

The scenarios are applied to both improved and unimproved pasture lands.

Levels and effectiveness

Four levels of dam condition were defined by the Rural Management Practices Technical Group. The effectiveness of each level at trapping pollutants was estimated from data published by Erskine, Mahmoudzadeh & Myers (2002), Erskine, Mahmoudzadeh, Browning & Myers (2003) and Verstraeten, Prosser & Fogarty (2005). These three studies report on trapping efficiencies for dams near Sydney (Erskine *et al*. 2002, 2003) and Canberra (Verstraeten *et al*. 2005). The condition of the 29 dams and their small catchments (<1,000 ha) reported by the authors were used to assign a level based on the levels and descriptions defined by the Rural Management Practices Technical Group. The percentage effectiveness for each level was calculated from the average trapping efficiency of the dams studies by Erskine and Verstraeten assigned to each level.

Table A20.3. Myall Lakes – Effectiveness at trapping pollutants for each level of dam condition.

Level	Description	Effectiveness
1	• turbid water, algal blooms • little groundcover over and around dam • poorly functioning spillway • free stock access • headwall in danger of being breached • gullies entering dam eroded • high level of nutrients in catchment area • shallow sedimented dam • not effective in trapping sediments and nutrients	29%
2	• stock controlled by shifting stock around – can move anywhere • freeboard and spillway	55%
3	• stock access points • partially fenced	65%
4	• clear and clean water • stock excluded • spillway stable and appropriately managed • dam wall stable and appropriately managed • gravity-fed trough farm dam • catchment area well-grassed, minimal nutrient input contributed to dam • buffer zone intercepting flow • aquatic plants around fringes • no erosional headcut of dam • effective in trapping sediment	91%

Number of dams

Data collected by staff at the Department of Environment and Climate Change (DECC) was used to estimate the number of dams per hectare on pasture lands. The surveys did not specifically focus on dams, although there were questions related to the presence of dams on the property, the location of the dam spillway and extent of fencing around the dams. This information was mapped and provided to iCAM as geographical information systems (GIS) 'shape files'. Shape files of properties and dams were overlayed with land use maps to obtain estimates of dam numbers. A total of 126 dams were recorded across the 4,990 ha of management practice project areas that are classed as pasture, corresponding to a rate of one dam per 40 hectares. [32]

There is a total pasture area of 14,966 ha in the Myall Lakes catchment. A rate of one dam per 40 hectares gives 374 dams in total. It was estimated that 20 dams would be repaired or removed as part of this scenario in the Myall Lakes catchment.

Total effectiveness of dams

The proportion of dams corresponding to each level under each scenario was defined based on discussions with the Rural Management Practices Technical Group, and are shown in Table A20.4.

Table A20.4. Myall Lakes – Proportion of dams at each level of dam condition, by management scenario.

Level	Existing situation (%)	Existing programs (%)	Expanded programs (%)
1	40	34	20
2	49	48	35
3	10	15	35
4	1	3	10

These proportions were then multiplied by the effectiveness of each level to calculate a total effectiveness of dams for each scenario. GIS was used to estimate an average catchment area for dams on pasture land in the Myall Lakes. The catchment area of the dams was about 5% of the pasture land in the catchment. For this scenario, dams are assumed to affect 5% of the runoff from pasture lands. This estimated effectiveness of dams under each scenario is shown in Table A20.5.

32 This value was initially estimated as being one dam per hectare, based on an assumption of one dam per holding and an average holding size of 13 hectares. At a meeting with the Rural Management Practices Technical Group in March 2008, it was suggested that a higher number of dams would have been expected in the catchments and that the DECC survey should be used to estimate the number of dams. Despite fewer dams than originally assumed, these scenarios use the rate estimated from the DECC survey data. An estimate of the number of farm dams for pasture land in the Myall Lakes using aerial photographs supported the fewer dams suggested by the survey.

Table A20.5. Myall Lakes – Estimated effectiveness of dams for management scenarios.

Scenario	Effectiveness of dams	Additional capture (from base case) (%)
Existing situation	0.023	-
Existing programs	0.024	0.14
Expanded programs	0.028	0.55

Action-specific costs

Assumptions made to estimate the costs specific to the dam remediation or removal actions are summarised in Table A20.6. They include direct costs or remediation and / or removal, as well as program costs.

Table A20.6. Myall Lakes – Estimation of costs for remediation of dams.

Description	Assumptions
Direct costs	Based on the description of the levels, it was decided that the cost of the dam repair should only cover work to the spillway, fencing off the dam and putting in a single trough to replace the dam. The dam repairs should be costed at $3,000–$5,000 per dam (assumed value = $4,000 per dam). A total of 85 dams per year (see below) across both the Wallis and Myall catchments; 22.3% (roughly 20 dams) in the Myall ($79,417)
Program costs	*Existing situation* • Currently 1/6 of a Catchment Officer achieves 10 dams per year • One full-time person per catchment *Expanded programs (across both the Myall and Wallis catchments)* • 140 dams need to move from level 1 to 4, which means that 45% of the dams need substantial work • 268 dams (20%) need to move out of level 1 to 2, and this would not require very much work (one day per dam) = 268 days • 350 dams (25%) need to move from level 2 to 3; this group is assisted to move from this group through the grazing program • it was noted that one would need to spend the same amount of time to move people through each of the levels, and it was therefore decided to allow 2.5 days per dam for the Catchment Officer negotiations 638 dams x 2.5 days = 1,595 days. At 210 effective working days per year = 7.5 yrs = shifting 85 dams per year One full-time Catchment Officer for Wallis and Myall (excl. Crawford). Based on proportion of dams, Myall will have 0.233 x Catchment Officer per year, ($23,171 [Year 1], $23,066 per year [subsequent years]. The different costs between Year 1 and other years are outlined in the section on general cost assumptions)
	• Technical person required to design dams and off-stream watering • This would cover the repair or removal of dams *Expanded programs* • 11.7% of a year for a technical person for both catchments = $11,586 • One workshop for the Myall catchment per year ($5,500 per workshop)
Total expanded program	Year 1: $119,673 Annual (excl. Year 1): $119,515 per year Total over 30 years: $3,585,000

Scenario implementation

A trajectory of impacts over 30 years is used to demonstrate the benefits of implementing the Plan compared with the current condition (‘WQIP’), and the effects of development and redevelopment under current controls (‘No Plan’). The scenario combinations for the ‘No Plan’ and ‘WQIP’ scenarios are shown in Table A20.7.

Table A20.7. Myall Lakes – Scenarios for Plan implementation for dam refurbishment.

Component scenario	No Plan		WQIP	
	Seven years	30 years	Seven years	30 years
Dams	Existing programs	Existing programs	Expanded programs	Expanded programs

Nutrient management

This scenario group is based on assumptions defined by the Rural Management Practices Technical Group. It has been applied to improved pastures only. Several levels of management have been identified and the proportion of the improved pasture lands operating at these levels under each of the scenarios has been identified. A ‘score’ has been given to each level of management to indicate the level of nutrient available. These have been used to calculate the equivalent percentage change in fertiliser.

Table A20.8. Myall Lakes – Description of the levels of nutrient management scenarios.

Level	Description	Score [33]
1	Does not implement any current recommended practice (CRP). Features may include: • low perennial grass cover • poor nutrient management (e.g. fertiliser application prior to rain, no soil testing) • no buffer • higher stocking rate and continual stocking (i.e. no response to season or drought strategy)	10
2	Land is not managed to CRP. Features may include: • some nutrient management practices in place (occasional soil testing on some paddocks) • low to moderate perennial grass cover • continual stocking (i.e. no response to season or drought strategy)	7
3	Land is not managed to CRP. Features may include: • moderate perennial grass cover • some nutrient management practices in place (some soil testing on paddocks, dung beetles) • continual stocking (i.e. no response to season or drought strategy)	4
4	Land is managed to CRP, e.g. poultry litter guidelines. Features include: • high and persistent perennial grass cover • white clover in winter • best practice nutrient management (e.g. regular monitoring of nutrient levels through soil testing; fertiliser application in spring; dung beetles) • best practice riparian management (e.g. buffers ≥10m) • best practice stocking management (e.g. drought strategy implemented)	1

33 Used to estimate the percentage decrease in equivalent fertiliser use that is applied using the DSS.

The nutrient management / fertiliser scenario then considers different proportions of total improved pasture area to be operating under each of these levels, as shown in Table A20.9.

Table A20.9. Myall Lakes – Proportion of total improved pasture area at each level of nutrient management, by management scenario.

Level	Existing situation (%)	Existing programs (%)	Expanded programs (%)
1	20	20	15
2	40	30	20
3	30	35	35
4	10	15	30

Using these proportions and the scores for each level gave a final weight scores, from which a percentage change in 'fertiliser' level was calculated to give the fertiliser multiplier. This multiplier was applied to improved pastures only.

Table A20.10. Myall Lakes – Scores and fertiliser multipliers, by nutrient management scenario.

Scenario	Score	Fertiliser multiplier
Existing situation	6.10	1.00
Existing programs	5.65	0.93
Expanded programs	4.60	0.75

Action-specific costs

Assumptions made to estimate the costs specific to the nutrient management actions are summarised in Table A20.11.

Table A20.11. Myall Lakes – Assumptions in costing the nutrient management actions.

Description	Assumptions
Program costs	This program would involve a person in a Catchment Officer role promoting and providing advice to people about fertiliser management. This would include the expansion of the dung beetle program, as it may replace the need to use fertiliser. The Catchment Officer would also need to have the technical skills to interpret soil tests so the person would cover all aspects of this program. One person to cover all three catchments with 1/3 effort in each of Myall Lakes, Wallis Lake and Crawford River. This reflects the fact that the biggest proportion of use of fertiliser is in the Myall Lakes and Crawford River, and the catchments are smaller so therefore they will get proportionally more effort per area ($33,067 [Year 1], $32,917 per year [subsequent years]).
	Need to run two LANDSCAN™ courses per year over all catchments. This would involve 40 people. Over the period of seven years this would involve 280 people (note that LANDSCAN™ is one of the key requirements to move landholders into level 4). Cost of a LANDSCAN™ course is $580 per farmer. Assuming 10 per group, $23,200 x two per year = $46,400 across all catchments (Wallis = $15,467)

Description	Assumptions
Direct costs	Costs of providing basic soil tests in the first three years = $70 per sample (phosphate, nitrogen). Assuming that the number of dams is close to representing the number of places you will want to do a soil test (this is a big assumption and is probably not correct): to move 20% of people to level 2 (occasional soil test some paddocks) = 289 people x $70 = $20,230 to move 35% of the people to level 3 (occasional soil test number of paddocks) = 525 people x two soil tests x $70 = $73,000 to move 30% of people to level 4 (regular soil tests) = 450 x three soil tests x $70 = $94,500 *Costs split over seven years* Cost for Wallis = ($20,230 + $73,000 + $94,500) / 7 / 3 = $8,940 Note that dung beetles have not been costed as part of this program but are included in groundcover management, even though they are part of the recommendations for nutrient management.
Total expanded program	Year 1: $57,473 Annual (excl. Year 1): $57,323 per year Total over 30 years: $1,720,000

Scenario implementation

A trajectory of impacts over 30 years is used to demonstrate the benefits of implementing the Plan compared with the current condition ('WQIP'), and the effects of development and redevelopment under current controls ('No Plan'). The scenario combinations for the 'No Plan' and 'WQIP' scenarios are shown in Table A20.12.

Table A20.12. Myall Lakes – Scenarios for Plan implementation for nutrient management.

Component scenario	No Plan		WQIP	
	Seven years	30 years	Seven years	30 years
Nutrient management	Existing programs	Existing programs	Expanded programs	Expanded programs

Groundcover

This scenario group is based on assumptions defined by the Rural Management Practices Technical Group. It was applied to all pasture (grazing) areas on both low slope and high slope areas. This scenario consists of an assumed proportion of the grazing lands with different levels of groundcover. Groundcover levels are given in Table A20.13.

Table A20.13. Myall Lakes – Description of the levels of groundcover condition scenarios.

Level	Description	Groundcover
1	• overstocked all of the time • preferential grazing • only grass cover • bare / scalded / erosion • noxious weeds, pests • no feral animal control • poorly designed access • regular burning • non-strategic water supply (isolated) • no dung beetles • cultivation • no drought management plan	<60%
2	• overstocked in adverse conditions • periodic burning (up to every five years)	60–80%
3	• stocking rate to maintain 80–90% cover • drought management plan	80–90%
4	• non-cultivated • maintain groundcover • maintain native vegetation (shrubs, grasses, trees) • land use matches capability – stock exclusion • build well-designed access tracks • rehabilitate erosion sites • prevent tracks and fences downslope • hazard reduction burning only • care with management of dispersible soils • match stock to feed • allow paddock resting • provide multiple stock watering points for even grazing • control weeds and pests • dung beetles, monitoring • drought management plan • stock exclusion during rainfall periods	>90%

The groundcover scenarios consider different proportions of the grazing lands to be under these different management levels as shown in Table A20.14.

Table A20.14. Myall Lakes – Proportion of groundcover area at each level of groundcover management, by management scenario.

Level	Existing situation (base case) (%)	Existing programs (%)	Expanded programs (%)
1	10	10	10
2	82	78	65
3	5	9	17
4	3	3	8

Note that existing programs and expanded programs both refer to the impact of programs over a seven-year time frame.

These values were then used to calculate an effective groundcover level for each of these scenarios. These proportions were used to weight values for each of the groundcover levels: level 1 is 50%, level 2 is 70%, level 3 is 85% and level 4 is 95%. The effective groundcover levels calculated across all steep pasture lands for each of the scenarios is:

- existing situation is 69.5%

- existing programs is 70.1%
- expanded programs is 72.55%.

The AnnAGNPS model has been used to estimate the effect of changes in groundcover on pollutant loads. The results from this model imply that a shift from current groundcover level (equivalent to 69.5% groundcover) to 100% groundcover on steep sloping pasture lands would have the effect of decreasing pollutant loads generated from these lands by:

- 90% for TN
- 94% for TP
- 95% for TSS.

Note this is the median value by sub-catchment in the Myall Lakes catchment – there are some small differences by sub-catchment but the method is the same.

The effect of existing programs and expanded programs were then estimated proportionally using these decreases and the calculated effective groundcover. The multiplier on load implied by these changes was used as the basis of the interpolation (Figure A20.1). Note actual values for each sub-catchment were used directly within the DSS. These values are just used for illustrative purposes.

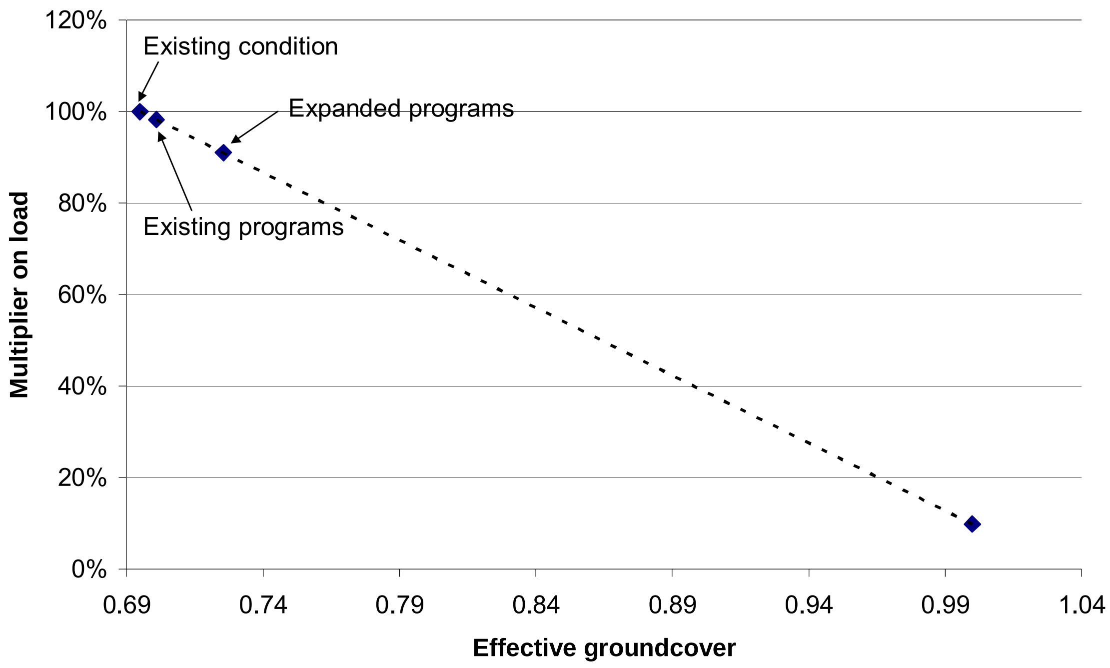


Figure A20.1. Interpolated effect of management programs for groundcover.

These were then applied in the model using the input settings allowed. Note the DSS allows for five groundcover levels to be applied to proportions of the catchment. Current groundcover corresponds to level 3. This meant that an equivalent proportion of area set to level 4 was calculated and run as the scenario to capture the effect of these changes in groundcover.

Action-specific costs

Assumptions made to estimate the costs specific to the groundcover actions are summarisedin Table A20.15.

Table A20.15. Myall Lakes – Estimation of costs for groundcover management.

Description	Assumptions
Program costs	Note: There was a sustainable grazing officer that worked across the Wallis and Myall catchments. This position no longer exists as from June 2008. This means that the impact of existing programs will not be as great as predicted in the scenarios. It will also mean that it will be more work to get expanded programs up and running due to the loss of momentum. *Expanded programs* • with a break between sustainable grazing officer appointment (e.g. 1 year) • 1 Catchment Officer ($99,200 [Year 1], $98,750 per year [subsequent years])
	Expanded programs • one group in the Myall with 10 workshops / field days a year costing around $500 per workshop ($5,000) • one formal workshop per year across the Myall = $5,500 • one Prograze course across all catchments 15 properties attending per course @ $580 per farmer costs $26,000. Cost for Myall catchment = $13,000
Direct costs	Dung beetles – one colony per year covers 200 ha and costs between $450 and $750 depending on the species. In the Myall this equates to 3.4 colonies. Assuming a cost per colony of $600 = $2,200 It was also noted that in level 4 that we need to provide for multiple stock watering points to assist with even grazing. It was estimated that providing stock water would be approximately $2,500 per 40 ha. This would include solar pumps, gravity-fed systems and some internal fencing. In the Myall, this equates to 68 stock watering points. Assuming a cost per watering point of $2,500 = $ 24,268
Total expanded program	Year 1: $149,368 Annual (excl. Year 1): $148,918 per year Total over 30 years: $4,470,000

Scenario implementation

A trajectory of impacts over 30 years is used to demonstrate the benefits of implementing the Plan compared with the current condition (‘WQIP’), and the effects of development and redevelopment under current controls (‘No Plan’). The scenario combinations for the ‘No Plan’ and ‘WQIP’ scenarios are shown in Table A20.16.

Table A20.16. Myall Lakes – Scenarios for Plan implementation for groundcover management.

Component scenario	No Plan		WQIP	
	Seven years	30 years	Seven years	30 years
Groundcover	Existing programs	Existing programs	Expanded programs	Expanded programs

Unsealed road remediation

Costs associated with upgrading an existing rural road (unsealed) to a consolidated and sealed surface with associated drainage / sediment controls were explored for three different unsealed road upgrades carried out by GLC. These projects provide broad examples of the locations and geology likely to be encountered within the Great Lakes local government area, and provide examples of the difficulties associated and the consequent range of costs involved (see Table A14.6 in Appendix 14).

In all situations, preparatory works are required to bring an existing unsealed road and its substrate up to a standard capable of providing an appropriate carriageway surface for sealing.

Such works can include:

- realignment or widening of the existing road
- adding or augmenting drainage systems to the existing roadway
- excavation of the road footprint, followed by stabilisation and reconsolidation of the roadway structure to suit anticipated traffic loads
- extensive rock excavation and removal (including the use of explosives)
- elevation of the new road surface (via the importation and compaction of suitable gravels)
- implementation of sediment and erosion control structures
- clearing of near-roadside vegetation for rehabilitation, safe clear distances and establishment of table drains.

Given the extreme variability in the requirements of any given road project – and the additional complications of site location, availability of suitable plant and equipment, geological substrates and the availability of appropriate construction materials – each project is unique and, accordingly, is usually costed on an individual basis.

Once a road substrate and surface has been improved to a suitable standard, costing further improvements becomes simplified:

To provide sealing coat to a prepared rural road surface:
crushed gravel layer (emulsifier-coated) with bitumen spay sealer coat = \$7.50 per m^2

In order to account for the variability in the costs for road rehabilitation works, the cost of the unpaved road scenarios were based on the rounded average of the three examples provided below (\$600 / m^2).

The models assumed that the upgrade of the roads would result in an 80% reduction of loads off the improved areas.

For the Myall Lakes, the approximate cost of other rehabilitation programs were used to determine the amount of road rehabilitation that would be run through the DSS. This resulted in 4.2 km of roadwork over 30 years (980 m over seven years). While the models could not determine where exactly the rehabilitation would take place it was assumed that high-risk areas – such as approaches to creek crossings and at creek crossings – would be sealed as a priority. Road remediation activities were focussed in the Crawford River sub-catchment.

Unsealed road protection

Unsealed road protection assumes that the cost of best practice sediment and erosion control features, such as mitre drains, are included in the maintenance costs of road grading (and are therefore not costed in this Plan). The costs that are identified in the Plan cover identifying the priority areas for rehabilitation and building the capacity of staff undertaking the road grading to reduce sediment losses to the waterways. The costs of these actions are outlined in Section 3.3.3 of the WQIP and the costs have been attributed to each lake (Wallis, Smiths and Myall) according to the proportional size of their catchments.

Riparian remediation

This scenario examines the impacts of remediating identified sites of high stream bank erosion. These sites are assumed to laterally erode 1 cm per year over a height of 1.5 m with 1.5 tonnes per m^3, giving an average load of 0.0225 tonnes per year per metre of stream bank. Sites were based on GIS data layers provided by the Great Lakes Council.

The costs of in-river repair works will vary with the length of the eroding site. Small sites are assumed to require 50 m of fencing and physical structures that cost $1,000. Large sites are assumed to require 300 m of fencing and physical structures that cost $10,000. The number of sites and costs for repairing active stream bank erosion sites in the Myall are shown in Table A20.17.

Table A20.17. Myall Lakes – Extent and costs of repairing stream bank erosion.

Sub-catchment	Length of riparian (km)	Erodible (%)	# of sites	Average length of site	Cost of site ($)	Total cost
Myall	98	0.0000	0	-	1,900	0
Boolambayte	80	0.0000	0	-	1,900	0
Upper Myall River	520	0.0196	51	2	1,900	96,900
Crawford River	162	0.0012	1	2	1,900	1,900
Bombah Broadwater	114	0.0000	0	-	1,900	0
Lower Myall River	28	0.0000	0	-	1,900	0
Total		**0.0208**			**11,400**	**98,800**

In the Myall Lakes catchment, all fencing can be completed in seven years at an annual cost of $14,114. From Years 8 to Year 30, costs will be incurred to maintain the works. With no information available, the annual cost for this period is assumed to be $14,114. Site costs for remediation are **$423,429**.

Costs for staff time in remediating these sites were also accounted for. It was assumed that a large site would require four days each of the Catchment Officer's and Technical Officer's time, and that a smaller site would require four days of the Catchment Officer but only two days of the Technical Officer. This means that staff time would cost approximately $705,000 for the sites planned to be remediated in the Myall Lakes catchment.

The total cost of riparian remediation including site costs and staff costs is $1,130,000 over 30 years.

Wetland protection

Wetland protection involves acquisition of 645 ha of healthy but threatened wetlands. These wetlands would be acquired over a period of 10 years at a total cost of $3,605 per ha (including 3% loading for possible remediation works). There is also assumed to be 5.6 ha of fencing required at a cost of $11,000 per km. Program costs are for 0.2 of a Catchment Officer to manage the wetland acquisition program in the catchment. Total costs of wetland protection in the Myall Lakes are **$2,585,000**. When scoped over a seven-year period, approximately 450 ha of wetland would be protected at a cost of $**9,943,000**.

Details of a wetland protection strategy are described in Table A20.18.

Table A20.18. [DG82] **Wetland protection strategy. Wallis and Myall lakes.**

Program	Actions	Responsible authority	Cost
Future investigation	Identify the location and condition of wetlands, and priorities for conservation and rehabilitation ~	Contractor	30,000
	Prepare management plans for wetlands (including restoration, conservation and land use management) ~	Contractor, GLC	30,000
Future extension	Encourage community participation in the management and restoration of wetlands ~	GLC, CMA	
	Raise the profile of wetlands and their role in providing environmental services through tours, field days and educational material suitable to the general community ~	GLC, CMA	
Future on-ground	Reinstate natural wetland hydrology, particularly in acid sulfate landscapes ~	State, local and federal government	
	Zone coastal wetlands to an environmental protection zone based on future investigation findings (priority areas likely to be Wallingat River wetlands, Minimbah Creek and wetlands, Wallamba River wetlands, Shallow Bay wetlands) ~	State and local government	
	Develop partnerships with state and federal agencies to secure the buyback of conservation priority wetlands ~	State, local and federal government	

~ Input from Rural Management Practices Technical Group.

Riparian protection

Riparian protection involves protection of 220 km of remnant riparian vegetation (and some revegetation as required) in agricultural areas. It is assumed that only 50% of these streams will be suitable for fencing. Where fencing is used, the costs of providing fencing and off-stream water are $18,000 per km. Where fencing is not appropriate, riparian areas will be protected using Property Vegetation Plans. These are estimated to cost $700 per ha. Riparian areas are assumed to be 20 m wide on either side of the river (i.e. 40 m in total) so a total of 440 ha of Property Vegetation Plans were estimated as being required. It was assumed that 0.5 of a Catchment Officer per year would be required to implement the program.

The total cost of the riparian protection program is **$3,775,000** over 30 years.

Greenfield developments

Greenfield developments involve implementation of a 'no net increase' policy for new development areas. This means that developments must achieve 'existing' pollutant loads (either agricultural or forest area, depending on what the development replaces). The cost of acquisition of controls for this scenario has been estimated at $1,520,000 with annual maintenance costs estimated at $59,400. These costs have been distributed over years using an expected trajectory of Greenfield developments for the Myall as shown in Table A20.19.

Table A20.19. Urban development of Greenfield sites for the Myall Lakes catchment.

Area on map	16
Area	Bulahdelah residential
Starting point (baseline for no net increase)	
Certainty of development	Medium
MUSIC modelling complete	no
Doc ref.	n/a
Estimated area of land to be developed	30
Predicted development type / % of each	100% Low Residential
Certainty of predicted	Medium
Predicted dwelling yield	300
Estimated timing for first release	5-Oct
Estimated years for % of development	1–10 5%

The total cost of the controls on Greenfield developments is **$3,005,000** over 30 years.

Management of urban land including protection and remediation (water sensitive development of Greenfield sites, water sensitive urban design protection[pt83])

These scenarios are based on modelling undertaken by Tony Weber (BMT WBM) using MUSIC – an urban stormwater model – for Wallis Lake. The modelling involved:

- nutrient and sediment export from existing land use area
- nutrient and sediment export from future land use area
- implementation of Water Sensitive Urban Design (WSUD) devices

- redevelopment of 27% of existing urban land in selected sub-catchments
- 15% adoption of rainwater tanks in selected sub-catchments.

Greenfield developments

The future release areas (Greenfield sites) are non-urban lands, such as agriculture or native vegetation cover, which have been identified as sites for future urban development. The Great Lakes Council policy of 'no net increase' of pollutants for Greenfield sites means that future development of the land must not exceed the current level of nutrient and sediment export. Generation rates for Greenfield sites were obtained from AnnAGNPS model results.

Costs for Greenfield sites were split into those for previously agricultural and forest lands. Approximately 20% of areas were assumed to be prior forest and 80% to be agricultural lands based on advice from Council. This gave a total acquisition cost of $1,520,000 and an annual maintenance cost of $59,400. These costs have been distributed over up to 10 years using an expected trajectory of Greenfield developments for the Myall Lakes catchment (Table A20.19).

In addition, program costs were also accounted for as one-sixth of the cost of the 'general awareness WSUD' noted in the section on WSUD protection below. Finally, costs for developing heads of consideration for voluntary planning agreements (Section 3.4.2 of the WQIP) were also accounted as: one week of staff time, $5,000 for a consultant (Year 1); proportional costs according to the areas of release areas within each catchment.

The total cost of the Greenfield option is $3,005,000 over 30 years.

WSUD protection

The program outlined in this section is to be applied across the Wallis, Smiths and Myall lakes. The costs of these programs have been included in the management action 'WSUD protection' and have been established for each lake proportionate to the size of the urban area.

