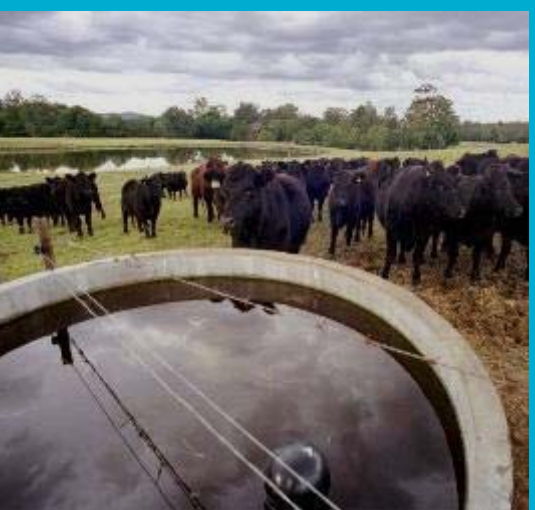
Great Lakes Coastal Catchments Initiative

Great Lakes COUNCIL

Australian Government

Great Lakes Water Quality Improvement Plan

Wallis, Smiths and Myall Lakes



Cover photos (clockwise from top left): Signing Statements of Joint Intent (K Meares), Smiths Lake (A Staniland) and off-stream watering (A Fardell).

Great Lakes Water Quality Improvement Plan

Great Lakes Council
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EXECUTIVE SUMMARY

Wallis Lake, Smiths Lake and Myall Lakes and their catchments are located on the Mid North Coast of New South Wales. These lakes are the subject of this Water Quality Improvement Plan (WQIP).

The ecological significance of these lakes and their catchments have long been recognised at local, state, national and international levels as documented in the relevant estuary and catchment management plans. Formal recognition of ecological values varies across the area and includes national park estate (including the Port Stephens–Great Lakes Marine Park), international migratory bird agreements such as Japan–Australia Migratory Bird Agreement (JAMBA) and China–Australia Migratory Bird Agreement (CAMBA), and recognition of wetlands of national and international importance including Ramsar listing for the Myall Lakes.

This plan further recognises the significance of these systems, drawing on new research, modelling and community engagement to identify a range of rehabilitation, protection and management support actions to protect and support (and where required, restore) the ecological health of these systems.

In 2005, the Australian Government provided funding to Great Lakes Council through the Coastal Catchments Initiative (CCI) to undertake research and develop this WQIP. The aims of the project were to:

- identify the specific levels of nutrients and sediments that are required to provide conditions for a healthy lake ecology and environmental values desired by the community,
- identify the best way to manage activities to reduce key pollutant loads entering the lakes
- review pollution control and faecal coliform management systems as they pertain to the management and protection of the lakes.

The WQIP has been developed for practitioners and catchment / estuary management groups. It is divided into three parts:

- **PART 1: CCI planning process**
  Provides a background to the Coastal Catchments Initiative and the process of developing the WQIP

- **PART 2: Individual lake Water Quality Improvement Plan actions**
  - Wallis Lake – research results, ecological targets, catchment management actions and associated costs for the Wallis Lake catchment
  - Smiths Lake – research results, ecological targets, catchment management actions and associated costs for the Smiths Lake catchment

- Myall Lakes – research results, targets, catchment management actions and associated costs for the Myall Lakes catchment.

- **PART 3: Implementation framework**

  Covers detailed management and support actions that are to be used to implement the plan across all three lakes, covering rural land, rural residential and urban land, lake use, pollution control systems, institutional arrangements, and adaptive management.[NB2]

Developing the Water Quality Improvement Plan

The WQIP has been developed in partnership with agencies, industry groups and the community. The focus of the planning process was to provide opportunities for capacity building and joint learning with stakeholders, as well as create opportunities to build awareness within the general community about water quality issues and catchment management. The engagement of stakeholders in developing the WQIP, and the nature and level of their involvement, has been summarised below.