This program contains several components that have been costed separately:

- include water quality management clause in LEP (Section 3.4.2 of the WQIP) – three weeks staff time (Year 1), $5,000 for additional consultant costs, proportional to urban area
- review Rural Living Strategy (Section 3.4.2 of the WQIP) – six weeks staff time, $15,000 for consultant assistance (Year 2), distribute costs across per area of catchment
- build WSUD into road standards (Section 3.4.2 of the WQIP) – six weeks staff time, $20,000 for consultant assistance (Year 2), distribute costs according to size of urban areas per catchment

- resource erosion and sediment control (Section 3.4.2 of the WQIP) – eight weeks staff time to explore options for regional or sub-regional programs, $8,000 to develop programs (Years 2–5), spread costs evenly over the time and distribute costs proportional to urban area
- sediment erosion control internal audits (Council staff) (Section 3.4.2 of the WQIP)
  - two workshops every two years (start in Year 2)
  - workshop costs
  - consultant – $5,000 to design the audit program in Year 2
  - internal audits every year (staff costs for two months; this also covers the cost of preparing for the workshops)
  - audits every year – costs proportional to the size of the urban area
- urban stormwater management community education (Section 3.4.2 of the WQIP). Details are outlined below.
- sediment erosion control capacity-building (builders, contractors) (Section 3.4.2 of the WQIP)
  - two workshops every two years
  - two weeks to prepare and coordinate (staff member)
  - consultant – five days
  - workshop costs
- general awareness of WSUD (businesses, consultants, builders, real estate, Council staff) (Section 3.4.2 of the WQIP)
  - two workshops every two years for the first five years, then one workshop every two years after that (starting in Year 2); one advertisement per year for the first five years
  - two weeks to prepare and coordinate (staff member)
  - consultant – five days
  - workshop costs
  - Year 2 to Year 7 – bus required for field trip ($600 per day per workshop)
- general awareness of WSUD – general community (Section 3.4.2 of the WQIP)
  - demonstration WSUD sites field day with community
  - one every two years from Year 2 to Year 7, then one every four years after that
  - include workshop costs + bus costs + advertising
- water quality education program
- three ‘stormwater scampers’ with primary schools in the first year and then one every year after that. Each stormwater scamper would cost **$5,539** to run and include: 60 stormwater scamper booklets ($1,883), 10 stormwater scamper reports @ $28.47 each ($284), Stormwater Scamper calico bags x 60 ($212), coach hire ($400), staff contribution (four @ $45 per hour) = 60 hours ($2,700), 40 laminated certificates ($60)

- one Seagrass Education Workshop per year, which would cost $1,620 based on two staff members working 36 hours in total (@ $45 per hour)
- integrating the WQIP findings into the school curriculum is a one-off project to be developed in Year 1. This would involve 14 weeks staff time to integrate locally relevant examples of water quality issues and solutions, as well as lake ecology, into subjects such as Geography, Marine and Aquaculture Technology, and Environmental Science in Year 1 ($34,149).

The total cost of WSUD protection programs is $1,000,000 over 30 years. Given the urban area in the Myall Lakes catchment, this represents $125,000 over 30 years

Improved pollution control systems / management systems

Recommendations are summarised from Section 3.7 of the WQIP.

- Undertake an internal audit of compliance with conditions of consent – four weeks staff time undertaking audit, four weeks staff time developing the management systems to support compliance with conditions of consent (total of two months in Year 1).
- Review the need for a pool of pollution control experts – 1.5 weeks for Council staff, four weeks for a state government staff member (Year 2).
- Review fee structure of On-site Sewage Management Strategy – 1.5 weeks Council staff (Year 1).
- Report on On-site Sewage Management Strategy – 1 month staff time, $25,000 to develop GIS-based data base for reporting (Year 2).
- Revise On-site Sewage Management Strategy – 1.5 weeks staff time (Year 2).
- Explore the possibility of increasing cross-delegations for compliance with conditions of consent and pollution control regulations – six weeks staff time (Year 2).
- Investigate alternative models for formalising responses to complex pollution cases – 1.5 weeks Council staff time and six weeks state government staff time (Year 2).
- Initiate options for strengthening cross-agency networks – 1.5 weeks staff time (Year 1).

The total cost of programs to improve pollution control systems in Myall Lakes is $35,000.

Ecological monitoring program

The ecological monitoring program is to be undertaken every year unless otherwise stated.

Table A20.20. Myall Lakes – Costs of implementing ecological monitoring program.

Monitoring program	Estimated frequency	Itemised expense (per sampling time)	Estimated cost per occasion	Estimate cost per annum
Monitoring of runoff from high-risk areas	Event monitoring, and hence frequency, depends on rainfall	24 water samples, analysed for nutrients and TSS	24 x $150 Approximately seven events a year	$25,200
		Officer time: Four hours per high-risk area. Assume five high-risk areas	Four x hourly cost of a field officer x five sites = 20 hours = 2.8 days x seven events a year = 20 days a year @ $300 / day	$6,000
		Equipment hire (car, autosamplers, water level sensors)	$150 / day; $30,000 per annum each	
		Data analysis and reporting	One week @ $370 / day	$1,850
Total				$33,050
Best management practice assessments / monitoring at six sites	Three-yearly	Fish sampling?	$3,000 per site x six sites	$18,000 ÷ three years = $6,000
	Three-yearly	Officer time: Riparian and in-stream habitat assessments	Two x one day = $600	$600 ÷ three years = $200
	Three-yearly	Vehicle costs: Riparian and in-stream habitat assessments	Four days @ $150 / day	$600 ÷ three years = $200
		Data analysis and reporting	One week @ $370 / day	$1,850 ÷ three years = $616
Subtotal				***$7,016***
Estuary condition targets				
Chlorophyll and turbidity	Six-weekly = nine samples per year, plus three event samples	Two staff for two days (includes water quality meter calibration)	$1,200	$14,400
		Boat and vehicle use		
		Chlorophyll analyses (24 samples @ $30 each)	$720	$8,640
Seagrass / macrophytes	Quarterly	Community sampling	Use the same costs as the sponge monitoring Four times a year	Add the community monitoring costs

The total cost of the ecological monitoring program for Myall Lakes is $445,000 over 30 years.

Future investigation relating to the Farm Scale Action Plan (Section 3.3.2 of the WQIP)

The majority of the costs identified in the Farm Scale Action Plan have been costed in the program costs (i.e. the cost of a catchment management practitioner's time to implement the actions identified – Sections 2.7, 2.11 and 2.15 of the WQIP). There are some cases where the Rural Management Practice Technical Group identified the need for additional specialised assistance such as researchers or other experts to assist with implementing the programs. These additional costs are summarised below. Details are outlined in Table 3.3.2 of the WQIP.

- Encouraging landholder uptake of improved management practices
  - future investigation – $60,000 (Year 1), $3,000 (Year 2), $7,000 (Year 3[DG84])
  - future extension - $10,000 (Year 2 to Year 3)
- Riparian management
  - future investigation – $32,000 (Year 2 to Year 4), $60,000 (Year 6 to Year 8)
- Wetland management
  - future investigation – 40,000 (Year 3 to Year 5), $20,000 (Year 2 to Year 4), $2,000 (Year 3)
- Groundcover management
  - future investigation – $5,000 (Year 1), $20,000 (Year 3 to Year 4), $5,000 (Year 2), $10,000 (Year 2 to Year 3)
- Farm infrastructure management
  - future extension – $20,000 (Year 2- to Year 3), $15,000 (Year 2) then $10,000 every year after that
- Nutrient management
  - future investigation – $25,000 (Year 2), $15,000 (Year 2), $10,000 (Year 2), $65,000 (Year 5 to Year 7).

The total cost of future investigation and extension actions to support the farm action plan for Myall Lakes is $445,000 over 30 years.

Adaptive Management Strategy

The costs of this program are four weeks of staff time each year to do reporting and collating spread across all lakes. The Myall Lakes contribution to this cost is $100,000 over 30 years.

Appendix 21: Drinking Water Strategy for the Crawford River

The Crawford River Drinking Water Strategy focuses on actions to improve water quality at the outlet of the Crawford River sub-catchment. This area provides drinking water for local urban populations. The decision support system (DSS) was used to consider the impacts of potential remediation actions focussed on the Crawford River catchment. No protection actions are considered in this part of the Plan, so no estimate was made of potential deterioration in condition under the 'do nothing' situation. This strategy is not included as part of the Water Quality Improvement Plan, as the viability of such a strategy has not been tested and feasibilty will need to be considered through further discussion with stakeholders.

1.[DG85] Exploratory analysis of potential remediation actions in the Crawford River catchment

An additional set of management actions targeted at protection and remediation are recommended to protect the special values associated with the Crawford River sub-catchment. These actions expand on recommended programs for the Myall Lakes and also include development of a riparian reserve.

1.1 Description of scenarios tested

Table A21.1 outlines the actions considered for the Crawford Drinking Water Strategy.

Table A21.1. Remediation actions considered for the Crawford River catchment.

Program	Program description	Time frame for implementation
Groundcover management	Groundcover management refers to a sustainable grazing program for landholders focussed on improving groundcover management on pasture lands. It involves field days and formal workshops with experts, developing information and training material on stocking rates, formal training courses such as Prograze, a dung beetle release program and a program of on-ground works that will assist landholders to better manage their groundcover levels (including off-stream watering, solar pumps and fencing).	Seven years to implement and 30 years for maintenance of the program
Nutrient management (Fertiliser)	Nutrient management is a component of a sustainable grazing program focussed on the appropriate application and storage of nutrients. It involves working with landholders to trial different types of fertilisers, formal training courses such as LANDSCAN, subsidising and promoting the use of soil tests, and providing assistance with interpretation of the tests so that the results can be integrated into the whole farm plan. This program also supports a dung beetle program – however, it is costed in the groundcover management program.	Seven years to implement and 30 years for maintenance of the program

Program	Program description	Time frame for implementation
Infrastructure (Dam) management	Infrastructure management includes the refurbishment of dams that are a water quality risk as well as decommissioning those that are not functioning, and potentially acting as a source of nutrients and sediments to the system. It involves working with landholders to undertake repairs of the dam spillway, fencing off the dam and providing a trough for stock watering. It also involves landholder training, as well as training and accreditation of contractors. Additional actions related to the management of infrastructure have also been identified including road and laneway management. However, these kinds of actions were not able to be modelled.	Seven years to implement and maintenance of the program over 30 years
Riparian reserve	The riparian reserve program involves buying back and rehabilitating properties along the Crawford River, including riparian fencing and rehabilitating the riparian areas as required. The exact mechanism for establishing a riparian reserve has not been outlined here. However, if a riparian reserve was considered feasible, further discussions would need to be undertaken with stakeholders.	Implement over 30 years

1.2 Catchment exports

The percentage change in TN, TP and TSS loads for the Crawford River sub-catchment with implementation of the Crawford Drinking Water Strategy is shown in Figure A21.1. Full implementation of the Crawford River Drinking Water Strategy reduces exports from the Crawford sub-catchment by 9.1% (TN), 17.5% (TSS) and 22.3% (TSS) by Year 30. Note that for drinking water, TSS is an important indicator of potential heavy metal concentrations, so reductions in TSS are very important for drinking water quality. Heavy metals are largely transported into waterways attached to the surface of soil particles.

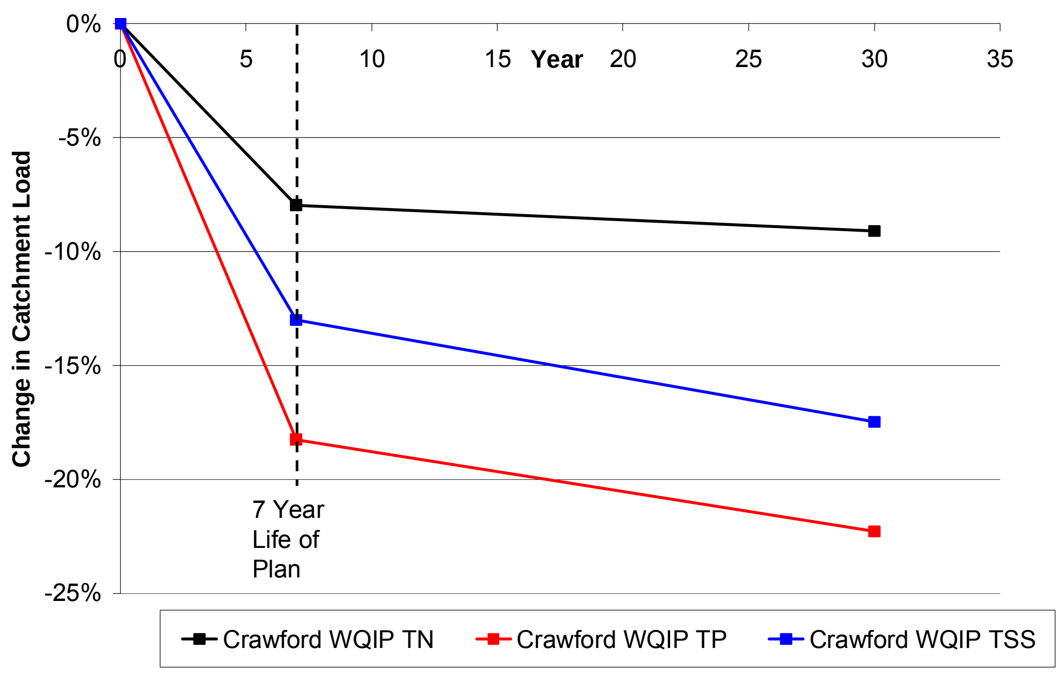


Figure A21.1. Crawford River – Percentage change in catchment exports of TN, TP and TSS with (WQIP) implementation of the Water Quality Improvement Plan.

Figure A21.2 demonstrates the relative effectiveness of the Crawford Drinking Water Strategy component actions on pollutant exports for the sub-catchment. Groundcover management and the riparian reserve account for over 75% of the TN and TP load reductions, and 97% of the TSS load reductions. Nutrient management has a large impact on TN exports while dam remediation or removal activities have little influence on exports at a catchment scale. Again, this does not account for the protective effects of dam removal in reducing the risks of dam failure.

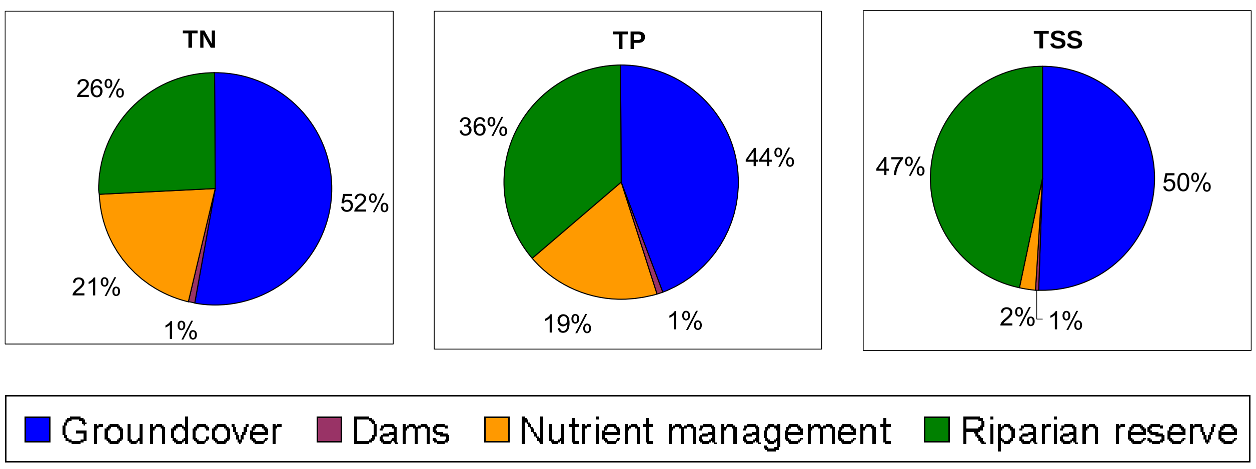


Figure A21.2. Crawford River – Relative impact of component remediation actions for the whole catchment.

1.3 Estuary condition

The percentage reduction in chlorophyll-a concentrations in the Myall Lakes is shown in Figure A21.3.

Reductions in chlorophyll-a concentrations of 2.3% are achieved in the Bombah Broadwater with full implementation of the strategy. Smaller reductions are achieved for the Boolambayte (1.8%) and Myall (0.8%) lakes. The changes for the Bombah Broadwater and Boolambayte Lake are of a similar magnitude to those modelled in Section 2.15 of the WQIP for the overall Myall Lakes plan, although the benefits are smaller for Myall Lake.

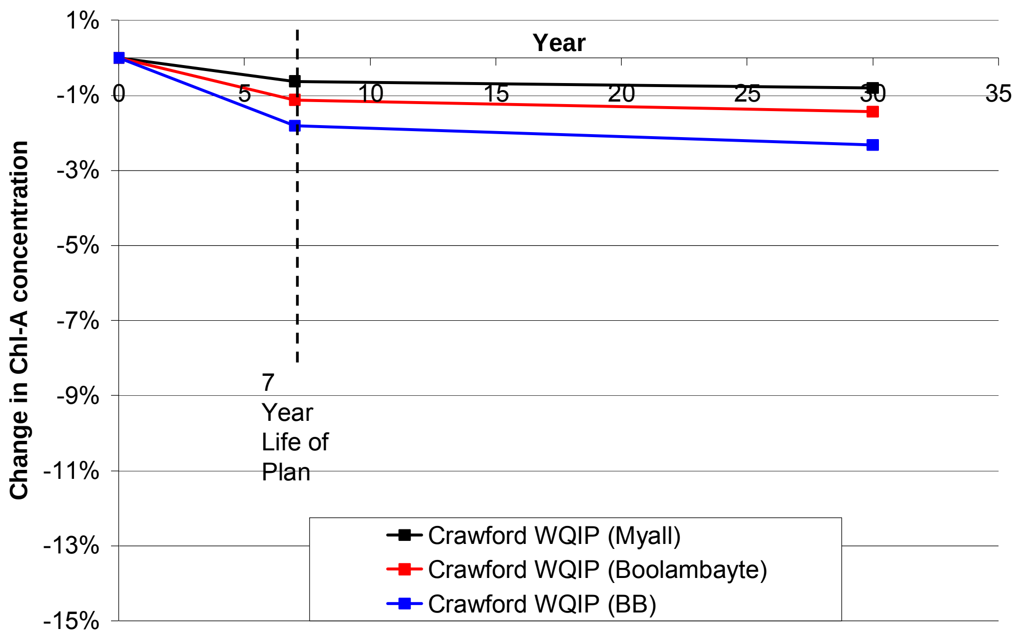


Figure A21.3. Percentage change in chlorophyll-a achieved in the Myall Lakes due to the potential Crawford River Drinking Water plan actions.

Table A21.2. [DG86]**Chlorophyll-a levels resulting from expanding programs according to the Crawford Drinking Water Strategy.**

	Year 7		Year 30	
	Existing	Expanded	Existing	Expanded
Myall Lake	2.3	-0.6	9.5	-0.8
Boolambayte Lake	1.6	-1.1	6.8	-1.4
Bombah Broadwater	1.1	-1.8	5.0	-2.3

1.4 Costs of actions

The cumulative costs of implementing and maintaining the component actions of the strategy over the 30-year trajectory are shown in Figure A21.4. Details of the assumptions used to define these figures are provided in Appendix 20. The riparian reserve and groundcover actions are the most expensive to implement and maintain. Dam remediation or removal is the cheapest option.

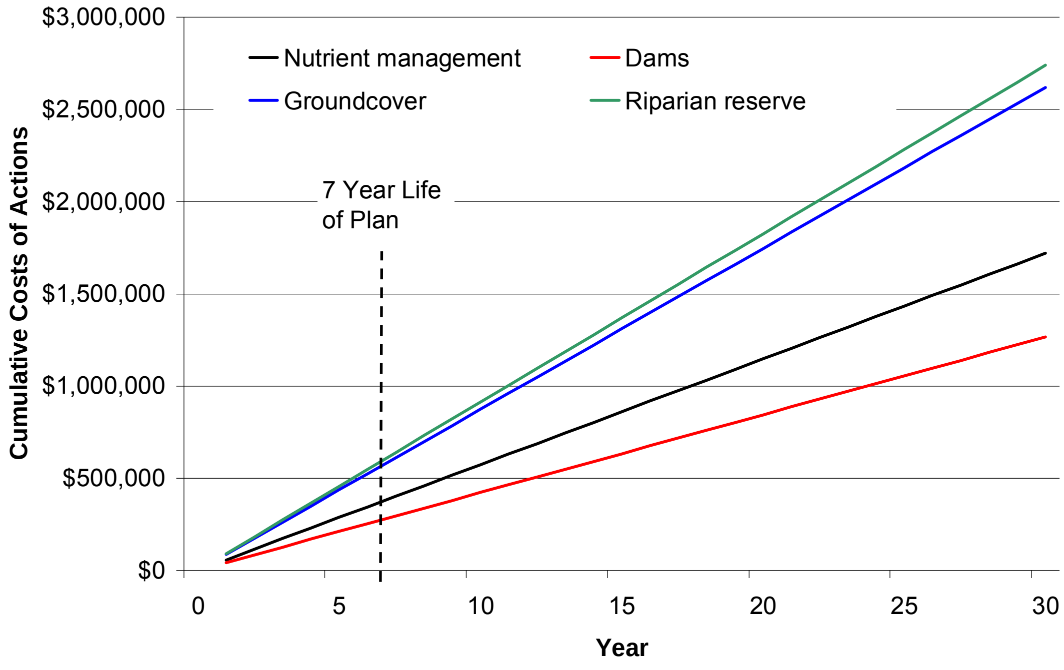


Figure A21.4. Cumulative costs of potential Crawford WQIP actions.

However, the cost per unit of load controlled by each action (Table A21.3) illustrates that groundcover and riparian reserve programs are a cost-effective means of reducing pollutant loads from the Crawford River sub-catchment. In addition, creating a riparian reserve is likely to have many in-stream benefits that have not been accounted for here (these are accounted for in the benefit-cost analysis in Appendix 15). Dams are the least cost-effective, as they have a large cost to implement and maintain, and show very little impact on exports at the catchment scale or in the estuary.

Table A21.3. Cost ($) per unit of load controlled by rural actions applied across the Crawford River catchment. A unit is 1 kg for TN and TP and 1 tonne for TSS.

	Groundcover	Riparian	Nutrient	Dams
TN	$2,666	$8,684	$10,350	$143,834
TP	$10,571	$20,434	$38,185	$550,321
TSS	$27,526	$47,520		$1,665,444

2. Summary of recommended programs for protection and remediation of the Crawford Drinking Water catchment

A summary of the recommended programs for the Crawford River is given in Table A21.4.

Table A21.4. Summary of recommended protection and remediation management actions in the Crawford River sub-catchment.

Program	Resources	Program descripton
Groundcover management	2/3 of Catchment Officer Group workshop Formal workshop Dung beetle release Provision of off-stream water	Groundcover management refers to a sustainable grazing program for landholders focussed on improving groundcover management on pasture lands. It involves field days and formal workshops with experts, developing information and training material on stocking rates, formal training courses such as Prograze, a dung beetle release program and a program of on-ground works that will assist landholders to better manage their groundcover levels (including off-stream watering, solar pumps and fencing).
Nutrient management	1/3 Catchment Officer LANDSCAN Soil tests	Nutrient management is a component of a sustainable grazing program focussed on the appropriate application and storage of nutrients. It involves working with landholders to trial different types of fertilisers, formal training courses such as LANDSCAN, subsidising and promoting the use of soil tests, and providing assistance with interpretation of the tests so that the results can be integrated into the whole farm plan. This program also supports a dung beetle program – however, it is costed in the groundcover management program.
Infrastructure (Dam) management	1/6 of Catchment Officer Workshop Dam repair / removal costs	Infrastructure management includes the refurbishment of dams that are a water quality risk as well as decommissioning those that are not functioning, and potentially acting as a source of nutrients and sediments to the system. It involves working with landholders to undertake repairs of the dam spillway, fencing off the dam and providing a trough for stock watering. It also involves landholder training, as well as training and accreditation of contractors. Additional actions related to the management of infrastructure have also been identified, including road and laneway management. However, these kinds of actions were not able to be modelled.

Riparian reserve	0.5 of Catchment Officer Workshop Fencing and off-stream water for 22.5 km of streams Land acquisition (113 ha)	The riparian reserve program involves buying back and rehabilitating properties along the Crawford River, including riparian fencing and rehabilitating the riparian areas as required. The exact mechanism for establishing a riparian reserve has not been outlined here. However, if a riparian reserve were considered feasible, further discussions would need to be undertaken with stakeholders.

The total costs of the Crawford Drinking Water Option over 7 and 30 years are presented in Table A21.5.

Table A21.5 Summary of total costs of Crawford River drinking water options recommended by the Plan at seven years and 30 years.

Action	Cost at seven years	Cost at 30 years
Nutrient management	$401,000	$1,720,000
Dams	$295,000	$1,265,000
Groundcover	$611,000	$2,620,000
Riparian reserve	$639,000	$2,740,000
Total	**$1,946,000**	**$8,345,000**

This table shows that the total cost of the Crawford Drinking Water Option is approximately $1.9 million over seven years and $8.3 million over 30 years. As previously, no discounting has been used to account for costs incurred in later years.

3. Summary of benefit-cost analysis results for the Crawford Drinking Water Supply Strategy

As for the Myall Lakes Plan, a separate benefit-cost analysis was also undertaken for the Crawford Drinking Water Strategy by Gilllespie Economics. The results from this analysis are presented here. Full details of assumptions made and methods used for estimates the benefit-cost results presented here can be found in Appendix 15.

The present value of costs and benefits of the Plan, using a 4%, 7% and 10% discount rate are provided in Table A21.6. The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the sum of the discounted benefits less the sum of the discounted costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the project, because the community as a whole would obtain net benefits from the project. Table A21.6 indicates that the Crawford Drinking Water WQIP would have a NPV of $16 million, at a central discount rate of 7%, hence it is economically efficient and desirable from a community perspective.

An alternative decision criterion is benefit-cost ratio. Benefit-cost ratio is the sum of discounted benefits divided by the sum of discounted costs. A benefit-cost ratio greater than 1 indicates that the investment is economically efficient and hence desirable from an economic perspective. The results show that under the central discount rate of 7% the benefit-cost ratio of the Crawford Drinking Water Plan is 5.6. This also shows that the Plan is economically efficient and desirable from a community perspective.

Table A21.6. Crawford Drinking Water Plan benefit-cost analysis results.[DG87]

	NPV @ 4%	NPV @ 7%	NPV @ 10%
ECONOMIC COSTS			
Direct program costs			
Fertiliser	$991,373	$711,462	$540,514
Dams	$729,616	$523,612	$397,800
Groundcover	$1,509,597	$1,083,140	$822,701
Riparian remediation	$1,577,898	$1,132,325	$860,206
Subtotal	***$4,808,484***	***$3,450,539***	***$2,621,221***
Indirect program costs			
Riparian			
Opportunity costs of riparian	$0	$0	$0
Dams			
Cost of alternative water supplies for dams	$86,839	$84,404	$82,102
Subtotal	***$86,839***	***$84,404***	***$82,102***
TOTAL COSTS	**$4,895,323**	**$3,534,943**	**$2,703,323**
Benefits			
Improvements in estuary health	$553,243	$431,268	$346,575
Improvements in river health	$2,460,723	$1,918,198	$1,541,503
Increased native vegetation conservation	$141,385	$137,420	$133,673
Increased wetland conservation	$0	$0	$0
Benefits to oyster growers	$0	$0	$0
Benefits to commercial fishers	$233,868	$148,490	$100,098
Benefits to non-market recreation	$21,111,720	$13,404,492	$9,036,080
Benefits to commercial recreation	$5,166,724	$3,280,515	$2,211,422
MidCoast Water water treatment cost savings	$31,904	$20,169	$13,505
Subtotal	***$29,699,567***	***$19,340,552***	***$13,382,856***
Indirect program benefits			
Groundcover and fertiliser			
Reduce fertiliser costs and increased productivity	$449,953	$322,893	$245,296
Dams			
Increased agricultural production	$12,769	$9,163	$6,961
Subtotal	***$462,722***	***$332,056***	***$252,257***
TOTAL BENEFITS	**$30,162,289**	**$19,672,608**	**$13,635,113**
NET BENEFITS	**$25,266,967**	**$16,137,667**	**$10,931,790**
Benefit-cost ratio	**6.2**	**5.6**	**5.0**

Results were also presented as part of the benefit-cost analysis to show the costs and benefits of each of the individual actions in the Crawford Drinking Water WQIP (Table A21.7). This facilitates consideration of which action is providing the greatest return on investment, as represented by the benefit-cost ratio. Allocation of benefits to each individual action in the WQIP was achieved by estimating the contribution that each action makes to general water quality improvement in the estuary and allocating benefits associated with water quality improvement, accordingly. Non-water quality benefits, e.g. vegetation conservation, were also allocated to the relevant WQIP action.