Table 0.1. [DG3]**Stakeholder engagement in WQIP development**

Stakeholders engaged	Nature of engagement
Advisory Committee	A total of 25 people representing 20 groups were engaged to provide strategic input to the CCI. There were 17 meetings held to allow information exchange between members and the project where decisions were made on the strategies to include in the WQIP
Rural Management Practice Technical Committee	This was a committee of catchment management practitioners with landholder representation to inform the rural part of the project. Between three and 16 members attended 25 meetings, workshops and field visits to provide input on rural management actions to include in the Farm Scale Action Plan.
Landholder Reference Group	This was a group of landholders from across the project area formed to provide on-ground input to rural management ideas in association with the Rural Management Practice Technical Committee. Two workshops with this group of six landholders helped to inform the Farm Scale Action Plan, ensuring that the recommendations in the plan were implementable and practical.
Individual landholders and landcare groups	A total of 55 landholders completed surveys, and several landholders allowed research to be conducted on their properties to better inform the rural part of the plan. Many of these landholders also provided direct feedback on management ideas at workshops, as did several members of local landcare groups.
General community – groups and individuals	A total of 175 interested people (representing 16 groups) helped review the environmental values of the three lakes and provide general suggestions. There were 62 community members who reviewed and suggested catchment management strategies at workshops. A total of 230 people were provided with a presentation on the CCI at two information sessions. Also,the general public received information through the media.
Internal Water Sensitive Urban Design stakeholder group	Between 10 and 14 officers from Great Lakes Council and MidCoast Water attended four internal working group meetings to help inform urban actions in the WQIP.
External Water Sensitive Urban Design stakeholder group	Between seven and 14 stakeholders from building, architecture, design and planning companies attended three meetings to ensure the recommendations in the plan for urban areas were implementable and practical from an industry perspective.
Management Systems group	Between five and nine officers from Great Lakes and Greater Taree councils, and MidCoast Water, attended three meetings to provide input on the types of systems needed to ensure the recommended actions would be implemented.
Other government agencies and groups	Ten agency stakeholders attended a full-day workshop to review current pollution control systems. A total of 23 presentations on the CCI were made to other agencies, boards and committees.

In developing the WQIP, the Great Lakes Coastal Catchments Initiative had three main components:

- water quality research to identify the current status of the systems, and develop catchment and estuarine models of sediment and nutrient loads to the Myall, Smiths and Wallis lakes
- identifying rural, urban, rural residential and management support actions to reduce sediment and nutrient loads entering the lakes
- a decision-support system to assist with decision-making in relation to how activities on the land will impact on water quality and ecology of the lakes.

Water Quality Improvement Plan summary

The Water Quality Improvement Plan focuses on algae concentration and water clarity as indicators of the estuaries' ecological condition. These parameters were selected, as increased algal biomass and deceased water clarity can lead to harmful algal blooms, loss of habitat such as seagrass, reduced fish abundance, loss of higher predators (e.g. birds, dolphins, sharks), and overall loss of biodiversity and estuarine function. The WQIP used abundance of microalgae (chlorophyll-a), water clarity (turbidity, Secchi depth) and the extent of seagrass as the primary indicators of estuarine condition. Water clarity and chlorophyll-a concentrations were considered to be the appropriate measures of ecological condition – rather than water quality parameters – because they were direct measures of ecosystem status and were the only indicators of condition linked to catchment disturbance.

To determine the actions required to maintain or improve the ecological health of the systems, the current status of the lakes and the river estuaries were identified and ranked in relation to their relative conservation values. Conservation values were established based on the chlorophyll-a concentration recorded in the field. Three levels were established:

1. High conservation value
2. Moderately disturbed
3. Heavily impacted.

Current condition of the lakes and ecological condition targets

Wallis Lake

The **southern end of Wallis Lake** is in a *High conservation value* or near-pristine state. It supports a wide variety of seagrass, healthy algae and brackish water plant (macrophyte) communities to a depth in excess of 3 m. All these benthic (bottom-dwelling) plant communities are dependent on clear, clean water with very low nutrient loads. These near-pristine conditions have allowed the continued survival of the ecologically important seagrass and macrophyte communities, with their associated biodiversity (including the increasingly threatened estuarine sponges found to be present). The long-term target identified for the southern end of the lake was to maintain its current near-pristine condition.

Localised conservation value issues were identified in a number of areas.

In **Coomba Bay area**, chlorophyll-a measurement showed elevated concentrations when compared with the southern bays of the main Wallis Lake body. A large gully estimated to be up to 300 m long, 3–4 m wide and 2 m deep – which resulted from a failed dam – exported a large volume of sediment into the waters of the bay. In this event, seagrass communities were killed due to burial and the resuspension of the deposited sediments that caused long-term turbidity. The impact of a seemingly small failure in catchment management emphasises the scale of risk that can stem from localised catchment conditions. The long-term target identified for Coomba Bay is to improve its current condition to more closely resemble *High conservation value* conditions. This means chlorophyll-a levels need to be reduced by 41%.

The **Pipers Creek and Pipers Bay** area is the receiving waters for the medium-density urban and light industrial developments on the eastern side of the Wallis Lake, and includes the majority of the Forster urban area. Chlorophyll-a concentrations in Pipers Creek were among the highest measured in the system, with the average value five to six times greater than values expected for this type of environment. The research indicated that this part of Wallis Lake is significantly degraded, with extensive macroalgae growth recorded on the seagrass. This area was identified as in the lower end of the range for a *Slightly to moderately disturbed* ecosystem value. The long-term target for the Pipers Bay area is to improve its current modified condition to more closely resemble a *High conservation value* condition. This means chlorophyll-a levels need to be reduced by 50%. This will also provide a degree of protection to the main Wallis Lake body because during high-flow periods, pollutants flow from Pipers Bay towards the southern bays of Wallis Lake.

The **lower Wallis Lake estuary** (comprising the lower reaches of the Wallamba, Wang Wauk and Coolongolook Rivers; the lake entrance; and the eastern and western channels), despite receiving much of the catchment input of pollutants from the major rivers, was determined to be generally in good condition. This area is well flushed (i.e. there is significant tidal exchange with the ocean) when compared to other parts of the system. The lower Wallis Lake estuary was determined to be in the lower category of *High conservation value*. Given that the lower estuary is where most of the aquaculture and lake-based recreation occurs, the long-term target is to maintain and, where possible, improve on current conditions to provide a buffer against possible future increases in pollutants, including those arising from single, localised events.

While the lower reaches of the Wallamba, Wang Wauk and Coolongolook rivers have good ecological condition, the **middle reach of the Wallamba river estuary** has an ecological condition that is *Slightly to moderately disturbed*. The **middle reach of the Coolongolook and Wang Wauk river estuary** are also *Slightly to moderately disturbed*, although they are in better condition than the middle reach of the Wallamba River. The adopted long-term target for the middle reaches of the Wallamba, Coolongolook and Wang Wauk River estuaries was to improve from their current modified condition to more closely resemble *High conservation value* conditions. This requires a long-term reduction in chlorophyll-a by 21% in the Wallamba River, 14% in the Coolongolook River and 2.7% in the Wang Wauk River.

The **upper reach of the Wallamba river estuary** has an ecological condition that is *Slightly to moderately disturbed*. The degree of impact is higher than the middle reaches of the river. The plan recommends that the upper reaches of the Wallamba river estuary be managed to improve it from its current modified condition to more closely resemble *High conservation value* conditions. The long-term goal requires a 30% reduction in chlorophyll-a.

Smiths Lake

The current ecological condition of Smiths Lake was identified as of *High conservation value*. The ecological condition target identified for Smiths Lake is to maintain its high conservation value and, where possible, improve on current conditions to provide a buffer against possible future increases in pollutants or impacts of lake use activities.

Myall Lakes

Myall Lake and Boolambayte Lake both have a good ecosystem quality and were considered to be of *High conservation value*. **Two Mile Lake**, while generally in good condition, has experienced higher levels of chlorophyll-a and nuisance algal growth, and appeared to have lost some deepwater plant communities at its southern end. The adopted long-term targets for Myall Lake and Boolambayte Lake are to maintain and, where possible, improve on current conditions to provide a buffer against possible future increases in pollutants. This was considered especially important, given that it is a Ramsar site (Wetland of International Importance).

Bombah Broadwater, in the Myall Lakes, is a *Slightly to moderately disturbed* ecosystem. The Bombah Broadwater has experienced some severe algal blooms over the past decade and the apparent loss of deepwater plant communities. The long-term target for the Bombah Broadwater is to improve its current modified condition to more closely resemble a *High conservation value* condition. This requires a 14% reduction in chlorophyll-a levels.