Table A21.7. [DG88]**Crawford Drinking Water WQIP benefit-cost analysis of individual actions.**

Direct program costs	Direct costs ($)	Indirect costs ($)	Total costs ($)	Direct benefits ($)	Indirect water quality benefits ($)	Total benefits ($)	Benefit-cost ratio
Fertiliser	711,462		711,462	105,216	4,132,584	4,237,800	6.0
Dams	523,612	84,404	608,016	9,163	315,979	325,143	0.5
Groundcover	1,083,140		1,083,140	217,677	6,455,286	6,672,963	6.2
Riparian remediation	1,132,325		1,132,325	2,055,619	6,381,086	8,436,704	7.5
Total	**3,450,539**	**84,404**	**3,534,943**	**2,387,675**	**17,284,935**	**19,672,610**	**5.6**

This analysis indicates that the Crawford Drinking Water WQIP actions all provide a positive return on investment, apart from dam refurbishment.

Attachment 1.

Assumptions behind the Crawford River Drinking Water Strategy

The Crawford River is a drinking water sub-catchment that services Bulahdelah and other townships in the Myall River catchment. This scenario groups focuses on the sub-catchment to improve water quality at the sub-catchment outlet. Particular concerns relate to heavy metals attached to sediment. The scenarios look at large shifts in nutrient management, dam remediation and removal, and groundcover management to highest level practice. The scenario also considers the establishment of a riparian reserve 50 m wide on both sides of the river on 75% of pasture areas.

Expanded agricultural programs

Nutrient management, dam remediation and removal and groundcover management scenarios are applied in the same manner as for the catchment WQIP scenarios (described earlier in this appendix), although the proportions of each level differ.

Groundcover

Table A21.8. Proportion of pasture land in each level in the Crawford River sub-catchment.

Level	Existing situation (%)	Existing programs (%)	Expanded programs (%)
1	10	10	10
2	82	82	15
3	5	5	25
4	3	3	50

Table A21.9. Costs specific to groundcover actions in the Crawford Drinking Water Strategy.

Description	Assumptions
Program costs	• 2/3 Catchment Officer / sustainable grazing officer ($66,133 [Year 1], $65833 per year [subsequent years])
	• Year 1: two groups with four workshops per year at $500 per workshop • (eight workshops) ($4,000) • Years 2+: 10 workshops / year ($5,000) • one formal workshop a year ($5,500)
Direct costs	• dung beetles: same cost per colony as described above. In the Crawford this equates to two colonies ($1,200 per year). • stock watering points: same cost per watering point to assist with even grazing. In the Crawford this equates to 27.5 watering points ($9,806 per year).
Total expanded program	Year 1: $86,639 Annual (excl. Year 1): $87,339 per year Total over 30 years: $2,619,471

Nutrient management

Table A21.10. Proportion of improved pasture in each level in the Crawford River sub-catchment.

Level	Existing situation (%)	Existing programs (%)	Expanded programs (%)
1	30	30	25
2	55	55	15
3	10	10	10
4	5	5	50

Table A21.11. Costs specific to nutrient management in the Crawford Drinking Water Strategy.

Description	Assumptions
Direct costs	Same direct costs as for the Myall nutrient management actions
Program costs	Same program costs as for the Myall nutrient management actions
Total expanded program	Year 1: $57,473 Annual (excl. Year 1): $57,323 per year Total over 30 years: $1,719,836

Dams

Table A21.12. Proportion of dams in each level in the Crawford River sub-catchment.

Level	Existing situation (%)	Existing programs (%)	Expanded programs (%)
1	40	40	30
2	49	49	20
3	10	10	30
4	1	1	20

Table A21.13. Costs specific to dam actions in the Crawford Drinking Water Strategy.

Description	Assumptions
Direct costs	Same cost per dam as described previously
Program costs	All dams in the catchment would need to be visited (34) to achieve the shift required. To shift to 50% in level 4 we need to improve 17 dams = three per year. To shift from levels 1, 2, 3 we will need to improve nine dams = 1.5 per year, which is an approximate total of five dams per year ($12,000 per year). 1/6 of a catchment officer person required to move people through all of the steps. It was noted by the committee that each year the same amount of work would be required to move people from steps 1 to 2, 2 to 3 and then 3 to 4 ($16,533 [Year 1], $16,458 per year [subsequent years]).
	• Technical person required to design dams and off-stream watering • This would cover the repair or removal of dams 1/12 of a technical person required they would be needed to advise on moving from levels 1 to 2 as well as level 3 to 4 ($8,267 per year).
	• One workshop for the Crawford sub-catchment per year ($5,500 per workshop)
Total expanded program	Year 1: $42,300 Annual (excl. Year 1): $42,188 per year Total over 30 years: $1,265,738

Riparian reserve

Heading upstream from the confluence of the Crawford River and Upper Myall River, three sections were identified where the width of the reserve will vary due to characteristics of the river (channel width and braiding). The area of land to be acquired in each case is 100 m from the edge of the river.

The exact mechanism for establishing a riparian reserve has not been outlined here. However, if a riparian reserve were considered feasible, further discussions would need to be undertaken with stakeholders to explore a range of mechanisms (e.g. establishing a revolving fund to purchase properties that come onto the market, development offsets).

- Section 1: 3.5 km – 150 m wide
- Section 2: 6.5 km – 450 m wide
- Section 3: 5 km – 200 m wide.

Approximately 75% of each section is assumed to be put into reserve.

The costs of implementing the Crawford Drinking Water Strategy are shown in Table A21.14.

Table A21.14. Costs for implementing the Crawford Drinking Water Strategy.

Component	Cost ($)
Land acquisition costs	675,000
Area of land to be acquired (ha)	112.5
Fencing and off-stream watering costs	405,000
Program costs (per year)	55,250
Fencing (km)	22.5
Total costs	$2,737,500

Appendix 22: Principles of learning for sustainability

The following principles should be considered and used across all education programs delivered by the CCI.

Visioning and futures thinking

- Does the program / activity contribute to change towards CCI's vision for sustainability?
- Does the program / activity assist participants in creating their own vision for a sustainable future?

It is important that participants envision their future, if they are expected to guide their actions towards their idea of a sustainable future. The process of visioning is closely associated with being able to clarify ones values, and judge long-term against short-term values. Often in today's society we act upon short-term values, rather than considering the implications against our longer-term values. A visioning process enables the learner to clarify their long-term values, and identify steps and actions that can lead one towards the envisioned outcome.

Envisioning…

- provides a non-threatening learning space conducive for discussion
- creates the ability to identify and critically question what participants want for a sustainable future
- assists in ensuring relevance to people's own lives and social / cultural context
- incorporates and is inclusive of Aboriginal and intercultural perspectives, as well as non-expert knowledge
- uncovers and deconstructs what we value and why we value, as well as what other people value
- provides an opportunity to consider conflicts, contradictions and similarities with other people's visions
- helps participants see the process of change as a series of steps, and helps them to reflect on factors / choices that bring about different types of change
- emphasises that participants are the owners of their vision, process and outcomes. This action paves the way forward for collaboration, solutions and action.

Critical thinking and reflection

- Does the program / activity engage participants to think or reflect critically upon their role in creating change for sustainability?
- Does the program / activity enable participants to ask *why?*

Critical thinking and critical reflection are important processes that encourage participants to ask 'why?' of themselves and others. Critical reflection will enable the learner to questions assumptions surrounding their own actions, values, beliefs and practices in an effort to understand personal conflicts in creating change towards their vision of sustainability.

Critical thinking takes this process a step further not only to consider the assumptions and agendas of other stakeholders, but also to think about the way in which we ourselves take on new information. Participants are encouraged to develop skills in asking questions 'why?' in order to seek out new solutions for change, rather than just accepting information as given.

Critical thinking…

- challenges us to critically question assumptions, and recognise bias and power behind institutions, governments, media, companies and the people around us
- deconstructs our socialised views of the world to comprehend that others around us see the world in similarly complex ways
- explores power relationships in our communities, schools, workplaces and wider world and questions the motivations, interests and powers behind hierarchies and leadership
- helps to identify root causes of problems, instead of just their symptoms
- together with values clarification, helps us to explore the influence of our culture in shaping our views of the world
- gives us the ability to participate in change, both individually and collectively, and to develop a sense of our own power to shape our own lives.

Participation in decision-making

- Does the program / activity enable participants to engage in decision-making concerning social or environmental change?
- Does the program / activity teach participants how they can further engage in decision-making concerning social or environmental change?
- Does the program / activity inform the learner of their rights and responsibilities regarding the environment?

Participation in actions for change, such as planting trees or collecting litter, is an essential component of environmental education. Just as important is the ability to be able to participate, as a stakeholder, in decisions that affect us and our community. It is important in environmental education to empower participants and assist participants by creating opportunities to participate in decision-making. This may occur in the home, in the community and local institutions, or within Council. Importantly, participation in decision-making, in terms of this Plan, does not stop simply at the individual – as such, it is not enough for someone to decide that they will walk today rather than drive – participation in decision-making might mean that they work with their local P&C to assist in car sharing or 'walking bus' type programs. It might mean that people volunteer in organising their local bushcare, or it could mean joining a committee. Significantly, participation might mean that the educator engages the target participants in designing the proposed education program.

The process of participation in education for sustainability…

- is broadly inclusive, involving all participants throughout the process
- increases the confidence of participants to participate, particularly in groups that may be marginalised in a community
- actively builds knowledge among participants through dialogue
- builds the capacity of participants for self-reliance and self-organisation, and increases community identity
- engages participants with the skills, motivation and confidence to participate in political, legal and physical actions for change
- embeds in participants the capacity for ongoing, long-term participation in change towards sustainability.

The content of participation in education for sustainability…

- helps recognise the rights of all groups to participate, particularly minorities, women and youth
- helps design and facilitate processes that engage people in sustainability
- helps work towards developing locally relevant solutions
- helps put decision-making and responsibility for outcomes in the hands of participants.

Partnerships

- Does the program / activity actively seek to engage stakeholders in partnerships that involve shared vision and goals, resources, knowledge and innovation, benefits, and risk?
- Does the program / activity plan for and address the power issues around the subject and stakeholders?
- Does the program / activity considered how the learning can be used and occur through the process of engaging in the partnership?

Partnerships for sustainability involve the coming together of stakeholders looking for similar outcomes. Partnerships may be internal, between branches or divisions. They may involve community stakeholders or business. Or they may even extend outside the shire to include other councils, government agencies or businesses. Partnerships can assist those involved in learning to understand barriers and issues from a variety of perspectives. Importantly, many of these barriers can be political, and by forming a partnership, politics can be addressed and dissipated.

Partnerships…

- create synergies between organisations to work for change
- foster building shared visions among partners
- allow partners to combine resources and talents
- increase capacities to attract financial and technical support
- help to break hierarchies and power relationships by linking partners at different levels and across different disciplines
- bring together people and partners with different perspectives to reconcile interests and challenge world views
- add value to local initiatives while maintaining relevance
- help motivate partners to work toward long-term, institutional change.

Systemic thinking and systems change

- Does the program / activity enable participants to think systemically about issues of sustainability?
- Does the program / activity enable participants to step into the shoes of other stakeholders to gain understanding from their perspectives?
- Does the program / activity teach participants to think about the results of their actions systemically?
- Has the program been designed to enable continuous evaluation and improvement?

Being able to think across biological, time-based and social systems takes skill. It is important that participants are able to see how their actions – individually, cumulatively and collectively – can impact both today and in the future, both locally and internationally. By engaging participants to think critically and to be able to map the systems or habits by which environmental degradation occurs is important in ensuring a sustainable future. Further, it is also important that participants are able to determine how to seek solutions within a system, assess potential actions or solutions, and generate the highest level of positive impact.

Systemic thinking…

- looks at the whole, larger context, resisting our tendency to simplify problems and solutions
- sees the larger properties of whole systems that emerge from the interaction of individual parts
- integrates decision-making and adaptive management, and encourages more participative and interdisciplinary approaches to problem solving
- helps us to look at multiple influences and relationships when we explore and participate in resolving problems
- helps us appreciate others' viewpoints

- expands our world view, and helps us to be more aware of the boundaries and assumptions we use to define issues
- helps restore a sense of connection to place, to others and the wider world
- recognises the influences of our values, self-perception and interpretations of the world, as well as our intuitional and non-rational ways of knowing
- helps us accept uncertainty and ambiguity, and to participate and learn from change
- identifies strategies that better generate sustainable solutions for system change, emphasising self-organisation and resilience.

Further questions to assist in developing education programs

- How was a cooperative and collaborative vision developed?
- How is the design innovative?
- How is the program design flexible, ready to change direction when the situation changes?
- What is the relevance of the program to identified participant needs?
- How is the program interdisciplinary and holistic?
- How were monitoring and reflection of the program included?
- How were participants empowered? How did they feel ownership over the ideas and projects?
- How was it acknowledged that participants have insights for the solutions rather than the educators?
- How was the capacity of individuals to work with others built?
- Were obtainable outcomes set? How was the big picture painted, yet achieved through celebrated small initial steps?
- How was meaningful dialogue encouraged ~ dialogue that creates knowledge from participants, builds relationships, helps participants to understand other world views, empowers participants and gets to the heart of sustainability issues?
- How were partnerships and networks fostered?
- How was commitment encouraged?
- How was trust built and maintained?
- How are the educational processes consistent with the desired objectives?
- What were seen as the critical success factors?
- How have reflections from the evaluation process been incorporated back into the program design?
- How has the program created outcomes and achievements towards sustainability?
- What are the expected long-term impacts of the program?
- How is the program expected to be self-sustaining? What are the mechanisms for long-term effective continuation?

Appendix 23: Building consummate leaders for sustainability

Vision and leadership are key to enabling sustainability to emerge within an organisation. The most recent generation of theory on *leadership* looks towards a transformational approach in which leaders become visionaries and agents of change within their sphere of influence (Doyle & Smith 1999). Transformative leadership moves beyond simple transactional-based approaches, towards leaders that act as visionaries (Bolman & Deal 1997).

A transformational leader can be recognised, as they seek to raise our level of awareness and consciousness about the significance and value of the designated outcomes, and ways of reaching them. They enable us to transcend our own self-interest for the sake of the team, organisation or larger community

Doppelt (2003) found that sustainability efforts rarely succeed within organisations unless the cultural beliefs, thinking and behaviour that are inconsistent with sustainability are altered. Effective leadership is critical to this shift. Despite this, Doppelt (2003) found little evidence to suggest that leaders fully grasp the deep-seated paradigm shift required for sustainability, nor do they have the skills or understanding to stimulate widespread organisational change. The WQIP will attempt to reverse this trend, ensuring that leaders fully grasp the situation and the level of organisational change required to achieve sustainability.

In just the past 12 months, the rise of the sustainability professional has been prolific. Coleman and Visser (in print) found that among corporations leading the charge towards sustainability, there is a trend towards shifting responsibility for sustainability to the executive management level, as well as a trend towards dedicated sustainability teams within strategy.

Not only is this shift beginning to see a more clear professional development paths for sustainability professionals, but also there is a need for all professionals to have competencies in sustainability. Most organisations that currently have a commitment towards sustainability are at an early stage in:

- identifying critical skills, experience and attitudes to move the organisation toward achieving its sustainability objectives
- determining the right people that require these competencies – from sustainability specialists to all employees
- planning and implementing the most effective learning processes that embed sustainability competencies across the organisation.

Fundamentally, if an organisation is to contribute to sustainability and develop competencies for sustainability among its professionals, it must take a holistic view of social, environmental and economic value; it must adopt a long-term perspective and consider the precautionary principle; and it must assume an inclusive approach to change.

Coleman and Visser (in print) developed a map of competencies for the sustainability organisation that is required of their sustainability professionals and leaders generally.

Table A23.1. Competencies of the sustainability organisation (Source: Coleman & Visser in print).

Competency theme	**Competency element**	**Understanding** ***Essential knowledge and skills (know-what)***	**Experience** ***How understanding is translated into practical action (know-how)***	**Attitudes** ***Personal values and ways of working***
Strategy *Sense-making and planning*	External Context	Understanding the local and global context in which your organisation operates, including the most significant opportunities and risks that it faces	Prioritising issues in terms of the level of opportunity and risk they present to the organisation, now and in the future	Holistic view: The importance you attach to balancing environmental, social and economic value
	Internal Focus	Understanding how your organisation can respond to these opportunities and risks for greatest business and societal value	Formulating strategic objectives that address the organisation's opportunities and risks, supported by business cases, resources and champions to put them into practice	
Stakeholders *Managing relationships*	Stakeholder Approach	Understanding why a stakeholder approach is essential to your organisation's long-term success	Determining who your stakeholders are, how the organisation affects them, and what they think about the organisation	Inclusive approach: The importance you attach to responding to the needs and aspirations of all people affected by your activities
	Dialogue and Partnership	Understanding how to engage with stakeholders in order to foster co-learning and build effective relationships	Engaging in dialogue with stakeholders and responding to their legitimate concerns in a transparent and effective fashion	
Leadership *Creating change*	Learning	Understanding the competencies you need to help your organisation deliver its strategic objectives	Developing and participating in learning and development processes that support the organisation's strategic objectives at personal and team levels	Long-term perspective: The importance you attach to recognising the interests and rights of future generations
	Action	Understanding the most effective approaches to influencing others and creating change in your organisation in line with its strategic objectives	Demonstrating personal commitment to the principles and values of sustainable development, encouraging and enabling others to make this a focus of business action	

This map can be used not only by organisations to identify and build competencies, but also it is useful in developing suitable models of learning for sustainability leaders.

Appendix 24: Landholder comments and practitioner notes regarding the Farm Scale Action Plan

This appendix directly repeats the strategy for implementing the Farm Scale Action Plan in Section 3.3.2 of the WQIP, but also includes comments from landholders and catchment management practitioners. The comments were gathered through numerous meetings of the Rural Management Practices Technical Group, meetings with the Landholder Reference Group, and workshops and surveys conducted with farmers. More information on the engagement that occurred with the rural community can be found in Appendix 1.

Table A24.1. Farm Scale Action Plan: Strategies to encourage landholder uptake of water quality improvement actions. Comments are shown in italics.

Objectives	Action type	Actions and comments (in italics) from landholders and catchment management practitioners	Responsibility	Identified costs (✓program costs)	Likely timing
Encouraging landholder uptake of improved management practices					
Encourage and support the uptake of management practices that maximise the water quality improvement outcomes at the farm scale. Support the coordination and implementation of these activities.	Future investigation	Undertake research to link the water quality assessment and planning tool to the DSS, and develop methods to update the DSS as scores are collated from farm visits ~ (Note: implementation of this tool is described in the recommended approach and an additional use of the tool outlined below)	Contractor with input from catchment management practitioners	60,000	2008
		Scope the potential for rewarding landholders who achieve good water quality scores or 'best management practice' (e.g. rate reapportioning stewardship payments or rate relief across all council areas) ~ * *Comment: Landholder Reference group suggested Environmental Special Rate or Grant money used to provide rate relief but noted this would require more administration staff. The reference group noted using rate money for works was more appealing to them than grant money as there are no up front costs*	Catchment management practitioners and senior management of key organisations	✓	2009–10
		Scope the possibility of rewarding landholders for Property Vegetation Plans and other conservation covenants (e.g. tax rebates or rate reapportioning) ~ *Comment: Rural MP group suggested commissioning this and the next two actions together.* *Comment: Mid Coast Dairy Advancement Group suggested a tax rebate was no use for individuals not paying tax.*	Contractor	3,000	2009
		Identify the tax benefits currently available for landholders to undertake environmental works ~ * ^	Contractor with input from catchment management practitioners	3,000	2009

Objectives	Action type	Actions and comments (in italics) from landholders and catchment management practitioners	Responsibility	Identified costs (✓program costs)	Likely timing
		Develop a case for revising tax laws to provide financial incentives for environmental works for both primary and non-primary producers (if necessary following further investigation) * #	Contractor with input from catchment management practitioners	4,000	2009
		Investigate ways for improving knowledge transfer of NRM issues for rural supply stores and real estate agents ~	Catchment management practitioners	✓	2008
		Assist landholders to collect data from their farms to establish a basis for informed decision-making using the model developed for Real Farm Planning Projects (Note: this information could then be used as a basis for establishing industry-based environmental management systems) ^ *Comment: Mid Coast Dairy Advancement Group committee suggested coordinated implementation of Real Farm Planning Projects involving the collection of farm data to establish a basis for informed decision making at the farm scale, and recommended investigating opportunities for setting up an EMS for the Dairy Industry based on the data collected through Real Farm Planning.*	Catchment management practitioners, Mid Coast Dairy Advancement Group	✓	2008–ongoing
		Investigate the possibility of flexible or alternative payment options for landholders to minimise financial impediments of large up-front costs associated with undertaking on-ground works (e.g. bonds, progressive payments) ~ # *Comment: Krambach landholders identified upfront costs as an impediment to doing on-ground works*	Catchment management practitioner in conjunction with NRM funding bodies	✓	2008–ongoing

Objectives	Action type	Actions and comments (in italics) from landholders and catchment management practitioners	Responsibility	Identified costs (✓program costs)	Likely timing
	Future extension	Implement planning system and the associated resources to rank a range of farm management practices in relation to their water quality risk – use the scoring system as a way of giving feedback to landholders * and encouraging improved farm management practices ~ *Comment: Mid Coast Dairy Advancement Group said that advice from catchment officers should only be by invitation from the farmer. Dairy self-assessment tool already exists, but could be added to.* *Note: Rural MP group agree. This assessment tool will not be mandatory. The dairy self assessment tool will be reviewed prior to developing the planning system tool.*	Catchment management practitioners	✓	2008
		Establish an award system linked to achieving good water quality scores ~	Catchment management practitioners	✓	2009
		Promote the tax benefits currently available to landholders doing environmental works by using case studies to demonstrate their application ~ *	Catchment management practitioners	✓	2009–ongoing
		Inform landholders that farm management plans are tax deductible *	Catchment management practitioners	✓	2008–ongoing
		Develop an education / information package on whole-farm management covering issues relating to water quality (include information on relevant grants for on-ground works) suitable for councils to distribute to new landholders purchasing subdivided rural land * # *Comment: Rural MP group said that Council needs to make sure the contractor reviews what has already been done.*	Contractor with input from local councils and catchment management practitioners	10,000	2009–10
		Improve NRM knowledge transfer between rural supply stores, real estate agents and clients ~	Catchment management practitioners	✓	2008–ongoing

Objectives	Action type	Actions and comments (in italics) from landholders and catchment management practitioners	Responsibility	Identified costs (✓program costs)	Likely timing
		Encourage dairy farmers to participate in Real Farm Planning Programs and the Mid Coast Dairy Advancement Group to assist them to achieve positive environmental (including water quality) and farm outcomes ^ *Comment: Mid Coast Dairy Advancement Group noted that all dairies in the CCI area should be encouraged to get involved in these programs and that as there are so few dairies left, this is an achievable recommendation.*	Catchment management practitioners, Mid Coast Dairy Advancement Group	✓	2008–ongoing
		Implement training and education programs for staff at rural supply stores and real estate agents on NRM farms in the local area (e.g. fertiliser application, stocking rates, drought management) ~ # *Comment: Rural MP group noted that this could include information on stocking rates, fertiliser application etc*	Training providers (e.g. CMA, TAFE, DPI, consultants)	✓	2009–ongoing
		Establish a 12-month calendar of training, workshops and field days integrating activities undertaken by DPI, landcare, CMA, GLC ~	Catchment management practitioners	✓	2008–ongoing
		Arrange field days for landholders to visit other landholders who can demonstrate local examples of how whole-farm planning can work #	Catchment management practitioners		
	Future on-ground	Work with landholders to use the water quality assessment and planning tool developed to identify priority areas for water quality improvement (at the farm scale), so as to develop an incentive scheme that supports the uptake of management practices with the greatest water quality benefit * Note: this may involve investing in activities outside of the current rural incentive scheme scope ~ # *Comment: Bunyah workshop concern over subjectivity of assessment and inherent local difference in the way farmers manage their properties.* *Note: Rural MP group highlighted the need of this tool to focus on outcomes (e.g. good riparian vegetation) not*	Catchment management practitioners, landholders	✓	2008–ongoing

Objectives	Action type	Actions and comments (in italics) from landholders and catchment management practitioners	Responsibility	Identified costs (✓program costs)	Likely timing
		process (e.g. fence along the streams). The assessment tool will be developed to take these difference into account and will be adaptive not prescriptive. *Comment: Mid Coast Dairy Advancement Group highlighted the need to identify the issues at the farm scale rather than having blanket solutions.* *Note: Rural MP group agreed, need to focus on outcomes, not process – see note above.*			
		Fund sufficient staff to provide one-to-one advice to landholders and industry groups on water quality management at the farm scale, including technical staff (e.g. off-stream watering design, riparian management, dam design, soil test interpretation, erosion control, sustainable grazing) ~ * # *Comment: Reference Group suggested grant money could be tied to advice.* *Comment: Mid Coast Dairy Advancement Group noted that industry specific would work best – e.g. beef and dairy are not combined. Also suggested that all dairy farmers in the CCI project area could be encouraged to become involved in the program, given that there are so few.* *Comment: Mid Coast Dairy Advancement Group suggested the Coordinator help find funding too, and that the Officer needs to be recognised in the Industry.* *Note: Rural MP group agree and think Dairy Advancement Group should continue to promote the need for this person. Suggests this should not necessarily be provided by funding but by Government.*	State, local and federal government; non-governmental organisations / private enterprise	✓	2008-ongoing

Table A24.2. Technical strategies for water quality improvement at the farm scale.

Comment: Mid Coast Dairy Advancement Group highlights the need to consider actions from a whole-farm planning perspective to ensure that the problem is not transferred elsewhere. For example, unless off-stream watering is planned well, fencing off a dam and providing off-stream water simply moves the problem. With a high stocking rate, the area around the trough becomes bare, compacted and susceptible to erosion.