Management strategies

The strategies outlined in the WQIP targeted two specific purposes:

- to remediate existing areas of high pollutant loads, and thus reduce catchment loads and improve estuarine health
- to protect areas of high conservation status that currently provide substantial water quality and biodiversity benefits to the rivers and lake systems.

While protection actions were not expected to improve water quality as such, the plan highlights that it is essential to protect against further declines in water quality. The WQIP confirms that it is more important and less expensive to protect current values and functions than to replace them once they have been lost. Given the cost of remediation actions and the limits to their effectiveness to improve water quality at the catchment scale, the WQIP [pt4] indicates that it is essential that a range of protective actions is implemented. Protection actions identified included maintaining existing vegetation buffers and placing limits on and controlling inappropriate development. This is particularly the case for the southern end of

Wallis Lake where the unique ecological values are at risk if significant protection of current values and functions is not undertaken.

A summary of the programs identified in the WQIP is shown below. The nature of the programs is similar between lakes. However, the extent of each program varies. This variation was based largely on the ecological condition of each lake (and therefore the amount of remediation or protection actions required), dominant land uses in each catchment and the feasibility of the adoption of actions in each area.

Table 0.2. Remediation actions proposed in the Water Quality Improvement Plan.

Program	Program description	Lakes	Plan section
Rural land			
Groundcover management	The aim of this program is to improve groundcover on rural lands, thus reducing the amount of sediments and nutrients washing into the waterways. Groundcover management refers to a sustainable grazing program for landholders, and is 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 groundcover levels (including off-stream watering, solar pumps and fencing).	Myall Wallis Smiths	3.3.2
Nutrient (Fertiliser) management	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 a whole-farm plan. This program also supports a dung beetle program. Additional actions related to the management of human and animal effluent include the upgrade of laneways and stock crossings. However, these kinds of actions, although recommended by the plan, were not modelled through the CCI project.	Myall Wallis	3.3.2
Infrastructure (Dam) management	Infrastructure management includes the refurbishment of dams that are a water quality risk as well as decommissioning those dams that are not functioning, and potentially acting as a source of nutrients and sediments to the system. It involves working with landholders to repair dam structural problems, controlling stock access to the dam or providing an alternative stock water supply from the dam. It also involves landholder training, as well as training and accreditation of contractors. Additional actions relating 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.	Myall Wallis	3.3.2
Riparian remediation	Riparian remediation programs include the rehabilitation of sites with active stream bank erosion. These sites are based on identified locations in existing plans, such as rivercare plans. This program includes significant in-stream repair work for bank stabilisation and fencing off the creek in identified areas.	Myall Wallis	3.3.2
Unpaved road remediation	This aims to identify and seal unpaved roads in priority areas, such as creek crossings in the Smiths Lake catchment and the Crawford sub-catchment of the Myall Lakes system. This would also include installing best practice sediment and erosion control features, such as mitre drains to divert road runoff into grassed areas.	Smiths Myall	3.3.2
Urban land			
Urban Mitigation (Water Sensitive Urban Design)	Urban mitigation includes the retrofitting of rainwater tanks supported through a program of rebates. It is recommended that the tanks are plumbed into the home to maximise the water quality benefits. It also involves an extensive program of urban retrofitting where Water Sensitive Urban Design (WSUD) systems, such as biofiltration (including trenches, raingardens and biopods), are built into the existing urban landscape to filter the urban stormwater. For Wallis Lake, the focus areas are the catchments of Pipers Creek and Pipers Bay. In Smiths Lake, the focus is in the existing urban area. This program also involves education and capacity-building on maintenance and construction of WSUD devices, adoption of a development control plan that specifies best practice water-sensitive urban design, and associated staff training and capacity-building. It also includes investigating options for a nutrient offset scheme for the Pipers Creek / Pipers Bay area.	Wallis Smiths	3.4.2
Water Sensitive Redevelopment	Water Sensitive Redevelopment involves the implementation of a development control plan that specifies best practice water-sensitive urban design (including biofiltration and rainwater tanks) on all redevelopments. The program of redevelopment has been estimated based on existing redevelopment rates.	Wallis	3.4.2

Table 0.3. Protection actions proposed in the Water Quality Improvement Plan.