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
Riparian management					
Support faster uptake of riparian fencing of Crown land	Future investigation	Identify priority riparian areas for protection and rehabilitation on Crown land ~ *Comment: Rural MP group suggested combining this action with the action below to total approximately 5 weeks work.*	Contractor with input from catchment management practitioners	30,000	2009–11
		Develop a case to Department of Lands to provide additional support to landholders fencing off riparian land ~	Contractor with input from catchment management practitioners	2,000	2009–11
	Future on-ground	Continue to provide funding to landholders to fence off riparian areas on Crown land with existing incentive programs ~	State, local and federal government / landholders	✓	2008–ongoing
		Fence off priority riparian areas on Crown land with minimum 50:50 funding from government (dependent on future negotiations with Department of Lands) ~	State, local, federal government (depending on owner of land); landholders	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
Minimise the impact of erosion of river and creek banks through stock exclusion**,** establishing off-stream watering, vegetation management and, where appropriate, in-stream works. Support the coordination and implementation of these activities.	Future investigation	Investigate difference in impacts of dairy and beef cattle in creeks and in different stream environments ^ *Comment: Mid Coast Dairy Advancement Group noted the need to consider riparian fencing as part of rotational grazing of riparian areas for weed control.* *Note: Rural MP Group noted the need to consider these actions in relation to the whole farm plan.* *Comment: Rural MP group suggested getting a PhD to do this work with lesser associated cost.*	Contractor (scientist) with input from catchment management practitioners	60,000	2013–15
	Future extension	Establish demonstration farms and field days to demonstrate best practice riparian management and technical aspects of off-stream watering design (pipes, pumps, troughs) ~ !	Catchment management practitioners	✓	2008–ongoing
		Provide landholders with information on the importance of large woody debris and existing information on best management practice. Recommend landholders seek professional advice on the legalities associated with and management of large woody debris *	Catchment management practitioners	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
	Future on-ground	Priority fund fencing, weed control and off-stream watering systems on 3rd, 4th and 5th order streams ~ *Comment: Mid Coast Dairy Advancement Group noted that any riparian fencing should include a plan for weed control.* *Comment: Mid Coast Dairy Advancement Group noted that off-stream watering could be an animal care and ethics issue for absentee landholders – dams need to be checked regularly during summer.* *Comment: Landholder Survey noted Riparian Fencing is not a priority if banks are too steep for cattle to access. Weeds and ongoing maintenance costs are also issues of riparian fencing however farmers survey noticed more bird life and less cattle loss to paralysis tick. They noted using a trigger hammer mulcher for lantana left protective mulch layer on soil.*	State, local and federal government / landholders	✓	2008–ongoing
		Priority fund active erosion sites focussing on vegetation management and stock control, particularly in areas of highly erodible soils and steep land. Where in-stream erosion is the underlying cause of bank erosion, undertake appropriate in-stream works based on professional advice ~ * # *Comment: Landholder Survey said trees need to be planted well back to allow time for them to grow without being washed away* *Comment: Myall Landholders noted that funding was required to fix creek banks and install off stream watering and fencing. They noted that gravel was difficult to get locally to do these types of jobs.*	State, local and federal government; landholders	✓	2008–ongoing
		Fund technical expertise to design and manage erosion / mechanical bank stabilisation projects ^ #	State, local and federal government	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Fund off-stream watering without permanent riparian fencing if alternative shade is available and the riparian areas are not at risk. This will assist with a faster uptake of improved riparian management on lower order streams ~ * # *Comment: Landholder Survey noted funding for off stream watering should include fencing off dams. They said given preference, cattle use troughs first, then dams, then streams.* *Comment: Mid Coast Dairy Advancement Group committee noted that fencing off gullies on hills could restrict cattle movement and then you can end up with cattle ruts that could cause erosion, suggested using temporary exclusion fences, e.g. for a 5 year period Note: noted by Rural MP group and added as an action*	State, local and federal government; landholders	✓	2008-ongoing
		Fund temporary fencing for gullies (until significant revegetation and stabilisation has occurred) to restrict cattle movement where alternative shade is available ^	State, local and federal government / landholders	✓	2008–ongoing
		Fund solar pumping systems to encourage greater uptake of off-stream watering systems for riparian management ~ *Comment: Landholder Survey noted that solar pumps are desirable but costly.*	State, local and federal government / landholders	✓ [34]	2008–ongoing
		Fund mobile shade to manage the spread of nutrients across the farm, manage groundcover and alleviate erosion –, particularly applicable in situations where alternative shade is not available when the creek is fenced off ~ * ^ *Comment: Mid Coast Dairy Advancement Group committee noted that this has worked in a case in Gloucester LGA.*	State, local and federal government / landholders	✓ [35]	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Promote and protect shade trees *	Catchment management practitioners / landholders	✓	2008–ongoing
Wetland management					
Protect natural wetlands from grazing pressures supporting their natural abilities to filter nutrients and sediments !	Future investigation	Collate relevant information on the benefits of maintaining natural wetlands (economic and environmental examples) ~	Catchment management practitioners	✓	2008–ongoing
		Identify the most effective locations to protect and rehabilitate freshwater and coastal wetlands for water quality improvement, including identifying wetlands at risk or with high nutrient loads ~	Contractor with input from catchment management practitioners	40,000	2010–12
		Undertake research on wet pasture management to determine if wetlands can be used as a paddock when managed appropriately (taking into account wetland type, species composition, stocking rates, timing of use) *Comment: Rural MP group suggested that this could be a PhD research project*	Contractor with input from catchment management practitioners	20,000	2009–11
		Develop a case to the Department of Lands to establish a lease condition to fence off wetlands on Crown land ~	Contractor with input from catchment management practitioners	2,000	2010
	Future extension	Develop and implement a training package that promotes the benefits of maintaining natural wetlands and outlines appropriate management (field days, information sessions, establish sub-section to existing programs such as Prograze, LANDSCAN and sustainable grazing program). Target field days and training to different wetland types ~	Catchment management practitioners	✓	2009–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Provide one-to-one advice to landholders on how to manage their wetlands, including avoiding the exposure of acid sulfate soils and the use of buffer strips ~	Catchment management practitioners	✓	2008–ongoing
		Provide one-to-one advice on how to incorporate wetland management into whole farm planning to increase uptake of wetland rehabilitation ~	Catchment management practitioners	✓	2008–ongoing
		Establish wet pasture management trials to support research findings on wet pasture management ~	Catchment management practitioners	✓	2009–ongoing
	Future on-ground	Protect wetlands by establishing a specific funding source for Property Vegetation Plans so that wetlands do not have to compete with other remnant vegetation in the assessment process ~	CMA, and associated state and federal funding bodies	✓	2010–ongoing
		Provide incentive funding to landholders to fence wetlands (only to be used as for system grazing / crash grazing) ~	State, local and federal government; landholders	✓	2008–ongoing
		Priority fund rehabilitation and protection of wetlands that are at risk of high nutrient levels ~	State, local and federal government / landholders	✓	2010–ongoing
		Protect and rehabilitate estuarine wetlands and mangroves as the 'last frontier' of nutrient management, including establishing specific funding mechanisms (including revolving funds) to buy back significant wetland areas ~ # *	State, local and federal government; landholders	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Fund rehabilitation and protection of natural wetlands by: fencing out stock, providing alternative watering points and shade, revegetation, reinstating natural flow regimes (including installing tidal flow floodgates if drains are in place), and establishing buffer strips around wetlands ~ * *Comment: Landholder Survey suggested planting of appropriate aquatic plants to soak up nutrients.*	State, local and federal government; landholders	✓	2008–ongoing
		Protect and rehabilitate high water management and conservation value wetlands through direct acquisition, incentives and revolving fund schemes for inclusion in the conservation estate <	State, local and federal government; landholders	✓	2008–ongoing [pt89]
Groundcover management					
Improve management of grazing on steep land (slope greater than 18°) to maximise groundcover and minimise the impact of erosion in these areas	Future investigation	Research the local productivity of steep lands and investigate the profitability of changing to a land use that has less impact on water quality ~ *Comment: Rural MP group recommended combining this project with the next action.*	Contractor with input from catchment management practitioners	10,000	2010–12
		Investigate the possibility of providing rate rebates for excluding grazing from steep land and gullies. Support the reafforestation of these areas ~	Contractor with input from catchment management practitioners	2,000	2010–12
	Future extension	Expand existing grazing management programs to implement an education and awareness program on maintaining groundcover on steep land ~	Catchment management practitioners	✓	2008–ongoing
		Provide training on hazard reduction burning appropriate to steep grazing land using the package developed by the federal government ~	Rural Fire Service		2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Promote whole-farm planning and management to support even grazing of steep lands incorporating strategic fencing, temporary fencing of gullies, crash grazing, off-stream watering points and shade. Promote resting steep grazing land during high rainfall periods (autumn) ~ *Comment: Landholder Survey suggested use of contour banks in steep areas* *Comment: Dairy Advancement Group suggested fencing off gullies and hills should be short term only, otherwise cattle ruts (and erosion) could develop. They also suggested encouraging cattle away from gullies with mobile shade.* *Note: Rural MP group agree, comments incorporated.*	Catchment management practitioners	✓	2008–ongoing
		Promote tax incentives that are available with voluntary agreements for conservation of vegetation #	Catchment management practitioners	✓	2008–ongoing
	Future on-ground	Provide funding for strategic off-stream watering, shade and fencing (e.g. temporary fencing) to allow better management of grazing on steep land. Assessments would be made on a case-by-case basis ~ *Comment: Rural MP group noted this might help reduce the costs of fencing off streams on steep land.*	State, local and federal government; landholders	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Undertake whole-farm planning and management to support even grazing of steep lands incorporating strategic fencing, temporary fencing of gullies, crash grazing, off-stream watering points and shade. Promote resting of steep grazing land during high rainfall periods (autumn) ~ *Comment: Dairy Advancement Group suggested fencing off gullies and hills should be short term only, otherwise cattle ruts (and erosion) could develop. They also suggested encouraging cattle away from gullies with mobile shade.* *Note: Rural MP group agree, comments incorporated.*	Landholders, catchment management practitioners		2008–ongoing
		Expand dung beetle release and monitoring program ~ # *	Catchment management practitioners, landholders	✓	2008–ongoing
Maintain dense groundcover with appropriate stocking rates, appropriate fertiliser application rates, watering point distribution, shade, fencing and supplements	Future investigation	Identify the most appropriate method for informing landholders on appropriate stocking rates ~ *Comment: Mid Coast Dairy Advancement Group indicated that beef and dairy have very different pasture management systems and therefore it is difficult to establish a standard stocking rate.* *Note: Rural MP group agree there would be differences and these would need to be taken into account.* *Note: Rural MP group discussed using DSE then explain each type (e.g. 1.2 sheep, 0.4 cattle etc)*	Catchment management practitioners, Rural Lands Protection Board	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Investigate the possibility of linking soil tests to fertiliser use as part of a training and education program for landholders ~ *Comment: Bunya workshop asked if this was needed if fertiliser rates are not a problem; they also said independent interpretation of results of tests needed, as did the reference group.* *Note: Rural MP group advises that the fertiliser rates may not be a problem in the Bunyah area but they are in others. This plan covers Wallis, Smiths and Myall Lakes catchments.* *Comment: Landholder surveys noted soil tests are useful but seen as an ongoing cost. Some farmers use soil tests every few yrs*	Catchment management practitioners	✓	2008–09
		Investigate the use of alternatives to chemical-based fertilisers suitable to the local area ~ *Comment: Landholder surveys suggested incentives needed for organic and slow release fertilisers* *Comment: Mid Coast Dairy Advancement Group changed this from "Investigate the use of Reactive Rockphosphate" because they said CSIRO have done the research and shown that there are none commercially available.* *Note: Rural MP group noted it is available commercially.*	Contractor with input from catchment management practitioners	5,000	2008
		Further investigation into the effect of providing off-stream shade, water and rotational grazing on water quality and riparian vegetation – including long-term data collection, case studies and demonstration sites ~	Contractor (scientist), catchment management practitioner	20,000	2010–11

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Investigate ways to encourage landholders to better plan for drought, adapt and develop drought management strategies (e.g. workshops, training, incentives), and develop and adopt strategies ~ # * *Comment: Landholder Reference Group noted that drought has a big impact on ground cover: even with no stock, the pasture blows away* *Comment: Bunyah workshop noted some subsidies go to middleman through price inflation. They said that there may not be one solution to drought: sometimes destocking, sacrificial paddock and gran feeding may be options depending on the situations* *Note: Rural MP group took subsidies out of the plan* *Comment: Rural MP group suggested training on establishing sacrificial paddocks, pit silage, fertiliser and grain feeding.*	Contractor or catchment management practitioners	5,000	2009
		Investigate how sequestration of soil carbon could be applied locally in relation to global markets and how incentives could be used to promote soil carbon, especially in relation to groundcover management during drought ~ *	Contractor with input from catchment management practitioners	10,000	2009–10
	Future extension	Implement training and education programs for staff at rural supply stores and real estate agents on NRM farms in the local area ~ # *Comment: Myall landholders suggested that this action would not have a big effect.* *Comment: Rural MP group noted that this could include information on stocking rates.*	Catchment management practitioners	✓	2009-ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Provide information to landholders on appropriate stocking rates to match feed availability, drought management strategies, nutrient management and pasture management through continued training programs, fact sheets, field days and visits to established farms with examples of what works locally ~ * # *Comment: Myall landholders noted that people do not know how to select pastures and interpret soil tests. One of the most effective approaches to ground cover management is nutrient management and providing easy to understand advice on pasture types (including pasture quality) which will make it easy for landholders to apply the recommendations.* *Comment: Myall landholders noted that identifying pasture types suitable to local conditions would be helpful including trials and visits to established farms with good examples of what works locally*	Catchment management practitioners, Rural Lands Protection Board	✓	2009–ongoing
		Continued training, workshops and field days on sustainable grazing to assist landholders to 'know' their farms, and access appropriate and effective training and workshops so that they can make informed management decisions about groundcover management. Programs such as these should include subsidies for soil tests and training program costs ~ # *Comment: Myall landholders noted that funding soil tests would encourage the use of them by landholders.* *Comment: Myall Landholders noted that access to subsidies for training courses such as those at Tocal would encourage attendance*	Catchment management practitioners	✓	2008–ongoing

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Implement education programs for staff at rural supply stores on fertiliser management and appropriate application rates, including developing a brochure for distribution with fertiliser ~ *Comment: Myall Landholders highlighted the need to have DPI provide advice on fertilisers rather than stores that supply the products*	Catchment management practitioners	✓	2009–ongoing
		Promote production and environmental benefits of maintaining good groundcover #	Catchment management practitioners	✓	2008–ongoing
		Provide training, field days and information on the types of summer legumes to grow in order to biologically fix nitrogen. Improve soil health and improve the management of the application of fertilisers # *Comment: Myall landholders noted that identifying the local pasture species would help.*	State, local, federal government / landholders	✓	2009–ongoing
		Establish case studies, field days and training for landholders on optimising the use of improved pastures and nutrient applications, such as silage of high-growth summer pastures for feed-out in winter # *Comment: Myall Landholders suggested that DPI should encourage this approach and assist landholders. There is an issue of access to equipment / contractors, and economies of scale (working with a number of landholders) would assist to overcome this*	State, local, federal government / landholders	✓	2009–ongoing
	Future on-ground	Expand dung beetle release and monitoring program ~ # * *Comment: Myall landholders noted that it was a good idea to have information available on how to manage / protect dung beetles and how to access funding for assistance.*	Catchment management practitioners / landholders	✓	2008–09

Objectives	Action type	Actions	Responsibility	Identified costs (✓ within program costs)	Likely timing
		Fund off-stream watering at strategic locations to encourage grazing away from riparian areas ~ * # *Comment: Landholder Survey said erosion can occur around troughs if located on a slope.* *Comment: Dairy Advancement Group committee noted that fencing off gullies on hills could restrict cattle movement and then you can end up with cattle ruts that could cause erosion. Suggested using temporary exclusion fences, e.g. for a 5 year period* *Note: Rural MP group noted and added as an action*	State, local, federal government; catchment management practitioners; landholders	✓	2008–09
		Fund mobile shade where alternative shade is not provided as an interim measure until permanent shade is established, to encourage even grazing away from riparian areas # ~ * *Comment: Landholder Survey noted structure would need to be metal to avoid termites and strong enough to tolerate wind. Artificial shade could also create cattle camps (faeces concentration).*	State, local, federal government / landholders	✓	2009–ongoing
Steep land protection					
	Future investigation	Explore mechanisms for protecting and rehabilitating steep lands including, but not limited to, options for land use change <	State, local, federal government	10,000	2009–ongoing

Farm infrastructure management					
Minimise the impact of erosion of dams and maximise their ability to filter nutrients through good design, construction and maintenance	Future investigation	Investigate the possibility of requesting development approval and technical certification for construction of all new dams in the Rural Residential and Rural 1a zones in GLC, GTCC and GSC ~ *Comment: Landholder Reference Group suggested DA fee be waived.*	Relevant agencies (e.g. GLC / GTCC / GSC / CMA)	✓	2009–10
	Future extension	Develop a training package for contractors and drivers involved in earthmoving works on private land, including an accreditation scheme linked to a training program that identifies appropriately trained staff # ~ *Comment: Mid Coast Dairy Advancement Group concerned about how this will affect real farmers.* *Comment: Bunyah Landcare workshop noted drivers need to be accredited – not just businesses.* *Note: Rural MP group agreed and included in action.*	Contractor with input from catchment management practitioners	30,000	2009–10
		Expand education and training program for landholders including demonstration farms of good dam maintenance, construction and design ~ *	Catchment management practitioners, landholders	✓	2009–ongoing
		Develop and distribute a dam building and maintenance and constructed earth works brochure, attaching information from Department of Water and Energy on harvestable rights * *Comment: Rural MP group noted: Do not want to go over the harvestable right or use inappropriately.* *Note: Department of Water and Energy have developed guidelines for landholders on harvestable rights. Revised in November, 2007.*	Catchment management practitioners	✓	2009
		Train Development Assessment planners on the application of harvestable rights so that they are taken into account when assessing subdivisions ~	GLC / GTCC / GSC	✓	2008–ongoing

	Future on-ground	Fund alternative energy pumping systems (e.g. wind or solar) to encourage greater uptake of off-stream watering systems ~	State, local, federal government; catchment management practitioners; landholders	✓	2009–ongoing
		Fund dam removal if they are not functioning effectively (as they may be a source of nutrients and sediments) ~	State, local, federal government; catchment management practitioners; landholders	✓	2008–ongoing
		Continue to provide funding to limit stock access to dams, especially the spillway and dam wall ~. When entire dams are fenced off, provide funding for off-stream watering including alternative energy systems # *Comment: Bunyah workshop suggested using tanks for stock watering.* *Note: Rural MP group noted this would be up to the individual landholders and what suited their property.*	State, local, federal government; catchment management practitioners; landholders	✓	2008–ongoing
Minimise the impact of farm infrastructure (roads, buildings, dams etc) on water quality with appropriate design, construction and maintenance	Future extension	Provide training to contractors (such as earthworks operators) involved in establishing farm infrastructure ~ *Comment: Rural MP group suggested this group of contractor work be delivered as an integrated package.*	Contractor with input from catchment management practitioners	10,000	2009
		Develop and provide training to contractors on design and maintenance of tracks on steep lands ~ Note: this action should be incorporated into a whole package of training	Contractor with input from catchment management practitioners	10,000 annually	2010–ongoing

		Develop an accreditation or licensing scheme linked to a training program which identifies appropriately trained contractors – this could be used as priority contractors when implementing incentive funding ~ * *Comment: Rural MP group noted the need to use accredited operators and contractors. Clearing weeds needs to be done by an accredited contractor.*	Contractor with input from catchment management practitioners	5,000	2009
		Promote whole-farm planning and management with landholders to ensure farm infrastructure is located, constructed and maintained to minimise erosion and associated water quality impacts ~ *	Catchment management practitioners, landholders	✓	2008–ongoing
		Develop and implement training and education programs for staff at rural supply stores, Council officers and real estate agents on appropriate farm management ~ *	Catchment management practitioners	✓	2009
		Design farm tracks and creek crossings to suit local conditions, minimise erosion and allow access for farm machinery ~	Catchment management practitioners, landholders	✓	2008–ongoing
	Future on-ground	Improve laneway management in high-traffic areas (more than 80 cows) and divert laneway runoff so that it flows into paddocks rather than creeks. Provide funding for upgrading laneways and stock crossings to minimise their impact on water quality ~ ^	Catchment management practitioners, landholders	✓ [36]	2008-ongoing
Nutrient management					
Appropriate nutrient application and storage	Future investigation	Undertake an independent audit of the nutrient management advice provided to landholders, including an assessment of the appropriateness of the recommended application rates and fertiliser types for the local area. Based on the audit findings, consider revising the recommendations *	Contractor with input from catchment management practitioners	20,000	2009

	Future extension	Staff who provide advice on fertiliser and chemical application and type should be trained under existing programs that cover a range of different fertiliser types and appropriate application rates, such as FertCare ^ ~ *Comment: Rural MP group noted this is limited to non-organic fertilisers. Suggest a range of fertiliser types.*	Catchment management practitioners		2008–ongoing
		Inform rural supply stores about the soil sample interpretation services available through DPI and other independent services ~ *Comment: Mid Coast Dairy Advancement Group raised that urban applications also needs to be applied correctly – i.e., appropriate type and rates of application.* *Note: Landholder Reference group estimated that 50% of the landholders in urban areas do not know what application rates are appropriate on their land.* *Note: Rural MP group suggest including a comment in the urban engagement part of the project on 'investigate appropriate methods for informing residential landholders on appropriate application rates'*	Catchment management practitioners	✓	2008
		Continued subsidies for fertiliser management training programs such as Prograze, including subsidies for soil tests ~	Catchment management practitioners; state, local, federal government	✓	2008–ongoing
		Collate fact sheets on the use of alternatives to mineral fertilisers to assist landholders to ask appropriate questions of people providing advice on suitable fertilisers and application rates (in order to yield advice on the range of options available, including mineral and organic fertilisers) * *Comment: Reference group made this point in relation to DPI primarily providing advice that suggested the use of superphosphate*	Contractor with input from catchment management practitioners	5,000	2009

		Establish fertiliser trial programs and field visits to trial sites to demonstrate the effectiveness of different fertilisers, including alternatives to mineral fertilisers ~	Catchment management practitioners, landholders	✓	2009
	Future on-ground	Subsidise soil tests and encourage the use of leaf analysis for landholders and promote their use. Where appropriate, build soil test results into whole-farm planning programs – linking the results to feed availability including the type and quality of the pasture, and how this relates to stocking rates ^ * # *Comment: Reference group also noted that the soil tests should be done by companies independent of companies that sell fertiliser so that there is no conflict of interest* *Comment: Myall landholders noted that identifying pasture types suitable to local conditions would be helpful including trials and visits to established farms with good examples of what works locally*	Catchment management practitioner	✓	2008–ongoing
Appropriate management of human and animal effluent	Future investigation	Investigate the effectiveness of alternative animal and human effluent management systems that minimise water quality impacts ~	Contractor, appropriate research bodies	15,000	2009
		Investigate the appropriate management of high-use and high-nutrient areas on farms (e.g. laneways, creek crossings, feed paddocks), including laneway construction methods ~	Contractor with input from catchment management practitioners	10,000	2008–ongoing
	Future extension	Extend the program of training landholders on nutrient budgeting linked to funding soil tests ~ ^	State, local, federal government	✓	2009–ongoing
	Future on-ground	Expand dung beetle release and monitoring program ~ # *	Catchment management practitioners, landholders	✓	2008–ongoing
		Provide funding and undertake upgrades of animal effluent management systems ~	State, local, federal government; landholders	4	2008–ongoing

		Provide funding for and upgrade laneways and stock crossings to minimise their impact on water quality ~ ^	State, local, federal government; landholders	4[n90]	2008–ongoing
		Encourage the establishment of nutrient containment areas for storage of nutrients away for waterways (e.g. bunding around chicken litter) ^	Catchment management practitioners, landholders	✓	2008–ongoing
Identify ways to maximise denitrification processes at the farm scale	Future investigation	Investigate how denitrification works locally in relation to soil types and particular areas of the catchment. Identify areas where maximum benefits can be achieved ~ *Comment: Rural MP group noted that this could be done by PhD research students*	Contractor with input from catchment management practitioners	40,000	2012–14
		Investigate the role of dams in denitrification and the appropriate design to maximise this function ~	Contractor with input from catchment management practitioners	20,000	2012–14
		Investigate actions (at the farm scale) that could maximise denitrification processes (e.g. creation of low lying sinks in paddocks), and consider how these will relate to harvestable rights ~	Contractor with input from catchment management practitioners	5,000	2012–14
	Future extension	Once investigations are complete, develop case studies and education material suitable for inclusion in existing education programs that demonstrate the areas on farms where denitrification can be maximised, including the role of dams and wetlands in this process ~	Catchment management practitioners, landholders	✓	2015
	Future on-ground	Once investigations are complete, fund adaptation of farms to achieve denitrification ~	State, local, federal government; landholders	✓	2015

Encourage the wider distribution of chicken litter to minimise the point source contribution to the rivers from concentrated application	Future investigation	Scope the options for extending use of chicken litter beyond localised areas – including the suitability of a transport subsidy for people using chicken litter, linked to a DPI course that demonstrates the appropriate rate and approach to its application ~ *Comment: Myall landholders noted that this was a good idea as it would then be possible to send the litter outside of the catchment during rainy conditions. The subsidy could either go to the consumer or the supplier. They also suggested there would need to be a freight subsidy for the lime that is required to mix with the litter.* *Comment: Landholder Survey identified transport cost as a major hurdle to wider usage.* *Comment: Landholder Survey noted application rates have been lowered due to better machinery.*	Catchment management practitioners	✓	2009–ongoing
		Subsidise the mixing of chicken litter with mulch, or develop a program of using green waste from the tip, so that the litter can be used in urban areas ~	State, local, federal government	✓	2009–ongoing
	Future extension	Training, education and awareness-raising on use of chicken litter on rural properties, including advantages and disadvantages. This would involve the wider distribution of existing information about appropriate use and storage ~ #	Catchment management practitioners	✓	2008–ongoing
		Encourage the bagging of chicken litter, linked to training for use in urban areas ~	Catchment management practitioners	✓	2009–ongoing
		Establish demonstration farms to highlight how chicken litter can be used responsibly from economic and environmental perspectives #	Catchment management practitioners		
	Future on-ground	Subsidise soil tests for landholders using chicken litter linked to relevant training program covering chicken litter management ~	State, local, federal government	✓	2009–ongoing

		Implement best practice management guidelines for the use and storage of chicken litter (location of storage, silt traps, bunding) *Comment: Myall Landholders noted that the producer needs to be the responsible person in terms of management and storage of the litter. Some farmers do not store it responsibly therefore we should encourage the guidelines to be met.*	Landholders, catchment management practitioners	✓	2008–ongoing

~ Input from Rural Management Practices Technical Group.
* Input from Landholder Reference Group.
# Input from landcare groups and landholder workshops / CCI Landholder Survey.
^ Mid Coast Dairy Advancement Group.
< Great Lakes Coastal Catchments Initiative Advisory Committee.
! Other community groups.

Note: It will be necessary to seed additional funding to enable the actions identified for contractors to be undertaken.

Appendix 25: Farm-scale water quality assessment and planning tool

To aid the consistent implementation of 'whole-of-farm planning' and advice given to landholders by practitioners, it is recommended that an assessment tool be developed. This tool would include a scoring system that can assist with identifying the key areas for action at the farm scale (this could include on-ground action or further education). The tool will be developed collaboratively with landholders to ensure its relevance and that its application does not come across to landholders as a compliance tool.

The tool will be used with the landholder in an action learning context, and involve assessing and scoring farm management practices based on a questionnaire that is completed with landholders when catchment management practitioners visit the farm. Each activity under the farm management themes will be given a score that relates to the level of risk that this particular activity poses to water quality (e.g. in the area of improved pastures – 'high application rates of nutrients' is the activity and the risk 'ranking' will relate to the location of the nutrient application in relation to the waterway). The scores would then be added up for each management practice and related to particular actions that could be taken to improve the management of water quality on the farm. This information would be used to assist the landholder and catchment management practitioner to establish a whole-farm plan.

Appendix 26: Catchment management practitioner notes for engaging with landholders

The following section outlines the detailed input provided by landholders and the Rural Management Practices Technical Group when discussing the most effective way to communicate with and engage with landholders to achieve on-ground actions.

Recommendations for direct engagement of landholders

- Acknowledge the past involvement of landholders in catchment programs. #
- When undertaking research be upfront about how information gathered will be used – use should be practical. #
- Ensure workshops allow a two-way flow of information (i.e. provide an avenue for technical advice for landholders). #
- Use case studies of landholders who they may know of that have already done work. #
- Involving fellow landholders in workshops provides an opportunity for networking. #
- Bottom-up approach works best where landholders come up with the issues and solutions. Ask what landholders need and want, rather than working from government agenda. ^
- Bear in mind scepticism over past regulation when approaching landholders. ^
- Lessons learnt from stage one of the Wallis Lake Catchment Plan implementation included establishing a cooperative management system framework ensures expediency, transparency, efficiency and ultimately success – and using a work flowchart that was direct, engaging and open – to encourage continued landholder support and using those landholders that assisted the development of the program as champions to other landholders.
- Officers need to be able to relate to landholders and have a good understanding of what is needed. Personal support is the key. #
- One-to-one advice on farms about what could be done by someone from the industry who is recognised by the industry. ^
- Need to have a flexible approach, as every property and landholder is different. #
- Maintaining contact with landholders and providing an ongoing commitment to keep people on board. *
- Building the capacity of landholders to work with their neighbours providing advice and training on improving land management practices in relation to water quality (using a ‘train the trainer’ model). #

Recommendations for the type of information provided to landholders

- Feedback on the results of planning, research and farm-scale recommendations. *
- Cross-knowledge sharing – within different industries, find out what other people are doing to improve water quality. *
- Evidence of production benefits to 'sell' the NRM works. *
- Identify more acceptable works from a landholder perspective to increase uptake, e.g. off-stream watering and shade without fences. *
- Provide feedback to farmers on research and opportunities for farms to share experiences on what works (for environment and production) across industries. *
- Promote funding opportunities. However, it was noted that many landholders know that funding is available. #
- Distribute information leaflets about the services provided by catchment management practitioners, so that landholders know what kind of assistance is available and where to source that assistance. This would include developing a catchment practitioner profile for distribution across the catchment. *

Recommendations for best methods for encouraging uptake of water quality activities

- Incentives, including financial incentives. *
- Direct invitation to be involved in projects. *
- One-to-one contact through door knocking / farm visits. # *
- Support from the industry being targeted. ^
- Arrange demonstration sites and field days to highlight best practice water quality management and associated production benefits ~ * #. It was suggested that farmers could be involved in doing the work to gain experience. #
- Fact sheets are helpful for those who do not want to attend workshops. #
- Information provided on-farm when people buy property (e.g. through councils, rural supply stores and real estate agents). *
- Directly targeting landholders in priority areas and in a way challenging landholders rather than waiting for interested landholders to come forward. *
- Achieving rapid and accountable on-ground success so that examples of the project could be shown to other interested landholders (case studies); if one person makes a change, it encourages others to follow. #
- General information on the opportunities available through a brochure mail-out and media, responding to general landholder enquiries / interest generated by natural resource management workshops. #

- Visit interested landholders face-to-face to provide an outlet for community concern, and to respond to community interest. ~
- When one landholder signs up for riparian fencing or other project, visit landholders on surrounding properties in an attempt to expand the program and increase landholder cooperation on a local scale. ~
- Undertake ‘whole-catchment approach’ to extension and implementing on ground works. *
- Build the capacity of landholders to work with their neighbours providing advice and training on improving land management practices in relation to water quality (using a ‘train the trainer’ model). #
- Special hardship policies for landholders that may not be physically or financially able to contribute to the project. This was noted with particular reference to small farmers who would find it difficult to pay all costs (i.e. they would need to be making a profit to be able to afford to pay for works). #
- Direct contact with landholders in priority areas through door-knocking and one-to-one farm visits. #
- Distributing information leaflets about the service provided by catchment management practitioners, so that landholders know what kind of assistance is available and where to source assistance. #

~ Input from Rural Management Practices Technical Group.
* Input from Landholder Reference Group.
# Input from landcare groups and landholder workshops / CCI Landholder Survey.
^ Mid Coast Dairy Advancement Group.
< Great Lakes Coastal Catchments Initiative Advisory Committee.
! Other community groups.

Appendix 27: Design points for on-ground works (rural management practices) (Draft)

This appendix has been compiled from the Draft report titled "Management Options for Water Quality in Rural Areas for the Great Lakes Coastal Catchments Initiative (CCI)" (Beale & Dalby in prep) provided by the Department of Primary Industries. Note: At the time of writing, details of some references could not be obtained. Consequently, full references may not appear in the bibliography.

1. Management options for riparian areas

1.1 Riparian fencing: Creeks and rivers

Issues

It was recognised that the riparian zone helps maintain the health of catchment waterways, and that a well-vegetated riparian zone can intercept and filter nutrients and sediments from runoff (Great Lakes Council 2003[DG91]). Even though the riparian zone can be ecologically and economically productive for agricultural pursuits, it is the last buffer zone for aquatic ecosystems (Lovett & Price 2007[DG92]). A reduction in streamwater quality can occur as the result of external influences such as light, temperature, pollutant loading, runoff, invasive species (Castelle, Johnson & Conolly 1994[DG93]), grazing and erosion.

In Australia, riparian land has been degraded with the clearing of native vegetation for agriculture and unmanaged grazing of domestic stock or native and feral animals (Lovett & Price 2007). Stock that have uncontrolled access to riparian zones can overgraze and trample vegetation, leading to bare soil; stock tracks to and from the area can cause erosion (Price, Lovett & Lovett 2004[DG94]). Past clearing and current grazing pressures are recognised as key threats in the Wallis Lakes catchment area (Great Lakes Council 2003[DG95]).

The fact sheet, *Managing riparian land* (Price & Lovett 2002[DG96]a), lists good reasons for managing riparian land:

- decreased erosion
- retention of nutrients
- landscape refuge
- shelter effects
- stock management
- lowered watertable
- maintaining rivercourse
- increased fish stocks
- decreased insect pests

- decreased algal growth
- improved water quality
- healthy ecosystems
- opportunities for diversification
- ecotourism
- increase in capital values.

Stock losses can occur if grazing is permitted in a riparian zone. Steep banks can prevent an injured animal having access back to firm ground. Soil loss from erosion, and increased nutrient supply from faeces and urine, reduce water quality. The following seven reasons to exclude stock from a riparian zone were provided in excellent CSIRO Land & Water Australia publications* *Stock and waterways: a manager's guide* (Staton & O'Sullivan 2006) and *Managing riparian land*, Fact Sheet 1 (Price & Lovett 2002a):

- Stock eat and trample vegetation and seedlings along banks, and this can make the banks unstable, resulting in erosion and loss of soil and nutrients.
- Stock trample and destroy the soil structure, which prevents vegetative growth and regeneration, permits weed invasion, causes erosion, loss of soil and nutrients, and added nutrient loading from faeces and urine.
- Stock pathways to the riparian zone can result in gully erosion which, in turn, can supply sediment to a waterway.
- Stock stir up water, and this can promote downstream sedimentation and pollution and destroy native aquatic habitats.
- Stock effluent pollution can encourage the proliferation of disease organisms, promote algal growth, destroy fish breeding cycles and reduce water quality for downstream users (Staton & O'Sullivan 2006).
- Stock can fall down steep banks or become bogged in riparian zones, and this can result in injury or death.
- Stock that drink water contaminated with silt, manure, algae or other pollutants can have growth problems, resulting in a loss of production (Price & Lovett 2002a).

(* These publications are available free of charge from Land & Water Australia, through CanPrint. See the Resource List at the end of this document for details.)

Advantages

Removing stock from riparian zones – or even limiting their access – can result in increased vegetative cover, stabilisation of banks, reduced soil erosion, improved streamwater quality, improved pasture cover, an increase in rainfall infiltration, an increase in the efficiency of nutrient use and a reduction in salinity (Staton & O'Sullivan 2006). A fenced riparian zone can be a valuable source of fodder during drought times. Economic advantages can be realised with this form of drought-proofing and crash-grazing facility. Stock deaths from attempting to negotiate steep stream banks will be prevented.

Increased vegetative cover and bank stabilisation will provide decreased runoff of soil particles during floods. Soil sediment and nutrients are trapped, and water quality is improved (Price & Lovett 2002a; Price & Tubman 2007[DG97]). Deep-rooted riparian vegetation can help stabilise river banks and protect the banks during floods (Price & Lovett 2002a). A reduction in bank erosion will also reduce the loss of valuable land (Price & Tubman 2007). An increase in taller vegetation (shrubs and trees) in the riparian zone can increase shelter in adjacent paddocks (Spearpoint 2006[DG98]). Shade can also help control nuisance aquatic plants and algae (Price & Tubman 2007).

With well-designed fencing and strategically placed gates, the riparian zone can be used as a stock laneway. Such laneways can also be used as 'long paddocks' during drought times, or for grass or weed control grazing (Spearpoint 2006). For more on this subject, refer to Section 3.1 of this appendix.

Disadvantages

The cost of fencing a riparian zone can be prohibitive, although less expensive alternatives such as electric fencing can be employed. Conventional fences can be damaged or washed away by floodwaters, adding to the expense. However, options such as collapsible fences can be used in floodways to counter this problem. For information on fencing see Section 3.1 of this appendix.

If the creek is the main source of drinking water for stock, then alternative watering options need to be provided and these could also be costly. Alternative options are discussed in Sections 2.2 and 2.3 of this appendix.

Weeds can invade the area and weed control measures need to be put in place. However, once the riparian vegetation establishes, weed growth will be suppressed or stopped.

Feral and native animals could still access the area and cause problems.

Stream bank erosion can still occur as the result of river processes or uses and erosion control measures need to be undertaken. This is discussed below in the subsection 'Impact and effectiveness of buffers in relation to stream bank erosion'.

Design points

Creating a healthy riparian zone buffer has many advantages, including improving water quality.

The width of the buffer is important and this depends on many factors (discussed below):

- Riparian zone health
  A healthy riparian zone should have extent and continuity of habitat, layered vegetation, dominance of native plants, presence of plant debris and natural regeneration of vegetation (Staton & O'Sullivan 2006). Riparian health can be assessed practically using the method Rapid Appraisal of Riparian Condition (RARC). Instructions on using

the method, together with a scoring sheet, can be obtained from http://www.rivers.gov.au.

- Riparian buffer zone width

  The depth of the riparian buffer is important if it is to be effective in managing sediments and nutrients for water quality. A buffer that is too narrow will not be effective, yet one that is too wide will deny farmers a portion of their land (Castelle, Johnson & Conolly 1994). Riparian zone buffer width depends on the size, shape and flow of the waterway; landform features; the existing condition of the riparian land; flood frequency and flood level; and the intended use of the area (Staton & O'Sullivan 2006). In addition, the type of vegetation cover, and the amount and type of pollutant (Price, Lovett & Lovett 2004) need to be considered.

  The foregoing factors need to be considered in relation to the targeted management objective, whether this is to manage nutrients and sediments in runoff from rural land or to remediate stream bank erosion. In a review of buffer size requirements, Castelle, Johnson & Conolly (1994) listed four criteria that determine buffer widths:

  - resource function value
  - intensity of adjacent land use
  - buffer characteristics
  - requirements of specific buffer functions.

  Even though these criteria were identified for aquatic resources, they are applicable for water quality.

  For practical guides on riparian management, the following publications from CSIRO Land & Water Australia are recommended:

  - *Managing riparian widths*, Fact Sheet 13 (Price, Lovett & Lovett 2004)
  - *Stock and waterways: a manager's guide* (Staton & O'Sullivan 2006)
  - *Principles for riparian lands management* (Lovett & Price 2007).

  These publications are available free of charge from Land & Water Australia, through CanPrint. See the bibliography for details.

  An effective riparian 'filter' strip of at least 10 m of grass and 10 m of natural vegetation adjacent to a stream will be effective in stopping about 90% of sediment reaching the water (Price & Lovett 2002a; Prosser, Bunn *et al.* 1999, Prosser & Karssies 2001; Prosser, Karssies *et al*. 1999[DG99]).

  Where water quality is the objective, a table for recommended grass filter strip widths is given in the fact sheet *Managing riparian widths*. Widths are based on annual soil loss and filter gradient, and range from 2 m to greater than 30 m wide for high soil loss and steep slopes (Price, Lovett & Lovett 2004). A combination of a 10 m wide riparian vegetation buffer plus a 5–10 m grass filter strip will trap most sediments, contaminants and nutrients (Price, Lovett & Lovett 2004). If stream bank erosion is the issue, another equation is used for riparian width and this is given in the section, *Impact and effectiveness in relation to stream bank erosion*.

Specific details on buffer widths for managing sediments, nutrients and stream bank erosion are given in subsections 'Impact and effectiveness of buffers in relation to managing sediments and nutrients' and 'Impact and effectiveness of buffers in relation to stream bank erosion'.

- Location of fences and gates
  An ideal fence is one that is built set back from the top of an embankment and placed where a change in land type or a natural landform such as a ridge is present (Staton & O'Sullivan 2006). It is better to build a fence above the floodline to reduce damage and loss to fences, and also to allow the riparian zone to function naturally in times of floods; drop-down fences are another alternative (Staton & O'Sullivan 2006). Straight fences are cheaper to build and if set back from the creek, are less prone to flood damage (Staton & O'Sullivan 2006). Gates can provide access to the riparian zone if necessary for weeding or pest control. Gates should be on high ground as far from the waterway as possible (Staton & O'Sullivan 2006).

  A riparian fence should be at least 5 m, preferably 10 m from the top of the banks of small creeks, at least 30 m for large creeks and rivers, and more than 50 m if a corridor for (wildlife) animal movement is required (Staton & O'Sullivan 2006). Price, Lovett & Lovett (2004) recommended a minimum width of 10 m minimum for a forested zone, or 5 m for a grass filter strip, upslope from the top of the bank if water quality is the issue. If the riparian land comprises trees and has no groundcover or only litter, the width of the riparian zone needs to be wider than a grass strip for the same effectiveness.
- Stock grazing management
  For more information on this objective see Sections 2.2, 2.3 and 2.5 of this appendix, or refer to the CSIRO Land & Water Australia publications *Managing stock*, Fact Sheet 6 (Price & Lovett 2002b) and *Stock and waterways: a manager's guide* (Staton & O'Sullivan 2006) available from Land & Water Australia through CanPrint.
- Vegetation management
  For more information on this objective see Section 4.3 of this appendix, or refer to the CSIRO Land & Water Australia publication *Stream bank stability*, Fact Sheet 2 (Price & Lovett 2002c).

Impact and effectiveness of buffers in relation to managing sediments and nutrients

A grass filter strip can effectively trap sediment, and other solid particles and contaminants, as well as absorbed nitrogen and phosphorus. Grass is able to grow through the trapped sediment, particularly if the species selected is one that produces roots from stem notes (Price, Lovett & Lovett 2004). Native species are recommended but the vegetation must have adequate groundcover to trap particles. A buffer strip of trees without groundcover is not as effective as a layered zone with trees, dense shrubs and groundcover. A combination of a 10 m wide riparian vegetation buffer plus a 5–10 m grass filter strip will trap most sediments, contaminants and nutrients (Price, Lovett & Lovett 2004).

Confined runoff from roadways, stockyards, stock tracks or minor works must have a sufficiently wide grass filter strip adequate for the potential contaminant load (Price, Lovett & Lovett 2004), particularly if these structures are adjacent to a riparian zone.

Impact and effectiveness of buffers in relation to stream bank erosion

Three process of stream bank erosion can occur (Price & Lovett 2002c; Price, Lovett & Lovett 2004):

- sub-aerial erosion where soil on the stream bank is loosened and made prone to being washed away. Good vegetative cover over the whole bank is recommended to prevent this type of erosion. In the CCI area, trampling by stock, and the impact of wind and rain, would be the main causes of sub-aerial erosion. Cracking clay soils are prone to sub-aerial erosion
- scour occurs when the force of water flow undercuts the bank, which can then fall into the waterway. This can occur particularly on outer bends of a stream meander
- slumping also occurs with undercutting, but can also happen if the stream bank soil is saturated from heavy rain or flood water. Banks slump into the waterway often after cracking along natural planes of weakness.

Riparian vegetation protects creek and river banks from erosion, and roots can help dry and reinforce bank soils to prevent cracking and slumping (Price, Lovett & Lovett 2004). Stock access to stream banks should be prevented or controlled so that vegetation is not grazed to bare ground. To protect against stream bank erosion, Price, Lovett & Lovett (2004) recommended a minimum width away from the top of the bank, and provided the formula:

Minimum riparian width = 5 m + bank height (in metres) + erosion rate (in metres)

The erosion rate is calculated as the rate of bank erosion in metres per year multiplied by the least number of years that planted vegetation will reach either maturity or a height of 10 m. For example, if the bank is eroding at 0.5 m per year and planted vegetation is mature in two years time but only reaches a height of 5 m, then the equation is:

Erosion rate = (0.5 m / year × two years) = 1 m.

Another example uses an immature tree that reaches a height of 10 m in four years:

Erosion rate = (0.5 m /year × four years) = 2 m.

Going back to the original equation, the minimum width of a riparian zone is calculated for an area where the bank erodes at 0.5 m per year, the bank height is 1 m, and a tree reaches a height of 10 m in four years but is still immature:

Minimum riparian width = 5 m + bank height (in metres) + erosion rate (in metres)

Minimum riparian width = 5 + 1 + 2 = 8 m.

Legislation, regulations, codes of practice, environmental management systems

The *Native Vegetation Act 2003* states that approval is required for clearing any protected regrowth and remnant native vegetation. The *Native Vegetation Conservation Act 1997* states that clearing is generally not permitted within 20 m of the bed or bank of a stream, or any part of a lake, without development consent. Clearing may be permitted under a regional vegetation plan.

Benefit-cost analysis

Each individual situation would need to be assessed before such an analysis could be made.

1.2 Riparian fencing: Wetlands and constructed wetlands

Issues

Wetlands act as a filter, and screen and recycle sediments and nutrients before they reach a waterway, thus improving water quality downstream. They also regulate streamflow and can help to slow flooding following storms (Brouwer 1995[DG100]). A wetland can provide a habitat and breeding ground for wildlife, including birds and fish (Ryan & Heinrich 1998[DG101]). Migratory birds protected by international agreements are often found in wetlands (Brouwer 1995). Even though wetlands act as a filter, they can be sensitive to an overload of nutrients or sediments. For this reason, the creation of a buffer zone around the wetland can assist a wetland in its water quality role of filtering and screening sediments, nutrients and pollutants.

Grazing pressure on a wetland can reduce vegetative species and remove perennial plants including tree seedlings, which can lead to erosion and siltation (Brouwer 1995). Other issues that affect wetlands through grazing are pugging of the soil, and alteration of the nutrient cycle with faeces and urine (Brouwer 1995). Weeds are often introduced to the wetland area by grazing animals or from water entering the system through catchment processes. The health of the catchment is also important for the health of the wetland where runoff occurs. Catchment management and whole-farm plans could also be essential in managing wetlands.

Many of the issues and management options in Section 1.1 of this appendix are applicable to the management of wetlands.

Advantages

Wetland areas, if fenced, can be a valuable source of fodder during drought periods.

Wetlands can act as groundwater recharge sites. A wetland that can hold excess surface waters drains slowly, returning (recharging) the water to the underground supply (Brouwer 1995; Ryan & Heinrich 1998).

Wetlands can improve water quality by filtering and screening nutrients, pollutants and sediments from water entering a waterway.

Wetlands encourage birds, which can help to control farm insect pests (Brouwer 1995).

Disadvantages

Loss of productive land can occur.

Also refer to Section 1.1 of this appendix.

Design points

Refer to Section 1.1 of this appendix, although simpler fences to those used there can suffice for a wetland area.

Use whole-farm management plans, particularly where catchment processes affect wetlands.

If the wetland is used for stock watering purposes, provide drinking troughs away from the wetland buffer area. See Section 2.3.

The buffer zone could be used for tree crops or flowering trees for bees to compensate for the land lost to other rural production (Allen & Walker 2000[DG102]).

- Riparian buffer zone width
  The minimum buffer width for a wetland differs from that for creeks or rivers. Price, Lovett & Lovett (2004) listed the recommended widths used in the Swan Coastal Plain in Western Australia:
  - maintain ecological processes: 20–50 m from the outer edge of open water
  - reduce nutrient inputs: 200 m from boundary of wetland-dependent vegetation
  - minimise sedimentation: 100 m from outer edge of seasonally inundated zone
  - protect groundwater: 2 km in direction from groundwater flow.
- Location of fences and gates
  Strategic gate placement will assist with management of a wetland area, particularly those that might be occasionally grazed, or for weed and pest management. Refer to Section 1.1 of this appendix.

  Fencing generally does not need to be elaborate for wetland areas (Spearpoint 2006) compared with that for a riparian zone adjacent to a stream.

Impact and effectiveness of buffers in relation to managing sediments and nutrients

Brouwer (1995) listed the importance of plants that grow in and around wetlands; they:

- stabilise the soil to prevent erosion
- slow the flow of water, effectively trapping and holding particles in suspension
- sieve particles before settling out
- use, and thus remove, nutrients such as nitrogen, phosphorus and metals.

A natural wetland on the Crakenback River near Thredbo effectively removes up to 44% of incoming phosphorus and up to 66% nitrogen (Brouwer 1995). Nutrient cycling is improved as wetlands dry out periodically.

Legislation, regulations, codes of practice, environmental management systems

SEPP 14 covers clearing, draining, filling or construction of levees for coastal wetlands.

Clearing within 20 m of a declared environmentally sensitive area requires approval under the *Soil Conservation Act 1938*.

The NSW Wetlands Management Policy encourages the management of NSW wetlands to halt and, where possible, reverse: loss of wetland vegetation; declining water policy; declining natural productivity; loss of biological diversity; and declining natural flood mitigation. Projects and activities that will restore the quality of the state's wetlands are encouraged, such as: rehabilitating wetlands; re-establishing buffer vegetation areas around wetlands; and ensuring adequate water to restore wetland habitats (DLWC 1996[DG103]).

The Ramsar Convention defines a wetland as:

> "an area of marsh, fen peat land or water, either natural or artificial, permanent or temporary, with water that is static of flowing, fresh brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

Only those wetlands that are designated under this Convention are affected. The Myall Lakes were designated as a Ramsar wetland in 1999 because they met the criteria (NPWS 2006[DG104]):

- Criteria 1a, 1c Representative or Unique Wetlands: The Myall Lakes wetlands cover an extensive area, are in near-natural condition, and are one of the most important remaining coastal brackish systems and a good example of the barrier lagoon system.
- Criterion 2a Plants or Animals: The Myall Lakes have a wide range of native animals including threatened species. A diversity of vegetation including threatened species is also present. A number of plant communities are recognised as having state significance due to their restricted distribution and pristine condition.
- Criterion 3b Waterfowl: The Myall Lakes are home to a large number of waterbirds including migratory species covered by JAMBA and CAMBA.

Constructed wetlands

Artificial wetlands can be constructed to help manage a variety of situations covering water storage, flood control, erosion control, conservation habitat for native birds and animals, landscape aesthetics or recreation (Brouwer 1995). These can be constructed purely as a wetland or incorporated with a dam. In the CCI area, artificial wetlands for managing dairy shed effluent would be a useful management option. The following publications and manuals are recommended for detailed information on this topic:

- *The Constructed Wetlands Manual* (Volumes 1 and 2), 1998, Department of Land and Water Conservation.
- *Treatment Wetlands*, 1996, Robert H Kadlec & Robert L Knight, CRC Press LLC, Boca Raton, Florida.

This book [DG105]is a comprehensive survey of the technology involved in constructing and managing wetlands for wastewater treatment. It examines the planning, design, construction, and operation of wetlands used for water quality treatment. Topics include wetland configurations, wastewater sources and combinations of climatic conditions. Detailed information is provided on wetland ecology, wetland water quality, selection of appropriate technology, design for consistent performance, construction guidance and operational control through effective monitoring. Design approaches that can be tailored to specific wetland treatment projects are also included (Amazon Books 2007[DG106]).

- *Natural systems for waste management and treatment*, 2nd ed., Sherwood C Reed, Ronald W Crites & E Joe Middlebrook, McGraw Hill Inc., New York.

1.3 Riparian fencing: Farm dams

Issues

Stock tend to congregate around dams and the surrounding area; stock graze, camp on and trample the edges and wall of a dam, which will become degraded, eroded and eventually unstable (Brouwer 1995). Similarly, the spillway can become destabilised and edges eroded, which can cause sedimentation in the spillway (Brouwer 1995) and be transported to nearby waterways. Trees, shrubs and grass will be grazed, further adding to the risk of erosion.

Sediment from dam surrounds that enters the dam will reduce the lifespan of the dam or increase maintenance requirements. Lloyd, Bishop & Reinfelds (1998) [DG107]cited examples where 37% to 85% of the sediment found in dams is derived from erosion of the dam bank and surrounds. This sediment can be transported to streams in high-flow events.

Stock congregate in and around the dam, and concentrations of nutrients and faecal material in this area will occur. As dams are constructed across waterways, a greater likelihood of runoff of this material will occur that could affect water quality downstream.

Stock camping in and around the dam will concentrate nutrients and faecal material in that area. Direct deposition of faecal material in a dam is a potential source for transmission of pathogens. This can lead to eutrophication of a dam, which can lead to stock poisoning by toxic blue-green algae (Willms *et al.* 2002[DG108]). Organisms of potential concern to young stock include *Escherichia coli* (*E. coli*), *Cryptosporidium*, *Salmonella* and *Leptospira* spp. (Lardner, Kirychuk, Braul, Willms & Yarotski 2005[DG109]; Willms *et al.* 2002).

Turbid and excretal matter contaminates water and reduces stock preference for drinking dam water (Willms *et al.* 2002).

Grass and tree buffers around dams, and macrophytes in dams, provide potential increases in the area of riparian and wetland function in the catchment (Casanova, Douglas-Hill, Brock, Muschal & Bales 1997[DG110]). Reduced cattle entry to the dam may reduce nutrient status and lower turbidity, which promotes macrophyte establishment.

The state of dams varies considerably in regard to factors such depth, turbidity or presence of macrophyte species, and degree of eutrophication (Casanova, Douglas-Hill, Brock, Muschal & Bales 1997). This can provide a visual indicator of catchment health and local processes.

Advantages

Fencing a dam implies either limited access to the dam, or the use of troughs fed by the dams. The use of troughs provides an opportunity to locate watering points out of the waterway to areas that may improve grazing distribution.

See Sections 1.1, 1.2 and 2.3 of this appendix.

Disadvantages

See Sections 1.1 and 1.2 of this appendix.

Design points

Fence the dam, inlet and spillway.

Install in-dam filters to help stabilise dam sediments; and decrease turbidity, excess plant growth and algal blooms (Ryan & Heinrich 1998).

Maintenance storage levels can be set using pipes through the dam, but allow additional capacity to capture major runoff events.

Provide watering points away from the dam in non-convergent landscapes.

Provide shade trees away from the dam.

Impact and effectiveness in relation to managing sediments and nutrients

See Sections 1.1 and 1.2 of this appendix.

Dam banks and surrounds are essentially riparian areas that respond to cattle exclusion in the same way streams do (Lloyd, Bishop & Reinfelds 1998).

Legislation, regulations, codes of practice, environmental management systems
See Sections 1.1 and 1.2 of this appendix.

2. Management options for the paddock

2.1 Creek crossings

Issues
At certain times in some situations, stock will need to cross the waterway to move from one paddock to another. Care in the design and construction of the crossing must be taken to limit creek damage caused by stock. The design should also not interfere with water flow or impede fish passage. Stock access to the crossing should be controlled by gates or grazing management measures.

Advantages
Easy stock movement between paddocks can be obtained with a well-designed crossing.

Fish passage is not impeded.

Disadvantages
Water quality can be compromised by stock effluent being deposited direct to the waterway.

Building a crossing can be expensive and time-consuming. Flood damage is a distinct possibility.

Design points
Build the crossing on a straight section of the waterway after a bend or at a crossover point in a meander where the main flow heads towards the centre of the channel (Price & Lovett 1999[DG111]). Water accelerating around a bend in the creek can cause erosion and damage to the crossing (Staton & O'Sullivan 2006). Staton and O'Sullivan (2006) provided points for selecting a crossing site:

- Choose a site that is at a higher point along the waterway.
- The site must have firm footing.
- The site should not be boggy, eroded or degraded.
- Bank slope should not be too steep and ideally less than 4:1.
- The site should be on a narrower, rather than wider, section.
- Easy stock movement must be considered.

The crossing need not be fenced if it is only used to move stock under supervision (Staton & O'Sullivan 2006).

For construction points, the reader is referred to the CSIRO Land & Water Australia publication *Stock and waterways: a manager's guide* (Staton & O'Sullivan 2006) available through CanPrint.

Impact and effectiveness of buffers in relation to managing sediments and nutrients

It is expected that this management practice will be almost as effective as fencing riparian zones for full exclusion of cattle. However, sedimentation may occur depending on the state of the roadway leading to the crossing. Nutrients, such as phosphorus and nitrogen, will reach the creek from stock urinating and defecating as they use the crossing. The extent of this will depend on whether stock crossings are managed or whether stock can cross freely at all times. In the case of stock having free access to the crossing, stock lingering in this area will add to the intensity of nutrients entering the water.

Legislation, regulations, codes of practice, environmental management systems

Approval to build a crossing may be required, particularly if the crossing alters the flow of the creek.

2.2 On-stream watering

Issues

In some situations the waterway is the main source of drinking water for stock, and off-stream watering might not be an ideal option. Water access points on creeks and rivers can be constructed to create minimal damage to riparian areas.

Advantages

This is a relatively inexpensive option that can significantly reduce stock impacts to the riparian zone (Price & Lovett 2002b).

Stock can be watered from a waterway without damage to the bank if the access point is built in the correct position (Price & Lovett 2002b).

Water access points can alleviate the need for expensive off-stream watering points.

Disadvantages

Water quality can be affected by stock effluent being deposited in the access area.

Flood damage is a distinct possibility.

Design points

Water access points are best located in areas with firm footing, away from boggy areas on the inside of a bend where water flow is slow and banks are less prone to erosion (Price & Lovett 2002b; Staton & O'Sullivan 2006).

The area should have little or no shade to discourage stock from staying in the area (Staton & O'Sullivan 2006).

Ideally, the access point should be on gently-sloping bank with a maximum slope of 1:6 to reduce erosion (Staton & O'Sullivan 2006). Construct the access point with compacted gravel, rocks, logs or concrete. It should be built at an angle in the downstream direction to prevent water flowing into the access point and eroding the bank (Staton & O'Sullivan 2006).

Water access points should be fenced.

For construction notes refer to the CSIRO Land & Water Australia publication *Stock and waterways: a manager's guide* (Staton & O'Sullivan 2006) available through CanPrint.

Impact and effectiveness of buffers in relation to managing sediments and nutrients

It is expected that this management practice will be almost as effective as fencing riparian zones for full exclusion of cattle. However, sedimentation may occur depending on the state of the laneway leading to the water access point. Nutrients can reach the creek from the access area.

Legislation, regulations, codes of practice, environmental management systems

Approval to build the water access point may be required in the event that the construction alters the flow of the creek.

2.3 Off-stream watering

Issues

Stream bank erosion and water contamination from stock grazing in a riparian zone are issues that can be addressed with off-stream watering. Stock grazing in riparian areas promotes vegetation loss and destruction of the soil structure, which leads to stream bank erosion. Sedimentation and pollution of waterways, as well as destruction of native aquatic habitats, can result from stock movements in the waterway. Water quality is affected by nutrients that are added through faeces and urine.

Fresh, clean water from a trough is often better in quality than that from farm dams. In addition, cattle prefer easier access to a water trough, as opposed to negotiating a steep creek or river bank (Spearpoint 2006). This was confirmed in a study by Sheffield, Mostaghimi, Vaughan, Collins & Allen (1997) that evaluated the effectiveness of providing cattle with an off-stream water source to reduce stream bank erosion and improve water quality. Cattle preferred to drink from a water trough 92% of the time compared with drinking from a waterway (Sheffield, Mostaghimi, Vaughan, Collins & Allen 1997).

Advantages

Watering points with access to shade, which are positioned close to preferred pastures, can reduce the amount of time stock spend in riparian areas (Price & Lovett 2002b). This can reduce the need for expensive riparian zone fencing.

Animal health, growth rates and productivity increase if stock have ready access to clean, unpolluted water (Price & Lovett 2002b).

Staton *et al.* (2005) [DG112]provided benefits of a watering system:

- cleaner water for healthier and more productive stock
- flexibility to match the needs of stock – such as pregnant and lactating animals – to pasture availability
- better control over grazing patterns and improved feed utilisation
- better control over stock movements including rotational or cell grazing
- reduced mustering times
- lower stock losses in times of flood
- improved riparian health with reduced stock access to the riparian zone.

Disadvantages

Initial installation can be expensive and time-consuming, and the system requires ongoing maintenance and operating costs (Staton & O'Sullivan 2006).

Time and effort need to be invested in the maintenance, monitoring and refilling of water troughs (Spearpoint 2006).

Water sources may need to be established, and this will require an initial cost outlay.

Design points

The watering system depends on the water source, the amount of water required, paddock layout, the distance between the water supply and delivery point, and the difference in elevation between the water supply and delivery point (Staton & O'Sullivan 2006).

Position the water trough in the paddock as far away as possible from the riparian zone.

Position the water trough away from boggy, fragile or degraded areas (Staton & O'Sullivan 2006).

Cross-paddock stock movements can be promoted if shade is provided away from the watering point. Allow about 3 km between shade and water points for effective grazing and animal production (Staton & O'Sullivan 2006).

Reposition fences to take advantage of an existing water supply – the existence of a spring, soak or depression for a dam; or for the gravity feed option [DG113](Staton & O'Sullivan 2006).

Allow for additional watering points during installation of the system. This will provide back-up if the main endpoint fails or needs repair, and assist in further stock grazing movements and plans (Staton & O'Sullivan 2006).

Height differential is another aspect that needs consideration when installing a watering system. A gravity-fed system – where the water supply is higher than the watering point – is optimal, provided the system is designed with peak water requirements in mind. If the watering point is higher than the water supply, then pumps need to be installed. The following pumping system notes are from Staton and O'Sullivan (2006):

- Electrical mains power
  If mains power is available, electric pumps are often the best option for continuous pumping of large volumes of water. The pump can be set up to stop with a change in pressure.
- Petrol or diesel pumps
  These fuel pumps need to be constantly refuelled and are not as easily automated as electrical pumps. Diesel pumps are suitable for continuous pumping of large volumes of water. Petrol pumps are suitable for occasional use such as a back-up pump in the event of electric pump or power failure.
- Solar power
  Solar-powered pumps are often ideal for use in remote areas. Solar power has become an economical and efficient way of supplying electricity. Even though solar pumps are not as powerful as other types of pumps, they are suitable for pumping low volumes of water over shorter distances (less than 2 km) and lower heights. Running costs are nil. Pumping performance varies with the season and the number of sunshine days. Used in conjunction with a tank – with a five-day capacity and back-up batteries – this can compensate for variability in performance or cloudy days.
- Wind power
  High maintenance costs and unreliability of wind-powered systems have resulted in a change to solar power. Wind is more suitable for pumping low volumes of water and the pumps are generally used in conjunction with a tank of 7–10 days capacity.
- Air
  An air compressor can be located near mains power but away from the pump. This can be advantageous if mains power is available but some distance from the watering point. Solar power can be used to power the compressor. Air-powered pumps are suitable for continuous operation at low volume and where the water supply is intermittent.

- Ram pumps
  Ram pumps use water flow to pump water from a waterway and, as such, are dependent on water velocity for the volume of water. A fall of at least 1 m is needed for the pump to operate. Ram pumps are suitable for pumping low volumes of water when the water flow is at its highest.
- Stock-operated pumps
  Stock can be easily trained to operate these pumps, whereby stock push against a lever to drive a piston or other mechanism to pump the water. Stock-operated pumps are cheap to purchase, easily mounted on skids for portability, have no operating costs and no water wastage. They are only suitable for low volumes.

Impact and effectiveness of buffers in relation to managing sediments and nutrients

This management option could be most effective if watering points mean stock do not having access to riparian zones or other sensitive areas.

Legislation, regulations, codes of practice, environmental management systems

A permit or licence may be required to take water from a waterway, water body or groundwater source (Staton & O'Sullivan 2006). Building a dam may require a licence and approval from the Department of Environment and Climate Change. The following information sheets clearly explain the procedure:

- *What are rural landholders' basic rights to water?* (Department of Natural Resources (DNR) 2006d; DNR is now the Department of Environment and Climate Change) http://naturalresources.nsw.gov.au/water/pdf/rural_landholder_basic_rights-f.pdf
- *Water for my rural property – do I require a licence?* (DNR 2006e) http://naturalresources.nsw.gov.au/water/pdf/do_i_need_a_licence_b.pdf
- *Farm dams – do you need a licence?* (DNR 2006f) http://www.naturalresources.nsw.gov.au/water/pdf/when_do_you_need_licence-g.pdf
- *Farm dams – where can they be built without a licence?* (DNR 2006g) http://www.naturalresources.nsw.gov.au/water/pdf/fd_where_can_they_be_built_without_licence-c.pdf

Benefit-cost analysis

A benefit-cost analysis for these management options would be difficult to present. It would depend on each situation, the distance of transporting the water, the type of pumps used and the cost of running the pumps.

2.4 Off-stream shade

Issues

Stream bank erosion and water contamination from stock grazing in a riparian zone are issues that can be addressed with off-stream watering and, in this option, off-stream shade.

Advantages

Access to shade, together with watering points, which are positioned close to preferred pastures, can reduce the amount of time stock spend in riparian areas (Price & Lovett 2002b). This can reduce the need for expensive riparian zone fencing.

Disadvantages

If no shade areas exist away from the waterway, setting up an area could be time-consuming and costly depending on the number of species that need to be planted.

Time is needed before the plants are mature and fencing of the area could be necessary while the plants establish.

Design points

For setting up a shade area, choose vegetation that is layered (trees, shrubs and groundcover), easy to establish and preferably native to the area.

Carefully select the area to be vegetated.

Realign paddocks around existing shade areas.

Cross-paddock stock movements can be promoted if the watering point is located away from shade areas.

Impact and effectiveness in relation to managing sediments and nutrients

This management option could be most effective if shade means stock have either no access or restricted access to riparian zones or other sensitive areas.

2.5 Stock grazing plans

Issues

Often the only way to completely restore riparian health is to exclude stock from the area (Staton & O'Sullivan 2006). The same applies to other degraded areas, such as gullies and even remnant woodland, on a farm. Once an area has been restored, controlled grazing could become part of the management plan.

Advantages

If these riparian zones and other areas are in very poor condition because of high grazing pressure, then it could be argued that complete exclusion of stock outweighs any benefits from grazing these areas (Staton & O'Sullivan 2006).

Disadvantages

These topics have already been covered in Sections 1.1, 2.1, 2.3 and 2.4 of this appendix.

Design points

Exclude or restrict and control stock using fencing, feed supplements, watering systems and shade.

Check for signs of actual or potential damage to a grazed area (Staton & O'Sullivan 2006). Remove stock from, or reduce grazing pressure to, this area according to the risk.

- Controlled grazing
  This management practice requires regular monitoring and being able to manipulate grazing pressure to avoid damage to pasture, vegetation and soil (Staton & O'Sullivan 2006). Signs of damage, such as pasture height and quality, need to be recognised. Staton and O'Sullivan (2006) listed points for manipulating grazing pressure by controlling the:

- timing of grazing.

  Riparian land and other sensitive areas should only be grazed when vegetation is dormant and soil moisture levels are low. Grazing of these areas should be avoided following heavy rain, floods or fire because these events can trigger germination in native plants. Grazing when plants are dormant – or when there is less impact on plant growth, seed and root production – increases the ability of plants to set seed and send out new growth. A good understanding of the growth cycles of plants is necessary. Stock should be excluded from riparian and other sensitive areas when heavy rainfall is expected to avoid pugging and compaction of moist soil. Stock should also be excluded from these areas in very dry times if vegetation is sparse to avoid erosion and degradation.
- duration of grazing.
- Continuous grazing or set stocking even at low pressure should be avoided in riparian zones and other sensitive areas. It has been shown that riparian areas recover quickly in response to periods of rest from either exclusion or controlled grazing (Ash, Corfield & Ksiksi n.d.; Jansen & Robertson 2001[DG114]).
- intensity of grazing.
- Conservative stocking rates or grazing young, lighter weight stock can assist in situations such as pugging or soil erosion; or when vegetation or pasture cover is low can assist in management of the riparian zone. Grazing intensity could be increased for weed control measures.

- Other methods of stock control

  Stock tend congregate around watering holes, under shade and in riparian areas if the feed is plentiful in that area. They also tend to congregate around artificial watering points. To entice stock from these areas, provide:

  - an alternative source of clean water in another location away from the area
  - feed supplements or mineral licks in another location
  - new growth by burning off another area to stimulate new growth.

  Watering points should be kept away from shade to deter stock from camping there. They also should not be placed in areas where faeces and urine could be channelled into a waterway. The provision of additional watering points will assist in stock control and movement (Staton & O'Sullivan 2006).

Impact and effectiveness in relation to managing sediments and nutrients

These topics have been covered in Sections 1.1, 2.1, 2.3 and 2.4 of this appendix.

2.6 Productive pastures and fertilisers

Issues

More productive pastures provide better grazing areas, and greater filtering and cycling of nutrients. In addition, better pasture cover can assist with infiltration of water into the soil.

Advantages

Knowledge of a paddock's fertility can save a lot of money in reduced fertiliser application or a change of fertiliser type.

Additional fertiliser application, while costly at the outset, can improve paddock fertility and stock health.

Disadvantages

Cost of soil testing procedures.

Design points

Care with fertiliser application can avoid nutrient leaching or runoff and associated costs of loss of fertiliser applied.

Sow legumes to supply nitrogen.

Reduce soil disturbance from conventional cultivation by direct drilling seed for pasture establishment in flood-prone areas (Spearpoint 2006).

If necessary, apply lime to raise soil pH to promote pasture growth.

Seek the help of an agronomist.

Use nutrient budgets to forecast removal of nutrients with grazing and rate to reapply for pasture production maintenance (Spearpoint 2006).

Undertake follow-up soil tests to assess fertility improvement in paddocks.

Fertiliser applications should be timed before seasonal rain (spring to early summer in the CCI area) to take advantage of this rainfall for pasture growth. However, do not time fertiliser application just before a predicted storm or other high rainfall event, so as to avoid runoff of fertiliser into adjacent waterways.

3. Farm infrastructure

3.1 Planning, construction and maintenance: Paddocks, stockyards, fences and gates

Issues

Water quality is the general issue addressed by this management option. Nutrients and sediments in runoff as a result of grazing land management practices need to be addressed. Many of these have been covered in earlier management options.

A farm management plan should be used to effectively plan paddocks, stockyards, fences and laneways.

Advantages

Paddocks designed and sized according to land classes that are based on fertility or management can make stock movement easier (Spearpoint 2006).

- Fences

  For riparian zone fencing, straight fences are cheaper to build and, if set back from the creek, are less prone to flood damage (Staton & O'Sullivan 2006). A set back of at least 10–20 m (Price & Lovett 2002b) is practical if the area is to be used to occasionally graze stock or for stock movements.

  Hanging fences built across narrow streams prevent stock bypassing fences and having access along the stream (Price & Lovett 2002b). Price and Lovett (2002b) described these fences that are suspended from a steel cable or multi-stranded, high-tensile fencing wire strung across the waterway. Attached to this cable or wire are hanging panels that are designed to ride up and down with water flows fluctuation; the panels are easily replaced if damaged by flood debris (Price & Lovett 2002b).

  Electric fences designed to use along and across waterways are cheap to initially construct and cheap to repair following flood damage. A clear diagrammatic design of a suitable electric fence and electrified flood gate is given in the CSIRO Land & Water Australia publication *Managing stock,* Fact Sheet 6 (Price & Lovett 2002b), available free of charge from Land & Water Australia.

  Drop fences are designed to be 'dropped', either manually or under pressure from floodwater debris. Stock or vehicle movement can be facilitated with a drop fence without the need for gates (Price & Lovett 2002b).

  Electronic fencing is another option that is in the design and development stage in Australia. Transmitters define a boundary and an electronic ear-tag gives an electric stimulus to the animal's ear if it ventures into the exclusion zone (Price & Lovett 2002b).

  For more information on fencing materials and construction, including advantages and disadvantages of each, see *Stock and waterways: A manager's guide* (Staton &

O'Sullivan 2006) available free of charge from Land & Water Australia. Information on building flood-resistant fences is also included.

- Gates
  Strategic placement of gates will allow for optional changes in the management of stock or for weed and grass control.

Impact and effectiveness in relation to managing sediments and nutrients

This management option could be very effective in managing nutrients if the positioning of paddocks, stockyards, fences, gates and laneways is carefully designed in conjunction with good pasture and grazing management.

3.2 Planning, construction and maintenance: Farm roads, tracks and laneways

Issues

Farm tracks and laneways can be a significant source of sediment to waterways due to:

- exposed soil surface eroding at a rate of 10 to 200 t/ha/yr (Lu *et al.* 2003[DG115])
- compacted soil, which reduces infiltration and increases the proportion of rain that is lost in runoff from a norm of 5–20% to 80% (Croke, Hairsine & Fogarty 1999[DG116]b).
- stock movement and vehicle traffic, which produces a reserve of fine sediments available for transport (Croke, Hairsine & Fogarty 1999b)
- connectivity to streams being high at crossing and farm entrance to roadways
- cuttings and drains exposing clay subsoils that have fine sediments that are more available for transport
- tracks often intercepting drainage lines across the farm, which can channel flows in concentrated pathways. This can lead to initiation of gullies.

Congregation of stock on tracks and laneways increases nutrient source and faecal contamination of runoff and leachate.

Prevention of gully formation is far easier than remediating gullies.

Advantages

See Sections 1.1 and 1.2 in this appendix.

Well-designed tracks can:

- reduce lameness in dairy cattle
- improve access
- enable timely farm management practice
- result in less vehicle maintenance.

Existing infrastructure can often be upgraded and redesigned to improve stock movement, water conservation and vehicle access. Many well-established techniques can reduce sediment delivery to streams from roads. Mitre drains are a good example.

Disadvantages

Costs of gravelling or rerouting existing roads can be high.

Design points

As with other issues, management involves reducing the impact of the source and restricting sediment transport.

Design requirements are dependent on:

- the frequency and type of use of the roadways
- the physical characteristics of the site, such as slope, soil type and rainfall
- connectivity of the outlets to drainage lines and watercourses.

To document the full extent of design requirements is well beyond the scope of this brief. The reader is directed to the following resources:

- *Managing sediment sources and movement in forests: The forest industry and water quality*. Industry Report 99/11 (Croke, Hairsine & Fogarty 1999a)
- *Tracks and roads*, DPI, Victoria (Cummings 1999) http://www.nre.vic.gov.au/DPI/nreninf.nsf/childdocs/-2BAF4D73531CD1544A2568B3000505AF-57D1EB72F146450ECA256BC80004E8DD-966D71ECF369B7C44A256DEA0027B670-3698841B41D97B34CA256BCF000AD50E?open
- *Guidelines for the planning, construction and maintenance of tracks* (DLWC 1994) http://www.dnr.nsw.gov.au/care/soil/soil_pubs/pdfs/guidelines_tracks.pdf
- *Soil erosion solutions. Fact sheet 6: Roads and tracks* (DPI n.d) http://www.northern.cma.nsw.gov.au/pdf/tracks.pdf

- Source-related controls
    - During construction, avoid exposure of subsoils.
    - Limit road distances required; for example, site house, sheds and stock yards, and other buildings reasonably close together and near the main road.
    - Site paddock gateways and laneways to avoid traffic through wet and boggy areas.
    - Use appropriate road base and surfaces such as a high proportion of coarse gravel, restrict fines, compact properly.
    - Avoid unnecessary use of tracks and use low-impact vehicles; even in dry conditions, use will create enough disturbance to generate a reserve of sediments.
    - Avoid stock and vehicle use in wet conditions.
    - Make stock laneways wide enough to avoid stock concentration.

  - Establish grass in stock laneways.
  - Time construction to avoid wet periods.
  - Do not put your house on top of the hill just to get the view.

- Transport-related controls
  - Locate high-use tracks away from water courses.
  - Establish wide, flat drains that can be grassed.
  - Keep drains rough, shallow and wide.
  - Design culverts with overflow capacity.
  - Use mitres, crossover tracks and relief culverts frequently to reduce runoff velocity.
  - Use grass or tree filter strips to help disperse water and intercept sediments both above and below roads.
  - Limit water access to the soil under the track.
  - Revegetate waste areas.
  - Do not let construction debris, including soil, enter waterways.
  - Install sediment traps until the area is revegetated and stable.
  - Use a raised outer edge on fill areas.
  - Stream approaches should be as flat as possible.

Impact and effectiveness in relation to managing sediments and nutrients

See Sections 1.1 and 1.2 of this appendix.

Any reduction in runoff from tracks will reduce sediments and nutrients entering the watercourse.

Legislation, regulations, codes of practice, environmental management system

See Sections 1.1 and 1.2 of this appendix.

Benefit-cost analysis (if possible)

A benefit-cost analysis for this management factor is very site-specific and impossible to calculate at this point.

4. Remediation measures

4.1 Remediation of gullies and other erosion areas

Issues

Gullies with steep slopes, eroding soil and high runoff volumes are not suitable for grazing. Grazing can cause further erosion and advance of the gully.

Advantages

Erosion can be curbed or even stopped with remediation measures.

Revegetation can provide shade and habitat for wildlife (Ryan & Heinrich 1998).

Nutrient loss and sedimentation as a result of runoff can be reduced with revegetation of eroded areas.

Disadvantages

Remediation measures, particularly gullies, are often very costly.

Impact and effectiveness in relation to managing sediments and nutrients

See Sections 1.1 and 1.3 of this appendix.

4.2 Remediation of creek and river banks

Issues

Riparian vegetation protects creek and river banks from erosion, and roots can help to dry and reinforce bank soils to prevent cracking and slumping (Price, Lovett & Lovett 2004).

Advantages

See Section 1.1 of this appendix.

Disadvantages

See Section 1.1 of this appendix.

Design points (Spearpoint 2006)

Stream bank erosion can still occur after remediation has commenced.

Water-edge plants can provide a protective barrier to undercut sections.

Planting river reeds can be less costly than structural woks.

Use fallen trees and plant behind these.

Use slumped bank areas for planting.

Stilt barriers to reduce water velocity and protect degraded areas.

Impact and effectiveness in relation to managing sediments

See Section 1.1 of this appendix.

Impact and Effectiveness in Relation to Managing Nutrients

See Section 1.1 of this appendix.

4.3 Revegetation, weed management and feral animal control

Issues

Riparian vegetation protects creek and river banks from erosion, and roots can help to dry and reinforce bank soils to prevent cracking and slumping (Price, Lovett & Lovett 2004).

Off-stream shade can help with stock control, and keep stock from riparian and other sensitive areas.

Impact of deer and some native animals can be detrimental in the CCI area. Although rabbits can destabilise stream banks, they are not considered a major pest in the area.

Advantages

See earlier management options such as Sections 1.1 and 2.4 of this appendix.

Disadvantages

See the management option in Section 2.4 of this appendix.

Design points

- Vegetation regeneration and planting

  Various methods can be used to re-establish native vegetation such as seedlings, direct seeding or indirect seeding using topsoil from other local buffer areas (Allen & Walker 2000). Assess the best time of year to plant; in Paterson, NSW, this was in autumn following rains (Spearpoint 2006), which would be applicable to the CCI area.

  Spearpoint (2006), unless otherwise referenced, provided the following suggestions:

  - Study species habits for suitability in certain areas: quicker to establish but short lifespan; slow to establish but long lifespan; invasive species; upper slope and lower slope species.
  - Natural revegetation can be encouraged by limiting stock for less effort and less cost compared with establishing new plants. However, this process may be slow and the new seedlings may suffer competition from weeds (Allen & Walker 2000).
  - Regenerate bush with people trained in native plant regeneration and weed control using ‘cut and paint’ methods and selective weed control.
  - Determine if a total revegetation plan is necessary and plan for understorey, mid-storey, trees and groundcover. Ensure plantings have a diversity of species.
  - Plant to suit maturing of trees; do not plant too densely to avoid groundcover loss.
- Windbreaks and wildlife corridors

  The location of windbreaks and wildlife corridors are important for water quality, and these should be considered for revegetation schemes or as part of the planning and design process of the whole farm.

  Windbreaks provide shade for grazing animals, and can improve water quality by helping control erosion and assisting with moisture infiltration into the soil.

- Weed control
  In sensitive areas it may be better to remove weeds by hand, as opposed to using herbicides (Allen & Walker 2000) or mechanical means.

  Use a range of control methods. Annual follow-up must be undertaken to eradicate weeds established from seedbank reserves. Strategic grazing can be used to control weeds and manipulate groundcover (Spearpoint 2006).

  Care needs to be taken to minimise soil disturbance when weeding, and work away from areas of native plants towards weeds (Allen & Walker 2000).

  Water weeds, such as alligator weed or water hyacinth, also need to be controlled.

- Pest control
  Check monitoring, controlling and baiting programs with the Rural Lands Protection Board (Spearpoint 2006).

Impact and effectiveness in relation to managing sediments
As for Section 2.4 of this appendix.

Impact and effectiveness in relation to managing nutrients
As for Section 2.4 of this appendix.

5. Pasture and grazing management

5.1 Managing groundcover

Issues
Maintenance of groundcover is **the** main strategy for protecting the soil in hillslope areas, and in the case of gullies and stream bank erosion.

Groundcover also has an important role in reducing runoff volume, and trapping particulate P and N and faecal matter. Pastures are essentially a buffer / filter strip in themselves.

Exposed soil is a store of sediments available for transport. The CCI area is rated a high rainfall erosivity area, hence the threat of erosion is always present. Exposed soils can erode 80 to 250 t/ha/yr.

Groundcover levels are threatened by:

- overgrazing
- burning
- cultivation for pasture establishment
- stock traffic on tracks, watering points, laneways and camps
- treading damage caused by stock movement in wet conditions.

The effect of these practices depends on the duration, degree and timing of groundcover loss. It is also dependent on the degree of soil disturbance and the slope of the land. Groundcover can be improved by fertiliser application, lenient grazing and promoting perennial grasses.

In the CCI area, observations suggest that native perennial pastures are most likely to have low groundcover. Dense kikuyu pastures are least likely to have low groundcover.

Advantages

Maintaining groundcover is a relatively simple, cost-effective tool that has both productivity and environmental benefits:

- Higher animal and pasture production can be achieved by maintaining a residual herbage mass of over 1 t/ha, which improves response time after grazing in perennial ryegrass (Fulkerson & Donaghy 2001; Lemaire & Chapman 1996; Parsons & Chapman 2000[DG117]).
- Pasture intake in cattle is minimal below 1 t/ha, with no real gain grazing lower than these levels. This is particularly true of the low-quality species such as carpet grass.
- Increased persistence of perennial grasses is also more likely by maintaining residual herbage mass over 1 t/ha (Dowling, Kemp, Michalk, Klein & Millar 1996[DG118]).
- Soil biota and nutrient cycling are improved by the effect of litter on soil temperatures, and the supply of labile carbon to the soil surface in the form of litter (Lodge & King 2006[DG119]).
- Evaporation losses can be reduced by litter and hence more water used for transpiration (Murphy & Lodge 2001[DG120]).
- Effective and cost-effective weed control can be achieved by good groundcover. Bare soil is essential for germination of most weed species, such as giant Parramatta grass and fireweed.

Disadvantages

Problems mainly arise when drought conditions cause low stock prices, and producers become reluctant to sell or farmers lack an appreciation of the benefits of maintaining groundcover.

Design points

- Hillslope erosion

  The most influential work is that of Lang (1979[DG121]). This was conducted on relatively mild slopes of 10% with an annual rainfall of 625 mm. A number of extension publications use this work to extrapolate benchmarks for different regions. Benchmarks are based on rainfall erosivity (Hacker & McDonald 2007[DG122]), and paddock-scale conditions such as slope and soil type (Lang & McDonald 2005[DG123]). As the risk of erosion increases with increased rainfall, slope or soil erosivity, the target groundcover rises.

Murphy (2002[DG124]) reviewed 11 groundcover studies proposing critical levels to reduce runoff ranging from 20% to 70%. McIvor, Williams & Gardener (1995) [DG125]found that major soil loss is reduced with as little as 40% groundcover, but that the concentration of suspended sediment reduced linearly up to 100% groundcover.

Hacker and McDonald (2007) suggested a regional target of 80% to 90% groundcover for the north coast of NSW. Lang and McDonald (2005) recommended over 90% groundcover for any slope over 10%, and 100% groundcover where soils are moderate to high erodibility. These targets reflect the high rainfall erosivity on the north coast of NSW.

Since the objective of the CCI is to produce water quality improvements, the higher end of the range will be more desirable.

- Drainage lines
  Lang and McDonald (2005) suggested drainage lines be maintained with 100% groundcover and that excessive herbage mass should not become an obstruction that encourages waterflow to concentrate in channels.

- Riparian areas
  Clary and Leininger (2000[DG126]) suggested residual herbage mass guidelines for grazing are inadequate for riparian areas. They suggested 10 cm as a benchmark.

  Litter targets have been an additional area for research in the past ten years. A target of 1,500 to 3,000 kg dry matter / ha was proposed by Lodge, Murphy & Harden (2003).

Impact and effectiveness in relation to managing sediments and nutrients

A number of researchers have demonstrated the importance of groundcover on reducing runoff volume and sediment transport (Carroll, Merton & Burger 2000; Carroll & Tucker 2000; Costin 1980; McIvor, Williams & Gardener 1995; Murphy, Lodge & Harden 2004a, 2004b[DG127]). The reduction in runoff volume is most significant in lower rainfall events (<50 mm) and when soils are not saturated. Effects are due to greater infiltration rates where cover reduces the velocity of runoff (Carroll & Tucker 2000). When soils are saturated, groundcover has less impact on runoff volume.

Of these papers, Carroll and Tucker (2000) robustly examined the effect of groundcover of established pasture on 10%, 20% and 30% slopes. They found large differences in runoff volume between slopes of 10% and 20%, but little difference in runoff volume between 20% and 30% slope. Groundcover as low as 30% significantly reduced runoff and sediment loss.

Groundcover also disperses the flow of surface runoff and so reduces rill erosion through preferred flow paths.

The reduction in nutrient transport depends on the concentration of N and P in the soil surface. Greater benefits to water quality will occur on farms with higher groundcover.

Benefit-cost analysis (if possible)

Maintenance of groundcover is very cost effective for all grazing enterprises, with increased production while improving water quality.

5.2 Ideal stocking rates for pasture management

Issues

Determining the appropriate long-term stocking rate can be difficult in a climate of such high seasonal variability and such a wide range of pasture conditions. The Prograze™ program promotes the use of a range of plant and animal indicators that enable farmers to assess the ideal stocking rate over time. These include:

- animal-based indicators of body condition score prior to joining, fecundity, weaning percentage and weight, proportion of saleable stock reaching market weight and average daily gain
- plant-based indicators of groundcover percentage, residual herbage mass and / or height, and pasture on offer.

When used in the right context, these indicators provide a good feedback mechanism that enables farmers to assess long-term stocking rate.

In addition, broad guidelines exist to provide a starting point for comparison, for example Blackwood *et al.* (2006). Pasture budgeting through the use of computer programs, such as FeedPlan and StockPlan®, is also an option to refine stocking rates.

Courses such as LANDSCAN™ aim to provide objective information on physical and chemical factors that influence carrying capacity:

- physical – rainfall, soil texture, depth, slope and aspect
- chemical – nitrogen, phosphorus, potassium, sodium (NPKS) status; acidity; and sodicity.

Many farmers are new to these concepts but respond well to objective reliable information.

Advantages

High stocking rates that reduce pasture cover are associated with reduced farm income, increased financial risk and animal health issues.

Disadvantages

Farmers who stock conservatively can forgo income and have higher weed problems.

Design points

See targets in the management option in Section 5.1 of this appendix:

- groundcover over 80% in all situations, up to 100% for slopes over 10%

- residual herbage mass of over 1 t/ha or 5 cm height
- litter mass of over 1,500 kg dry matter / ha.

Impact and effectiveness of buffers in relation to managing sediments and nutrients

Stocking rate is the dominant effect on herbage mass, groundcover and litter levels in many studies, for example Lodge, Murphy & Harden (2003). Timing of feed deficits and rainfall will determine these effects from year to year. Use of these benchmarks has potential to provide pre-emptive action that will preserve groundcover.

5.3 Burning as a pasture management tool

Issues

Blady grass pastures are burnt in spring to remove old leaves and promote new, fresh growth. Pasture quality is improved for 6–8 weeks but the practice promotes blady grass dominance, which does not bring long-term productivity increase. The burn is usually hot and removes most groundcover. The burn is timed for spring, which coincides with dry conditions. During the period after burning, reduced groundcover increases the risk of erosion.

Burning for blady grass pastures is cited as a significant threat to the water quality in the Myall Lakes Catchment Plan. In reality, this practice has it has declined over the past 10 years and it is estimated less than 3% of the area is burnt each year. The practice was traditionally used on steeper slopes where blady grass dominated, and other practices such as slashing were not practical. In the past it may have been repeated each year on the same fields, causing cumulative effects.

Burning is also practised in autumn as part of preparation for sowing new pastures. The aim is to remove plant material to establish new pasture, and the burn is not as hot or damaging to other pasture species. The area involved is small, less than 1% of pasture area, and it is unlikely to be repeated on the same area again.

Advantages

Burning is a relatively inexpensive method of removing plant material that is of no value to stock. As a one-off event for pasture establishment it is easy to justify, but repeat use in the same field for blady grass management should be dissuaded.

Disadvantages

Burnt material provides a sediment source, produces low groundcover and increases the risk of sediment delivery to streams.

Design points

Leave strips around the field unburnt.

Impact and effectiveness in relation to managing sediments and nutrients

Carroll and Tucker (2000) recorded the effect of burning on a buffel grass field. Sediment concentration in the year prior reduced from 45 g/L to only 15 g/L in response to groundcover rising from 70% to 100%. The burn reduced groundcover to less than 5%. Sediment concentration in runoff for the month after the burn rose to 65 g/L. Rapid re-establishment of grasses from the rain increased groundcover to over 50% within that month, reducing the concentrations again.

McIvor, Williams & Gardener (1995) also measured runoff after burning. Groundcover was reduced to only 20%, but they found that in low rainfall events of 20mm to 25 mm the condition of the soil remained better than plots with long-term low groundcover. This was shown in infiltration and reduced runoff and sediment, compared to plots with long-term low groundcover that had surface sealing problems. However, with high rainfall events (100 mm), the burn areas had similar runoff and soil loss to other plots with low groundcover, demonstrating the fragile nature of soil improvements under pasture.

Hairsine (1997[DG128]) measured soil loss after fires in the Victorian Alps and found inherent soil structural characteristics were responsible for the runoff effects, rather than removal of groundcover. Cornish (1989[DG129]) cited examples where soil loss was high, so effects are site-specific.

The effects of burning were short-lived in all these cases. The more profound sediment increases measured by Carroll and Tucker (2000) may be associated with a relatively short period since major soil disturbance, whereas the other cases had longer-term consolidation of the soil properties that enabled the soil to withstand rainfall effects. The repeated annual burning on large areas could contribute to progressive soil structural decline, and so lower water quality in streams. However, at current levels of adoption, it is unlikely to make a large contribution to sediment yield.

Legislation, regulations, codes of practice, environmental management systems

Fires can only be lit in NSW in certain situations (EPA 2007[DG130]):

- hazard reduction work (*Rural Fires Act 1997*)
- for agricultural purposes
- with approval from DEC.

Burning in the CCI area may need a permit and restrictions, as no-burn notices and total fire bans can apply at different times of the year. Checks can be made with the EPA and Rural Fire Service.

5.4 Drought preparation

Issues

Drought is a feature of the Australian environment. The computer software Rainman™ records 24 drought events of over 12 months duration in 122 years data at Taree; that is a one-in-five year occurrence (Clewett *et al.* 2003[DG131]).

Drought causes a decline in pasture conditions, followed by a decline in cattle prices. Producers who hang on to stock waiting for a turnaround can have livestock lose condition and become unsaleable. Pasture conditions continue to deteriorate as stock graze over the entire farm. Recognition of this downward cycle has led to massive investment by all levels of government and industry in climate forecasting and drought preparation through organisations such as the Bureau of Meteorology, Land and Water Australia, and state government departments.

NSW DPI currently has a drought plan program for the CCI project areas that uses groundcover (90% to 100%) and herbage mass (1 t/ha) as triggers to implement drought strategies. The Hunter-Central Rivers CMA now funds NSW DPI to deliver these plans to producers in recognition of it importance for maintaining groundcover. Some CMAs in NSW have even funded infrastructure for confinement feeding.

The program aims to:

- destock the main farm area and any sensitive areas, in particular riparian zones
- assess stock for immediate sale
- implement feeding strategies to either ensure sale of stock in good condition, or provide maintenance feeding for an acceptable period
- develop a sacrificial feeding area that has least impact on erosion and water contamination.

The CCI and other coastal areas have inherent weaknesses in dealing with drought. Fodder conservation is difficult to justify; with poor-quality forages available, stock are generally kept in a lower condition score due to feed quality..[DG132]Therefore, the ‘sell-early’ option is often the best.

However, the CCI area tends to have more reliable rainfall. This, together with the fact that most beef producers farm for a hobby rather than subsistence, means the decision to sell or feed is less critical. The problem for drought preparation is that these droughts can occur at any time and finish equally unexpectedly.

Advantages and disadvantages

The sell-early strategy is usually the best option in hindsight, but is difficult to see at the time. It generally requires a lot of experience to make the right decision.

Sacrifice paddocks require preparation in fencing, watering and mitigation of off-site impacts.

An education phase is required to develop the skills for drought preparation, predicting the climate, understanding market signals and feeding of livestock in drought.

Design points

Reference is made to the publications:

- *Visually assessing pasture condition and availability in a drought*. Primefact 283, NSW DPI (McKiernan 2006), http://www.dpi.nsw.gov.au/aboutus/resources/factsheets
- *Confinement feeding of cattle in drought: protecting the environment*. Primefact 554, NSW DPI (Mackay & House 2007), http://www.dpi.nsw.gov.au/aboutus/resources/factsheets

[DG133]***Impact and effectiveness in relation to managing sediments and nutrients***

Droughts are a frequent occurrence that can expose vast areas to low groundcover and erosion risk. Maintaining groundcover on the majority of the land area is essential.

Benefit-cost analysis (if possible)

Most well thought out drought plans will reduce losses due to drought. However, the investment required to prepare sacrificial feeding areas may reduce adoption.

6. Special topics

6.1 Afforestation of steep, cleared grazing land

Issues

Afforestation provides a long-term protection of steep slopes. Where harvesting occurs, well-established practices can reduce erosion.

In general, forests use more rainfall for evapotranspiration, deplete soil moisture to greater depth and consequently reduce runoff (Cornish 1989; Silberstein, Best, Hickel, Gargett & Adhitya 2004). Harris (2001) [DG134]suggested a target of 50% of the catchment should be returned to forests as an ideal for water quality. However, riparian vegetation is still the highest priority for reducing sediments and further erosion (Prosser *et al.* 2001[DG135]).

The effects of reafforestation are most pronounced at low flows in areas of deep soils, whereby trees use soil water to a greater extent than pastures. In situations with shallow, stony soils, the effects may be minor, as soil processes dominate the water balance.

Water use will vary with forest species and age (Cornish & Vertessy 2001).

Conservation planting that attracts carbon credits instead of an income could become an issue in future years.

- Requirements for agroforestry

  The economics of agroforestry is based on achieving acceptable growth rates. Benchmarks for high production are:
  - total annual rainfall above 1,000 mm/yr
  - soil depth greater than 600 mm
  - good soil drainage.

  These benchmarks limit the area sought by forestry. To date, current areas of plantations are limited to 'brush' soils (for example, Tipperary) that are deep and well-drained.

  Other limits are the ability to plant and harvest timber on steeper slopes. Slopes of up to 18% are desirable for plantations, as costs increase with steeper slopes. Areas over 25 ha are necessary to justify planting and harvesting costs. Some good examples of agroforestry already exist in the CCI area where generally better soils have been targeted.
- Loss of grazing area

  Simple rules to reafforest land with a slope of more than 20% will affect some farms more than others. Many farmers may be happy to develop some of the farm to forests but may wish to retain some grazing. Therefore, small areas may need to be targeted first. Strategic replanting may achieve better returns than widespread replanting efforts.
- Farm income

  The delay in income can be unattractive but could suit a 'superannuation' income scheme.

  Carbon credits may soon be an alternative income stream.

  The CMA targets only modest areas for revegetation to native forests (CMA 2007[DG136]). Better local information on the productivity of both forests and beef cattle on steep slopes would greatly assist in increasing adoption**.**

  Grants may be available for establishment of small revegetation areas, but this will not achieve afforestation on 25% of the catchment; therefore, other incentives and options are required in the short term.

  This subject is quite complex and requires more detailed analysis than time permits in this brief.

Advantages

Reafforestation can restore the water balance to natural levels and so reduce runoff.

Reafforestation provides long-term protection of steep slopes.

Groundcover protection is less dependent on seasonal conditions and an individual's management.

Loss of income from grazing is minimal on steep slopes.

Reduced access to public lands has renewed interest in deriving timber supplies from private land.

Disadvantages

Reduction in waterflows may affect downstream users.

Large areas are needed to make any major difference to the catchment and any benefits will take some time to be seen.

Design points

The goals of conservation and logging income need to match the land capability and land use goals of the landowner.

Impact and effectiveness of buffers in relation to managing sediments and nutrients

A number of sources show that afforestation reduces runoff (Cornish 1989; Lane *et al.* 2003). However, because many of the sediments are derived from channel sources, the net effects on sediment production may initially be small. Also, the location and degree of afforestation will have a major impact on the long-term benefit. At this point, it will be difficult to target afforestation to desired areas.

Benefit-cost analysis

Steep lands are the most obvious area for afforestation. However, increasing the area of riparian lands under forest may be a more effective option in terms of economic return, and reduction in sediments because of the bank stabilisation aspect.

A major shift in culture and economic return is required among landholders to embrace afforestation.

6.2 Dung beetles

Issues

Nutrients (P and N) and faecal coliforms in cattle dung are potential pollutants to waterways.

Advantages

Dung beetles offer a means to bury dung quickly (24 to 48 hours) and to some depth that may benefit water quality.

Dung beetles provide useful control of bush flies (*Musca vetustissima*) (Bishop, McKenzie, Spohr & Barchia 2005[DG137]) and are actively spread in the CCI region for this purpose.

An active dung beetle program already exists in the CCI area.

Disadvantages

Beetle activity is affected by season, soil type and cattle density. Activity is generally less in winter and in dry conditions (Davis 1996; Tyndale-Biscoe 1994[DG138]). Runoff events occurring after summer dry periods or drought may coincide with lower beetle activity.

Bishop, McKenzie, Spohr & Barchia (2005) found the activity of dung beetle in the Hunter Valley was insufficient to affect the population of the livestock biting midge, Kieffer (*Culicoides brevitarsis*).

Although the evidence suggests an overall positive outcome for water quality, in general the effects are likely to be variable and not always beneficial.

Impact and effectiveness in relation to managing sediments

Several studies report better pasture growth where dung beetles are active (Bang *et al.* 2005; Bertone, Green, Washburn, Poore & Watson 2006[DG139]). However, in low stocking rates typical of beef pasture in the CCI region, the effects will probably be limited to cattle camps where dung distribution is concentrated. Effect will be greater on dairies where fertility and stocking rate is higher.

Other processes of decomposition enable faecal pads to be incorporated in the soil within 40 to 50 days, and pasture production without beetles can be similar over time (Bang *et al.* 2005; Bertone, Green, Washburn, Poore & Watson 2006).

Impact and effectiveness in relation to managing nutrients

- Nitrogen loss

  As the main loss of N in grazed pastures occurs in urine patches (Ledgard 2001[DG140]), dung beetle activity in faeces will have a minor affect. N in faeces accounts for 20% of N returned by cattle.

  In faeces, N is relatively insoluble and slow mineralisation aids greater utilisation by pasture. Bertone, Green, Washburn, Poore & Watson (2006) cited other studies and their own work that indicated dung beetles increased the rate of mineralisation of faecal nitrogen in the soil. Increasing the rate of mineralisation also increases the potential for N leaching. Bang *et al.* (2005) cited studies showing reduced N losses to volatilisation of ammonia due to rapid burial of dung. The benefit of this will be greater in summer when volatilisation losses are higher. Burial may reduce N concentration in the topsoil of cattle camps. If burial increases the depth of organic matter distribution in the profile, there may be some benefit on increased denitrification.
- Phosphorus loss

  Dung pads deposit 100% of P from cattle (Ledgard 2001). Burial to a depth of over 10 cm will reduce the concentration of P at the soil surface and hence potential for runoff. Due to the low P concentration in the paddocks of most beef farms of the CCI area, this will provide little impact. It may be of benefit where cattle camps are close to streams. Again, effect will be more significant on P runoff in dairies because P levels are higher.

- Faecal coliforms

  Rapid burial of faeces should reduce the exposure of faecal material to runoff. Dung beetles have been suggested for reducing zoonoses that originate from dogs (Hayward 2004[DG141]). However, there is little literature available to confirm this role of dung beetles.

  Some authors indicate dung beetles may have role in dispersion of pathogens. Xu *et al.* (2003[DG142]) found pathogenic strains of the bacterium *Escherichia coli* (*E. coli*) colonising the intestine of dung beetles. Thus, it is apparent that *E. coli* can coexist with, and so be transmitted by, dung beetles. Mathison and Ditrich (1999[DG143]) found dung beetles reduced, but did not eliminate, the number of parasite oocytes, *Cryptosporidium parvum*, in dung. They stated:

  > "After 24 hr of feeding, the beetles were examined for the presence of oocytes on their external surfaces, in their gastrointestinal tracts, and in faeces passed during the experiment. Results indicate that although many oocytes pass safely through the mouthparts and gastrointestinal tracts of the beetles, the majority of them are destroyed. Coprephagous insects can, therefore, be considered an important aspect in the ecology of gastrointestinal diseases of man and livestock, as both agents of control and dissemination."

Appendix 28: Urban education program plan

Background

The use of non-structural stormwater management practices has been relatively common practice in Australia and overseas for a considerable period. Typically, these have focussed around education and awareness campaigns at a variety of levels. However, non-structural best management practices for stormwater are any measure which does not involve fixed, permanent facilities that are designed to facilitate changing behaviour to minimise pollutants in stormwater runoff. They can be economic, educational or institutional, and fit within five core groups:

- town planning controls (e.g. DCPs)
- strategic planning and institutional controls (e.g. the WQIP)
- pollution prevention procedures (e.g. environmental management procedures for Council activities)
- education and participation programs (e.g. the current Healthy Lakes Program)
- regulatory controls (e.g. enforcement of erosion and sediment controls).

Of these, this document outlines what may be required for further education and participation programs in the Great Lakes region that will support the proposed best management practices within the WQIP. These are focussed on raising awareness and encouraging behavioural change within areas that may be responsible for, or involved in, the implementation of Water Sensitive Urban Design (WSUD) in a retrofit, redevelopment or Greenfield context.

Target audience

Key target audiences have been previously identified by Great Lakes Council for these campaigns:

- Businesses
- Residents
- Developers
- Builders
- Real estate agents
- Council staff
- Students.

It is felt that the target audiences should also include local consulting agencies (or those working in the region) who may assist developers with proposals for development in the region, and contractors (e.g. earthmoving companies, landscaping firms) who may be responsible for delivering WSUD features 'on the ground'.

Aims of WSUD education and awareness program

When developing any non-structural program, it is important to set clear aims or goals of the program. This assists in not only defining the elements of the program, but also allows evaluation of those programs during or after implementation against clearly defined objectives such that the overall success (or otherwise) can be determined. The aims set out here are deliberately set as broad objectives. However, they should be further refined into more specific outcomes once the development a formal program is commenced.

The WSUD Education and Awareness Program should aim to:

- encourage the implementation of WSUD in new developments, redevelopments and in the existing urban area (via retrofitting) by raising awareness of the importance of these practices in protecting the water quality of Wallis Lake and other receiving waters of the Great Lakes region
- improve the consideration of integrating water quality, water quantity, ecology, water supply and wastewater management in all new development proposals received by Great Lakes Council
- raise awareness of the benefits (social, ecological and financial) of implementing WSUD within Greenfield and brownfield developments, and highlight potential constraints and pitfalls to be avoided
- improve the survivability of WSUD measures during development and house lot construction by raising awareness of their function and importance.

Target audience – businesses

Key campaign elements

- General overview of water quality issues in Great Lakes
- Identification of what is required to address issues
- Legislative requirements
- Water quality and the relationship to ecosystems health
- General information on WSUD and water cycle management:
  - what is WSUD?
  - types of WSUD measures
  - benefits
  - case studies or examples of WSUD developments.

Target audience – residents

Key campaign elements

- General overview of water quality issues in Great Lakes
- Identification of what is required to address issues
- Water quality and the relationship to ecosystems health
- General information on WSUD and water cycle management:
  - what is WSUD?
  - types of WSUD measures
  - benefits
  - case studies or examples of WSUD developments.

Development industry program

An education and awareness campaign that specifically focuses on the development industry (addressing the target audiences of developers and consultants) should include several elements to assist in addressing the program aims. It is envisaged that this would be through several awareness sessions, in addition to printed material (fact sheets).

Target audience – developers, consultants

Key campaign elements

- General overview of water quality issues in Great Lakes
- Identification of what is required to address issues
- Outline where development fits into solution space
- Legislative requirements
- General information on WSUD and water cycle management:
  - what is WSUD?
  - how it can be implemented
  - types of WSUD measures
  - benefits
  - problems
  - implementation
  - ongoing commitments
  - case studies or examples of WSUD developments
- Specify targets for varying development types
- ‘Deemed to comply’ solutions.

Target audience – consultants

Key campaign elements

- Specific information on targets for new development and redevelopment in a spatial context (Pipers, Wallis, Smiths, Myall, etc.)
- Detail on 'deemed to comply' solutions
- General information on developing WSUD treatment trains
- Technical design guidance for WSUD
- Advice on preparing Stormwater Management Plans
- Overview of MUSIC modelling
- Details of submission requirements
- Developing inspection and maintenance plans.

Builders and contractors program

This program would be similar to the general overview provided in the development industry program, but focussed more on the delivery of measures and how to protect them during construction phase works. It is envisaged that this would need to be presented in conjunction with a dedicated program on erosion and sediment control. This could be completed either as an awareness session run on building sites, or as part of site induction programs.

Target audience – builders, contractors

Key program elements

- General overview of water quality issues in Great Lakes
- Identification of what is required to address issues
- Legislative requirements
- General information on WSUD and water cycle management:
    - what is WSUD?
    - types of WSUD measures
- Protecting WSUD measures:
    - during house lot construction.

Target audience – contractors

Key program elements

- Establishment process for WSUD
- Constructing WSUD measures
- Protecting WSUD measures:
    - during subdivision stage
    - during house lot construction
- Landscaping requirements.

Real estate agents, valuers, other development industry stakeholders program

There is likely to be a need for more general information for this target audience to raise awareness of the need to implement WSUD and of the perceived benefits. This training is likely to be a subset of the development industry training and could actually be the first segment of that training if needed (i.e. a three-part training session – general overview for all target audiences, a segment for developers and consultants, then finally a consultant's segment).

Target audience – real estate agents, valuers, other stakeholders

Key campaign elements

- General overview of water quality issues in Great Lakes
- Identification of what is required to address issues
- Outline where development fits into solution space
- Water quality and the relationship to ecosystem health
- General information on WSUD and water cycle management:
    - what is WSUD?
    - types of WSUD measures
    - benefits
    - case studies or examples of WSUD developments.

Council staff program

This part of the campaign would focus on both higher-level WSUD awareness for all staff (especially senior management), then more detailed training for development assessment, compliance assessment and asset management staff. Delivery would be through training sessions and field inspections.

Target audience – all relevant council staff

Key campaign elements

- General overview of water quality issues in Great Lakes (perhaps not required if done through other programs)
- Identification of what is required to address issues (as above, may not be required)
- Legislative requirements
- Policy and planning implications
- Council responsibilities
- Outline where development fits into solution space
- General information on WSUD and water cycle management:
    - what is WSUD?
    - how it can be implemented

  - types of WSUD measures
  - benefits
  - problems
  - implementation
  - ongoing commitments
  - case studies or examples of WSUD developments.

Target audience – Council Development Assessment and Compliance Assessment staff

Key campaign elements

- Specify targets for varying development types
- ‘Deemed to comply’ solutions
- Specific information on targets for new development and redevelopment in a spatial context (Pipers, Wallis, Smiths, Myall, etc.).
- General information on developing WSUD treatment trains
- Technical design guidance for WSUD
- Assessment of Stormwater Management Plans
- Overview of MUSIC modelling and assessment of MUSIC models
- Details of submission requirements
- Asset handover requirements
- Maintenance requirements (general information).

Target audience – Council asset management staff

Key campaign elements

- Establishment process for WSUD
- Constructing WSUD measures
- Protecting WSUD measures:
  - during subdivision stage
  - during house lot construction
- Landscaping requirements
- Asset handover requirements
- Maintenance requirements:
  - general maintenance
  - detailed maintenance practices
  - developing inspection and maintenance plans
- Identifying WSUD problems and solutions.

The overall delivery mechanisms could be refined once development of the program commences, but ideally it would include a mix of media types such as dedicated training sessions, information nights, site induction programs, fact sheets with development application forms and advertising (radio, TV, newspapers) tailored to particular messages.

There is likely to be significant cross-linking with other education program elements (e.g. general water quality awareness, erosion and sediment control requirements, etc.), so this program should not be considered in isolation.

Evaluation

There are a range of evaluation mechanisms that may be suitable, from training evaluation forms through to measurements of improvement in water quality. Ideally, the above program would be assessed against the aims outlined. Further guidance on evaluating non-structural stormwater management measures is given in Andre Taylor's research published by the CRC for Catchment Hydrology, specifically Technical Report 03/14, *Non-structural stormwater quality best management practices: guidelines for monitoring and evaluation*.

This report contains three products to assist the evaluation process, including an evaluation framework, monitoring and evaluation protocols, and data recording sheets.

Target audience – students

Key campaign elements

- General overview of water quality issues in Great Lakes
- Identification of what is required to address issues
- Water quality and the relationship to ecosystems health
- General information on WSUD and water cycle management:
    - what is WSUD?
    - benefits
    - case studies or examples of WSUD developments.

Appendix 29: Plans and strategies in the Great Lakes region, and the areas in which they should be reviewed for consistency with the WQIP

Catchment management / environment plans

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Myall Catchment: Community Catchment Management Plan (2001)	Delivered in three parts, this plan provided a physical map identifying catchment problems, issues and solutions; a detailed account of the catchment's natural environment; and a strategic plan describing the catchment's land and water management issues and objectives, as well as detailed strategies capable of achieving those objectives (Smith 2001). At the time of writing this report, very few of the strategies detailed in the Community Catchment Management Plan have been implemented at a catchment-wide scale. The plan was developed following toxic blue-green algal blooms in 1999 – an indicator that whole-of-catchment management strategies were required to improve water quality.	Myall	• Estuarine management – boating activities • Erosion – road rehabilitation and maintenance • Urban – stormwater education • Land management – sustainable grazing, fertiliser management, property planning
Myall Rivercare Plan	In July 2000, the former Myall Catchment Landcare Group Inc. – in partnership with the NSW Department of Land and Water Conservation, Rivercare and Landcare NSW – released a Rivercare Plan and companion booklet for the Myall River (Schneider 2000). The Rivercare Plan set out a range of recommendations for actions designed to address existing problems affecting the Myall River; the companion booklet provides important support information related to stream process, problems and management principles	Myall	• Recommendations relating to water quality improvement actions

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Port Stephens–Myall Lakes Estuary Management Plan	This plan addresses water quality issues within Myall Lakes and surrounding environment, investigating environmental issues within the estuary system and identifying actions towards ecologically sustainable management of the area. Priority issues identified catchment erosion and siltation, with associated erosion control measures recommended. Other actions included fish passage and foreshore management. Great Lakes Council adopted the plan in 2000.	Myall	• Integrated Monitoring, Reporting and Review • Plan Review Process • A Management Plan for Riparian, Littoral and Wetland Vegetation • Fish Habitat Management Plan • Managing Nutrient Inputs into Myall Lakes • Understanding the Sediment Dynamics of Lower Myall River • A Boating Management Plan for Port Stephens and Myall Lakes
Water Sharing Plan for Lower North Coast Unregulated and Alluvial Water Sources (Draft)	Will set access rules for water extraction for rivers in the CCI area and hence define environmental flows	Myall, Wallis	• Intersections between environmental flows and water quality management
Myall Lakes National Park Management Plan	This plan is primarily focussed on the conservation of the natural and cultural values of Myall Lakes National Park and the Myall Coast Reserves, including Little Broughton Island Nature Reserve and Stormpetrel Nature Reserve. Visitor activities that are compatible with, and promote, the understanding and enjoyment of these values is also a key goal. The plan outlines management directions, desired outcomes and guidelines, and required actions. Extensive consultation with community, park visitors and stakeholders contributed to the plan.	Myall, Smiths	• Natural Heritage – catchment management and water quality; wetlands.

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Port Stephens–Great Lakes Marine Park Management Plan	The newly created Port Stephens–Great Lakes Marine Park has a formally adopted zone plan defining the various management zones within its boundaries. The Park Authority is in the process of preparing an operational plan as required under the *Marine Parks Act 1997*. The operational plan will formally set out the operations the Authority will undertake or permit within the park's boundaries.	Myall, Smiths	• Plan of Management is currently being prepared. Aspects of WQIP that will need to be consulted as part of this Plan of Management include the rural catchment management and lake use discussions.
Wallingat National Park Draft Plan of Management	This plan is currently in draft form. It is primarily focussed on the conservation of the natural and cultural values of Wallingat National Park. The plan outlines management directions, desired outcomes and guidelines, and required actions. Members of the public, whether as individuals or as members of community interest groups, have been invited to comment on this plan of management, with submissions closing in October 2007.	Myall, Smiths	• Park Protection – Water Quality and Catchment Management
Catchment Action Plan	The Hunter-Central Rivers Catchment Management Authority (HCR CMA) has developed a Catchment Action Plan for the entire Hunter-Central Rivers region. The intention of the Catchment Action Plan is to 'identify key natural resource features of the region which the CMA and stakeholders wish to see protected or improved, and then determine how best to achieve these outcomes'. The Catchment Action Plan uses management targets to outline specific outputs that the CMA will fund over the next 10 years.	Myall, Smiths, Wallis	• Part 4 – protect native vegetation; protect wetlands; erosion and sediment control; revegetate highly erodible soils; manage nutrient runoff; protect native riparian vegetation; urban stormwater management; sewage management.
Smiths Lake Boating Plan of Management 2005–2010	The plan provides a framework for the management and administration of boating activities on Smiths Lake, designed to respond to changing lake conditions and priorities, provide appropriate infrastructure, ensure boating management maximises user safety and enjoyment, while minimising adverse environmental impacts.	Smiths	• Lake – Wide Concepts and Strategies – Lake health; Protection of Seagrasses.

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Smiths Lake Estuary Management Plan	This plan aimed to achieve integrated, responsible and sustainable usage of Smiths Lake. Prepared in 2001, the plan recommends actions required for the health of Smiths Lake and surrounding environment. Great Lakes Council is currently reviewing the actions of the Smiths Lake Estuary Management Plan to revise priorities.	Smiths	• Management Objectives • Management Options – Erosion and Sedimentation; Water Quality; habitat Conservation: Waterway Access and User Conflicts
Coolongolook Rivercare Plan	The Rivercare Plan for Coolongolook River was developed by Hunter Land Management in August 2007, in consultation with the landholders of the Coolongolook River. The plan highlights the need to better manage the Coolongolook River, which feeds into Wallis Lake. The objective of the plan is to identify the strategies required to restore, rehabilitate and conserve the natural environment of the River over the next 10 years. This plan forms a link between landholders / community and local, state and federal government departments in defining a management direction for funding and on-ground works on the Coolongolook River. It is intended that the plan be reviewed after 10 years. This will have the dual purpose of being able to measure progress in implementing the plan and identifying any new issues with the River that may have arisen over the interim period.	Wallis	• General Management Recommendations– Erosion and Sedimentation: Stock Management; Native Riparian Vegetation. • Implementation – Income Tax Concessions; On Going Management.

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Darawakh / Frogalla Wetland Management Plan	This Plan aims to reduce acid sulfate discharge from the Darawakh / Frogalla wetland into the Wallamba River. The location of the acid sulfate soil problem was identified in 1998/99, although Wallamba River users had seen the effects of acid discharge (red-spot disease in fish, oyster mortality) for many years. Great Lakes Council monitored the water quality and confirmed the severity of the acid sulfate generation, and the significant acid flows to the lower Wallamba River. The discharge has negative impacts on commercial and recreational fishing, and oyster production, in the lower Wallamba River. The plan identifies the range of management solutions to this water quality problem, and has been implemented since 2004.	Wallis	• No change needed
Forster / Tuncurry and Wallis Lake Stormwater Management Plan	This plan aims to improve water quality and river health by identifying and prioritising stormwater discharge control measures within urban centres of Tuncurry and Forster, and throughout Wallis Lake catchment. The plan provides short and long-term solutions to mitigate environmental impacts of urban stormwater discharge.	Wallis	• Objectives for Management of Stormwater Quality within the Wallis Lake Catchment • Stormwater management Measures • Evaluation of Stormwater Management Options • Recommended Stormwater Management Measures
Lower Wallamba Rivercare Plan	Lower Wallamba Rivercare Plan and Companion Booklet (Skelton 2003) was developed with funding from Karuah Catchment Landcare Group (Natural Heritage Trust funds); Great Lakes Council; and Department of Infrastructure, Planning and Natural Resources (DIPNR). The Great Lakes Council assisted the Department of Land and Water Conservation to engage a planner to prepare the Lower Wallamba Rivercare Plan. All 80 landholders along the lower tidal section of the Wallamba River were directly consulted and numerous projects have derived from this consultation. The Rivercare Plan was produced	Wallis	• Riverbank erosion • Stock damage to riparian areas • Foreshore Reserve Management • Lack of a wide and diverse riparian vegetative buffer • Water Quality • Weeds – Herbicide Use Near Streams

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
	to assist landholders in the management of the tributaries to the Wallamba River, focussing on stream conservation and rehabilitation strategies. Key issues in this Rivercare Plan are: weed infestations; stock damage to stream banks and riparian vegetation; channel and riverbank erosion; in-stream impediments to fish passage; and threats to natural recovery processes (Lower Wallamba).		
Mid Wallamba Rivercare Plan	Mid Wallamba (including lower Firefly Creek and lower Khoribakh Creek) Rivercare Plan and Companion Booklet (Schneider 2005) was produced to assist landholders with stream conservation and rehabilitation. The plan provides recommended actions to address existing stream problems, and information for landholders to make educated decisions on stream and property management. Key issues in this Rivercare plan are: weed infestations; stock damage to stream banks and riparian vegetation; channel and riverbank erosion; in-stream impediments to fish passage; foreshore reserve management; lack of a wide and diverse native riparian vegetative buffer; water quality; acid sulfate soils; and log jams / snags.	Wallis	• Threats to Natural Recovery Processes • Channel Erosion • Livestock Damage to Streambanks and Riparian Vegetation
Wallis Lake Catchment Management Plan	The plan, a product of a partnership between the community and state and local government, was completed in January 2003. It was essentially science-based, using innovative and comprehensive field research, but it also reflected social and economic goals addressing community concerns. This plan was the primary vehicle for the implementation of proactive actions to promote and enhance catchment and water quality targets. The plan not only sought to achieve on-ground actions, but also to promote and facilitate interagency cooperation and involvement, and it endeavours to empower the community to play a vital role in the	Wallis	• Soil Erosion Action Plan • Surface Water Quality Action Plan • Riparian Zones Action Plan • Estuary Action Plan

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
	management of this significant resource. The plan outlines a strategic framework by which the catchment can be managed holistically to ensure that all parts of the catchment and its communities benefit equally from improvement made in the catchment's health.		
Wallis Lake Estuary Management Plan	This plan addresses issues affecting the social, cultural, environmental, recreational and commercial values of Wallis Lake. The plan identifies the current state of the Wallis Lake estuary, pressures upon it, and recommends actions required to protect, manage and restore the landscape. The plan describes the estuary as in relatively good condition, although pollution, urban development and use pressures are having a demonstrable impact. Plan implementation will improve the estuarine environment.	Wallis	• Water Quality and Flow • Oyster aquaculture • Sedimentation • Foreshore management • Waterway usage • Community education
Wallis Lake Wetlands Management Strategy	Currently under preparation, this strategy aims to effectively manage wetlands surrounding Wallis Lake to improve water quality. The strategy will include a formal management framework, wetland identification, classification and mapping. The need for an effective wetland management strategy was identified in both the Wallis Lake Catchment Management Plan and the Draft Great Lakes Vegetation Strategy – to ensure rational conservation, management and repair. This strategy is a pilot for the protection and management of wetlands in the remainder of the local government area.	Wallis	• Strategy is currently being prepared. WQIP sections on both urban and rural land management should be consulted as part of the development of this strategy
Wang Wauk Sub-catchment Plan	The Wang Wauk River Catchment Land and Water Management Plan was developed in 1999 by the Wang Wauk River Catchment Landcare group in association with the Department of Land and Water Conservation. It was also developed in conjunction with the Wang Wauk River Catchment Community Water Quality Monitoring Program, which was undertaken to inform the plan and its recommendations. The recommendations focus on improving land use to reduce	Wallis	• Recommendations relating to water quality improvement actions

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
	sediment and nutrient sources, particularly through riparian and catchment rehabilitation, with an aim to reduce sediment, nutrient and bacteria exports from the river into Wallis Lake.		

Land use planning / strategic planning

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Great Lakes Community Strategic Plan 2020	The Strategic Plan follows an integrated planning and reporting framework expected to replace Social Plans, State of the Environment reports and Council management plans. The plan is based on a quadruple bottom line: balancing economic, environmental, social and governance considerations.	Myall, Smiths, Wallis	• The Community Strategic Plan is a vision for the Great Lakes region that encompasses social, economic, environmental and governance outcomes. The WQIP vision and targets should have a central place within it.
Great Lakes Local Environmental Plan	The Great Lakes Local Environmental Plan 1996 (GL LEP 1996) outlines the land use zones over the Great Lakes local government area. The LEP is the principal statutory planning document, guiding planning decisions for the Great Lakes Council. It determines the location of rural, residential, commercial, industrial and environmental protection zones. It also includes special provisions for specific development and / or specific properties of local significance, where additional controls are required.	Myall, Smiths, Wallis	• Revised provisions already under discussion with the Department of Planning

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Hunter Regional Environmental Plan 1989	This plan aims to promote balanced regional development and requires the consideration of wide range of issues including social and economic development, land use, transport, natural resources, environment protection, conservation, and recreation. The plan must be considered in the preparation of LEPs, and policies and assessments of development applications within the area.	Myall, Smiths, Wallis	• Part 4 – Land Use and Settlement • Part 6 – Natural resources – Soil, water and forest resources • Part 7 – Environment Protection • Part 8 - Conservation and Recreation
Rural Living Strategy	The Great Lakes Council's Rural Living Strategy (2004) provides a framework for future development while preserving the valued identities and character of rural communities within the catchment. The strategy outlines the areas for future expansion of urban or rural residential development across the Great Lakes local government area, including each of the Wallis, Myall and Smiths catchment areas.	Myall, Smiths, Wallis	• Water cycle management standards and water quality management provisions need to be reviewed in the light of the WQIP's strategies for rural residential development.
Foster / Tuncurry Conservation and Development Strategy	This strategy aims to ensure a sustainable approach to land use planning and management in the Forster / Tuncurry area, identifying future growth options while maintaining environmental quality. The strategy includes environmental, economic and social considerations, and focuses on potential impacts of urban expansion on Wallis Lake. The strategy values the lake for conservation as well as the industries that rely on the water quality and ecological health of the system.	Wallis	• This strategy needs to be reviewed for its consistency with the Water Sensitive Urban Design approach developed for the WQIP, including both performance standards for redevelopment and accommodation of a catchment retrofitting program.

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Greater Taree Local Environmental Plan (1995) and Draft Greater Taree Local Environmental Plan (2008)	The Greater Taree Local Environmental Plan 1995 outlines the land use zones over the Greater Taree local government area. The LEP is the principal statutory planning document, guiding planning decisions for the Council. It determines the location of rural, residential, commercial, industrial and environmental protection zones. It also includes special provisions for specific development and / or specific properties of local significance, where additional controls are required. Greater Taree City Council is currently reviewing the LEP in line with the NSW standard template. The new draft LEP provides a direct transition from the current LEP, with the current zones and permitted land uses carried over to the new draft. There have been no detailed studies to review, or amend any land use or individual zoning, except 14 Local Environmental Studies that have been prepared as part of a site-specific rezoning request.	Wallis	• To be reviewed for consistency with the WQIP as part of preparation of the Draft LEP.
Hallidays Point Conservation and Development Strategy (2000)	This Strategy is only slightly relevant to Wallis Lake, as the large majority of the catchment area in Hallidays Point drains to the ocean and coastal lagoons, with only slight areas at the southern end draining to the Darawakh and Frogalla swamp. The strategy aims to ensure a sustainable approach to land use planning and management in the Hallidays Point area, identifying future growth options while maintaining environmental quality. The strategy provides a guide for community and Greater Taree City Council in decision-making on release of residential and rural residential land within this area up to the year 2010. There was a review of the plan in 2006.	Wallis	• Environmental Issues – Water Catchments and Flood Liable Land; Natural Vegetation Communities and Native fauna • Land Development Strategy • General Provisions and Requirements for All Proposals • Drainage Analysis to Accompany Rezoning Applications • Conclusions and Recommendations to Council

Plan	Description	Relevant catchment	Areas of the plan to review for consistency with the WQIP
Rural Residential Strategy and Release Program (2000)	This strategy provides a plan to preserve the identities of the rural and urban communities in the Greater Taree local government area. It determines the extent of rural residential development to 2020 and the relationship of future development to surrounding agricultural lands. The strategy draws from community values gathered in public meetings to develop a framework for future short and long-term actions. The strategy conveys Council's obligations under the Hunter Regional Environmental Plan for the development of rural residential land.	Wallis	• Procedures for Rezoning – Water
South Forster Structure Plan (adopted by Council February 2007)	This plan provides guidelines for development and conservation of the South Forster area, generally covering the vacant land on both sides of The Lakes Way south from the existing urban area of South Forster through to Booti Booti National Park. The plan guides the placement of services and facilities, drainage, wildlife corridors, roads, residential densities and pedestrian and cyclist routes. It will be applied when the Great Lakes Council prepares rezoning plans for land within the area.	Wallis	• Chapters 1 & 2 – include WQIP in context of Council planning provisions • Chapter 9 – implementation procedures
Smiths Lake Flood Study (2007)	The aim of the Flood Study was to identify the extent and magnitude of flooding and determine the number of buildings inundated in a range of design flood events. The study defines the nature of the flood problem and outlines a modelling platform that will form the basis for a subsequent Floodplain Risk Management Study and Plan.	Smiths	• Developing opening procedudres will impact on water quality. However, the WQIP does not make reccomendations in this area

Appendix 30: Ecological monitoring of the Water Quality Improvement Plan

This appendix is authored by Peter Scanes, Jocelyn Dela-Cruz and Brendan Haine, of the Department of Environment and Climate Change.

Monitoring of the WQIP should be used to determine whether the targets that are set in the Plan are being achieved. The Plan defines two major types of targets: Catchment Load Targets and Estuary Condition Targets. The monitoring outlined here specifically focuses on assessing the ecosystem protection value (the most stringent value in relation to the ANZEC guidelines approach) through the assessment of the indicators identified for lake ecosystems. Environmental health risks should also be monitored, but monitoring of those (e.g. bathing water quality including pathogens, algae, clarity; suitability of waters for aquaculture, etc.) occurs through other monitoring systems such as council bathing water assessments, NPWS[DG144] algal survey, oyster OAQC programs. These programs have specific aims and methods, and there is unlikely to be much overlap with the suggested Ecological Condition programs.

DECC Waters and Catchment Science feels that monitoring of the achievement of targets should be addressed differently for catchment and estuary. Catchment targets were set by modelling to reduce inputs to a level that allows the estuary targets to be achieved. There is always uncertainty in modelling complex systems, and the models only represent the best understanding of processes and the best input data available at the time. We believe that the most efficient approach to monitoring effectiveness of the WQIP would be to adopt an adaptive management framework for meeting targets. In short, this involves using the models to make the best-informed managerial decisions in relation to catchment loads that will protect estuary targets, and then monitor the estuary targets to ensure the desired outcomes are being achieved. If not, verify the catchment modelled loads using any updated input information (such as land use categories and associated runoff characteristics) as well as improvements in the models utilised. If they are being met, then the catchment targets will need to be revised downwards.

Catchment monitoring

Monitoring of the rural and urban catchment is not intended to assess quantitatively whether catchment load targets are being met by a collective of individual management actions (e.g. riparian management, sustainable grazing practices, artificial wetlands). Such an assessment would require a long-term commitment to an event-based monitoring program, which may be hampered by climate variability. Rather, our recommended catchment monitoring strategy will provide further information to improve the efficacy of the catchment models by addressing two objectives:

1. gather more runoff quality data for areas that were identified in the CCI process as having a high pollutant generating potential (termed ‘high-risk areas’).
2. assess at a local scale (e.g. farm or group of farms, or single land use type) the effectiveness of particular management practices.

Used together, this information will be of great value in refining and improving the catchment models.

Objective 1: Monitoring runoff from ‘high-risk’ areas

High-risk areas in the rural catchment may be defined as an area that concurrently gives rise to relatively large (≥ 75th quartiles) exports (e.g. kg/ha/yr) of nitrogen (dissolved inorganic, dissolved organic, particulate and total), phosphorus (dissolved inorganic, dissolved organic, particulate and total) and suspended solids. To quantify these long-term exports, a monitoring program – consisting of water quality sampling during rain events to determine concentrations of contaminants in runoff and continuous measures of flow rates – would provide the greatest amount of information. If flow measurements were not able to be gathered, then measurements of concentrations of contaminants in conjunction with modelled flow would suffice.

High-risk areas in the urban catchment

The urban areas where catchment performance is of greatest concern are:

- construction sites, where the goal is to lift performance to current best practice
- Greenfield developments, where the goal is to achieve no net increase in perpetuity, benchmarking against pre-existing urban and agricultural land uses
- urban redevelopments, where the goal is to substantially improve performance over current practice.

The design performance of WSUD devices and treatment trains of completed urban developments is reasonably well understood, so a first approximation to catchment performance can be attained by modelling what has actually been built (e.g. using MUSIC modelling). However:

- the relationship between construction site design and maintenance, and runoff water quality is not particularly well understood
- there are uncertainties, locally, about how well WSUD devices will be maintained, because in some locations many of the WSUD devices will be located on private land (so their maintenance will be the responsibility of the landholder), and because the councils’ asset management budgets are currently not large to maintain assets in good condition, overall.

The Greenfield development sites whose runoff will influence Southern Wallis Lake are of particular concern, because this is a high conservation value region with slow tidal flushing, so it is particularly susceptible to impacts from poor catchment management.

Construction site performance is a general concern, so would be better picked up by a state or national program. Local capacity to design, construct and particularly maintain Greenfield urban developments in ways that produce no net increase in nutrient and sediment loads needs to be measured locally, so a program of water quality monitoring to measure subdivision performance is recommended.

Objective 2: Monitoring effectiveness of management actions in 'high-risk' areas

Monitoring the effectiveness of management actions obviously provides a more immediate indication of whether the actions are working locally. Traditional methods of assessment of management practices are predominantly based on monitoring runoff water quality either above or below; at sites with or without; or before, during and after the implementation of the management action. This type of monitoring is effective in urban areas, but not in rural areas where effects are confounded by inherent landscape variability (e.g. varying soil types, geology, slope). Our recommended strategy for rural management practice monitoring is by a rapid assessment of a broad range of ecological attributes, and includes elements that contribute to ecological stress (robust and integrative stressors) and the consequent status of ecological communities. For example, management actions that seek to reduce stream bank erosion are best monitored by assessments of both riparian vegetation condition ('the stressor') and the local fish diversity ('the ecological community'). Essentially, it is recommended that assessments be based on monitoring both the stressor and ecological community.

As indicated in the addendum, monitoring of ecological communities, such as fish, is costly and requires a high level of technical expertise. If funds and technical expertise are limited, it is suggested that assessments be based on the condition or magnitude of the stressor. For the types of rural management actions listed in the Water Quality Improvement Plan (see Section 2.7.1 of the WQIP), the following types of stressors may be monitored (see also Appendix 14):

- effectiveness of groundcover management may be monitored by the height of pasture, the area of bare ground and the overall percentage of groundcover
- effectiveness of nutrient management may be monitoring by soil tests that examine the nutrient concentration and pH of topsoils
- effectiveness of dam management may be monitored by the number of annual overflows.

The above recommendations rely on the assumption that there is some evidence to demonstrate the link between the stressor and the ecological (community) response. There is specific local field data to support the links between riparian vegetation condition and fish diversity. Direct links between indicative stressors for groundcover and nutrient management actions, and the ecological community response, are limited given that the recommended monitoring strategy is relatively new. Quantitative support may, however, be implied from the results of the following studies that have examined the ecological condition and / or water quality of rivers / streams in agricultural areas:

- Brodie, JE & Mitchell, AW 2005, ‘Nutrients in Australian tropical rivers: changes with agricultural development and implications for receiving environments’, *Marine and Freshwater Research*, vol. 56, no. 3, pp. 279–302.
- Eikaas, HS, Kliskey, AD & McIntosh, AR 2005, ‘Spatial modeling and habitat quantification for two diadromous fish in New Zealand streams: GIS-based approach with application for conservation management’, *Environmental Management*, vol. 36, no. 5, pp. 726–740.
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Estuary monitoring

The estuary monitoring is specifically aimed at tracking performance against defined Estuary Condition Targets. It will cover three main objectives:

1. Determine whether the Ecological Condition Targets for the WQIP are being met (chlorophyll, water clarity).
2. Determine whether ecological outcomes for the macrophytes in the lakes are acceptable (this will encompass sampling of macroalgal abundance and seagrass / macrophyte abundance).
3. Measurement of some drivers of ecological outcomes (water clarity, salinity, temperature).

For objectives 1 and 3, the Estuary Condition Targets have been set for comparison over two time scales: long-term comparisons of average condition, and short-term event conditions. It is necessary to measure at both these times scales because, although the long-term 'average condition' is the true ecosystem response that is of interest (and is needed for future model calibration), it requires a while to gather sufficient data for a sound estimate. The short-term 'event' targets let the user assess whether there is stress on the system, which may develop into a change in the long-term condition – and hence intervene earlier.

Targets have been derived statistically for two main indicators – algal abundance (chlorophyll-a) and water clarity (turbidity, Secchi) – and defined mechanistically for a third, seagrass persistence. Algal abundance and seagrass persistence are included as ecological outcomes. Turbidity is a stressor (as opposed to an outcome), but is of particular importance for protecting the survival of seagrasses / macrophytes in the lakes and as a controller of sediment-based ecological processes. Turbidity is a major factor in the diminution of light that seagrasses / macrophytes need for growth. The actual target values for chlorophyll-a and turbidity were set by statistical methods recommended by ANZECC (see Appendix 10). The target values represent an estuarine / lake condition that is a trigger for action – a point at which the condition of the system is outside normal boundaries and it is worth looking at the necessity for further action. It is anticipated that for the long-term target, the annual mean value would be compared to the target using a single-sample t-test (or similar). For the short-term target, the values for each event are compared to the target, and if more than 10% exceed the target, then action should be considered.

Two different monitoring programs are required to assess compliance with the two types of targets (long-term and short-term events).

Long-term targets

Monitoring for the long-term targets will require regular sampling at intervals not greater than six-weekly to measure:

- chlorophyll-a
- turbidity
- salinity
- temperature
- Secchi.

These measurements should be made at the sites shown in Table A30.1.

Table A30.1. Monitoring sites for long-term targets.

	Latitude (WGS 84)	Longitude (WGS 84)	Type
Wallis Lake			
South	-32.32717°	152.50600°	WQ,SG
Central	-32.27817°	152.49667°	WQ,SG
Mid Wallamba	-32.09740°	152.44883°	WQ
Mid Coolongolook	-32.18518°	152.36345°	WQ
Entrance	-32.17433°	152.50850°	WQ, SG
Pipers	-32.20800°	152.51667°	WQ, SG
Smiths Lake			
Central	-32.38748°	152.49850°	WQ
Myall Lakes			
Myall 1	-32.41528°	152.43448°	WQ,SG
Myall 2	-32.43973°	152.37484°	WQ
Bool	-32.46210°	152.31101°	WQ,SG
2 Mile	-32.49050°	152.29500°	WQ
Broad 1	-32.52598°	152.29738°	WQ,SG
Broad 2	-32.53255°	152.25857°	WQ

WQ = water qualty, SG = seagrass.

At water quality sites, two independent replicate chlorophyll samples should be taken by a 1 m integrated sampler, and analysed by acetone extraction and spectrophotometric or fluorometric methods. Analysis of the CCI data showed that when chlorophyll concentrations are very small (e.g. central / southern Wallis, eight to ten replicates are sufficient to provide suitable power (0.8) to reliably detect a change in annual mean concentration from current to the trigger value (50% increase; standard deviation 0.6). Detecting changes of a few percent would require up to 100 replicates. Where concentrations are higher (e.g. upper Wallamba, Pipers), between 13 and 30 replicates are required to detect a 10% decrease in concentrations, depending on among-sample variability. The recommended level of replication here (16 samples p.a.) should be sufficient to detect 10% change under most circumstances experienced during the CCI project (standard deviation of 0.8). The level of replication could be reassessed after the first four years of data collection. The usefulness of in situ fluorometry could be examined. Fluorometers have been successfully utilised in oceanographic studies, but are subject to a range of confounding factors in estuarine applications (e.g. water colour, organic content, etc.). Their costs and benefits would need to be evaluated on a case-by-case basis. A suitably calibrated water quality meter should be used to measure turbidity, salinity and temperature (at least) at incremental depths of 0.5 m from just under the surface to the bottom. This will provide contextual data for interpreting results. Secchi depth should also be measured at the site.

The data should be compared to the long-term indicators targets in Table A10.5 (Appendix 10).

Monitoring for short-term targets (events)

This sampling uses the same sites and methods, but should be done three to five days after a major rainfall event (>50 mm rain across the catchment) that results in runoff to the lake. At least three events should be sampled each year. The suggested timing, event size and replication are for guidance only, and are based on experience gained during the CCI studies.

These data should be compared to the short-term event targets in Table A10.4 (Appendix 10).

For objective 2, at seagrass sites the amount of macroalgae and seagrass / macrophytes in shallow areas should be assessed along with the maximum depth of the seagrass / macrophyte bed quarterly. The aims of this monitoring would be to determine whether the abundance of seagrass is changing over time and whether the abundance of macroalgae in seagrass beds is increasing over time. One of the targets set was ‘no decrease in the abundance of seagrass’; no formal triggers exist for macroalgal abundance, but a trend of increasing abundance / biomass would be a cause for concern (n.b. ‘seagrass’ has been used as a generic term and in freshwater situations such as Myall lakes; the same techniques should be used for macrophytes).

Seagrass / macrophyte abundance should be done using a formal sampling design. The methods developed for the Community Seagrass Monitoring Project (http://www.cccen.org.au/) provide a good starting point for this monitoring. It will need to be augmented with a protocol for measurement of the maximum depth of the beds. This sampling could be done quarterly by community groups.

Aerial surveys should also be considered at time intervals of every five years. This will assist in putting the point and transect data into a larger lake-wide context. Note that aerial survey data may become available from the State Monitoring Evaluation and Reporting Program.

Relationship to NSW State Monitoring, Evaluation and Reporting Framework

The State Monitoring, Evaluation and Reporting Framework will put into place a monitoring strategy to track the condition of estuaries within the state. The indicators suggested for the CCI form a subset of the Monitoring, Evaluation and Reporting indicators, and are therefore directly comparable.

The Monitoring, Evaluation and Reporting Estuaries Framework is not finalised at the time of writing, but it is clear that not all estuaries will be sampled at a high frequency. Wallis Lake is currently part of the sampling program and, if it remains included, it will be possible to use the Monitoring, Evaluation and Reporting findings to review the trends in estuarine health for Wallis Lake compared to other NSW lakes over a longer time frame (e.g. 10 years) as a double-check of the local data.

Further research questions

The integration of catchment and estuary response models to examine how land-based activities affect the water quality and ecological health of receiving waters is now a common approach for sustainability assessments. However, a large part of the uncertainty in the estimates of input loads for the estuary models is a lack of accounting of the transformation and attenuation of nutrients within a river system. Previous work in the northern hemisphere has shown that these processes reduce the concentration of inorganic nutrients during transport, and alter the timing of delivery of nutrients to downstream water bodies. Up to 76% of N exported from upland catchments may be lost via denitrification or biotic sequestration. The amount attenuated, however, may depend on season and flow conditions, with greatest retentions occurring during slow or baseflow conditions. An investigation of in-stream processes was beyond the time and resources allocated for our modelling activities for the CCI, but is recognised as a priority area for future research.

More research is also needed into the effectiveness of rural management practices in general, given the lack of data in the Australia. Our monitoring was conducted in two seasons, but nonetheless showed distinctions between properties that had implemented a rural management practice and those that had not. Ideally, as done for previous rapid assessment programs (e.g. AUSRIVAS), future work could be focussed on identifying sensitive indicator species (of macroinvertebrates and / or fish).

Improving models

Improvements in the models will come about largely through increasing the sizes of the datasets available for calibration and verification. The monitoring suggested above will provide suitable data. It is suggested that after five years, the performance of the models should be assessed against the new data, and the need for changes assessed.

The models used in this study were the best available at the time of selection, but it has become apparent that they still had shortcomings. The majority of catchment models available for use have their origins in North America, and many of the parameters and relationships required substantial reworking for Australian conditions. The development of new catchment modelling tools that better reflect Australian conditions (particularly hydrology and nutrient mobilisation) would be a great step forward. The ecological response components of the estuarine model relied heavily on empirical relationships in existing data. This was because process understanding does not exist at a level that allows confident parameterisation of an estuarine response model. As our understanding of ecological processes increases through appropriate research, inclusion of that process knowledge in the response model has the potential to improve its utility, and its spatial and temporal resolution. For example, DECC Waters and Catchment Science is now in the process of examining relationships between resuspension of bottom (benthic) sediments, water column turbidity and seagrass cover using recently sampled field data from other lake systems. This recent work is being used to help partition the sources (i.e. catchment or resuspension) of water column turbidity, and will therefore allow future determinations of catchment targets for sediment loads.

Monitoring program costs

Table A30.2. Monitoring program costs.

Monitoring program	Estimated frequency	Itemised expense (per sampling time)	Estimated cost per occasion	Estimate cost per annum
Monitoring of runoff from high risk areas	Event monitoring, and hence frequency, depends on rainfall	24 water samples, analysed for nutrients and TSS	24 x $150	n/a
		Officer time: Four hours per high-risk area	Four x $45/hr = $180 per area	n/a
		Equipment hire (car, autosamplers, water level sensors)	$150 per day $30,000 pa each	n/a
		Data analysis		
Best management practice assessments / monitoring at six sites	Three-yearly	Fish sampling?	$3,000 per site x six (sites)	$18,000 ÷ three = $6,000
	Three-yearly	Officer time: Riparian and in-stream habitat assessments	Two x one day = $600	$600 ÷ three = $200
	Three-yearly	Vehicle costs: Riparian and in-stream habitat assessments	Four days @$150 per day	$600 ÷ three = $200
Subtotal				
Estuary condition targets				
Chlorophyll and turbidity	Six-weekly = nine samples per year plus three event samples	Two staff for two days (includes water quality meter calibration)	$1,200	$14,400
		Boat and vehicle use		
		Chlorophyll analyses (24 samples @ $30 ea)	$720	$8,640
Seagrass / macrophytes	Quarterly	Community sampling	nil	
		Supervision and data collation (two days)	$640	$640
Total (per annum)				**$30,080**

n/a = unable to provide total costs, as the number of 'events' is unknown. The total cost for this program will be underestimated as a result of this limitation.

Note: Sampling staff does not need to have any special qualifications other than basic awareness of scientific sampling and training in sampling techniques and QAQC – staff costs based on $30 / hr, 8-hour day and 22% on-costs would be $300 per person per day.

Addendum – Rural BMP monitoring of riparian fencing and off-stream watering

DECC research that assessed the effectiveness of riparian fencing and off-stream watering was tightly focussed on a specific set of questions, and the sites were located in relatively small watersheds with relatively uniform management. This enabled us to reduce inherent variability and upstream influences as much as possible. We recommend that the same level of site selection planning be made for future assessments of any type of rural management practice monitoring.

Fish community sampling was very informative and clearly separated management practices, and would ideally form part of future best management practice (BMP) assessments; but fish sampling is expensive, costing about $3,000 per site. The most cost-effective method of assessing the effectiveness of riparian fencing or off-stream watering is to monitor changes in riparian vegetation. During our study, sites where BMPs were in place had less bare banks and more trailing vegetation than sites without BMPs. These riparian habitat variables did not, however, differ between off-stream watering sites and riparian fencing sites. This indicates that assessments using fish assemblage data are more sensitive, but we suggest that the sensitivity of riparian habitat-based assessments can be increased by first sampling prior to BMP implementation. Fish sampling requires expertise in fish identification, and electrofishing and fish trapping techniques. It also requires electrofishing and fish trapping equipment. Assessments based on the condition of riparian vegetation require only limited training and an understanding of scientific method, and do not require complex and expensive equipment. Both fish sampling and riparian vegetation monitoring could be effectively sampled at similar intervals (two to four years) and, as such, the latter would prove far less expensive. Assessments based on riparian vegetation condition involve subjective visual estimations, so it would be preferable that these are done by teams of two people. Where possible, at least one of these people is present at any two consecutive sampling events. We suggest the following variables should be estimated at sites (100 m reach) prior to implementation, and at intervals of three years:

- proportion of banks that are bare (lacking vegetation or leaf litter) within 5 m either side of stream
- percentage cover of trees >10 m in height within 5 m either side of stream
- percentage cover of trees <10 m in height within 5 m either side of stream
- percentage cover of shrubs, vines and rushes within 5 m either side of stream
- percentage cover of trailing vegetation over stream surface.

This assessment should take about half an hour once at the site. If we include travel time to and between sites, two people could complete assessments at about five to eight sites per day.

Due to differences in soils, climate and topography, changes in riparian vegetation will differ among sites and should be examined on a case-by-case basis. Riparian vegetation structure and composition can continue to evolve for decades after BMP implementation. To generalise, decreasing proportional areas of bare banks and increasing values for the other variables would indicate improving riparian condition. There are interactions between these variables, though. Where there is a dense canopy of trees, trailing vegetation, shrubs, vines and rushes may be sparser, and the proportional area of bare banks may be larger.

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