Program	Program description	Lakes	Plan section
Rural land			
Wetland protection	Wetland protection involves the acquisition of wetlands, and undertaking management and / or rehabilitation as required (e.g. fencing, establishing property vegetation plans, management plans, reinstating natural hydrology). The program also involves assisting landholders to protect natural wetlands, with advice, training and on-ground works to control stock access. More generally, the program involves partnerships with the community, including raising the profile of wetlands and their role in providing environmental services, as well as encouraging participation in management and restoration.	Wallis Myall	3.3.2
Riparian protection	This program involves fencing and / or stock exclusion of areas of riparian revegetation, including off-stream watering and some planting where vegetation requires rehabilitation. It also involves establishing property vegetation plans in areas not suitable for fencing (e.g. high-slope areas).	Myall Wallis	3.3.2
Urban land			
Water Sensitive Development of Greenfield sites	Water- Sensitive Development of Greenfield sites involves establishing and implementing Local Environmental Plan (LEP) / Development Control Plan (DCP) provisions on Greenfield development sites in the Wallis Lake catchment. This will involve enforcing 'no net increase' in pollutants relative to the existing land use (agricultural and forest land use classifications). This program also involves establishing heads of consideration for voluntary planning agreements with developers.	Wallis Smiths Myall	3.4.2
Water Sensitive Redevelopment	Water Sensitive Redevelopment involves the implementation of a development control plan that specifies best practice water-sensitive urban design (including biofiltration and rainwater tanks) on all redevelopments. Predicted redevelopment rates in the Smiths and Myall lakes are low, and therefore in these areas it is considered a protection action.	Smiths Myall	3.4.2
Water Sensitive Urban Design protection	WSUD protection is an education and capacity-building program on stormwater management, including water-sensitive urban design and improved management of urban land. It involves workshops, field days and demonstration sites with stakeholders including the general community, business, students, and building and development industries. It involves updating plans, strategies and design guidelines (such as road guidelines), as well as resourcing a sediment and erosion control audit and training program.	Wallis Smiths Myall	3.4.2
Foreshore and riparian management in urban areas	Foreshore and riparian management in urban areas involves improving foreshore areas around Wallis and Smiths lakes through establishing site-specific management plans, education and engagement of residents surrounding foreshore areas to reduce the impact of their behaviours, and increased enforcement of environmental legislation in these areas.	Wallis Smiths	3.4.2
Best management of unpaved roads	Best management of unpaved roads includes construction of mitre drains to divert road runoff into grassed areas, and sealing and diverting runoff away from streams particularly in the vicinity of creek crossings. The program involves mapping the location and extent of road erosion sites, and undertaking risk analysis in each sub-catchment to prioritise roads for rehabilitation or closure. A program of training and auditing contractors and council staff specific to road construction to ensure best management practices are applied will also be undertaken as part of this action.	Wallis Smiths Myall	3.3.3
Other			
Protect sea sponge beds	To facilitate the protection of the unique sea sponges in Wallis Lake, identification and mapping of the location of sea sponges, and developing and implementing an action plan and case for formal protection, are required. This program also involves engaging with the community and key stakeholders to establish support for protection, as well as establishing appropriate community education and monitoring programs.	Wallis	Appendix 2.6

Program	Program description	Lakes	Plan section
Improved management of lake use activities	Improved management of lake use activities involves reviewing stormwater management plans to clarify the outcomes required to protect the environment and oyster growing programs to identify synergies with ecological monitoring programs (Wallis Lake). It also involves establishing memoranda of understanding with key groups of lake users, and investigating other management options such as closing boat ramps during high-flow events (Wallis Lake) and establishing markers to protect seagrass beds (all lakes). It also involves supporting actions in the Smiths Lake boating plan. In Myall Lakes, it recommends upgrading gravel boat ramps, assessing impacts of water sports and adopting no-discharge guidelines for greywater.	Wallis Smiths Myall	3.5.2
Improved pollution control systems / management systems	Improved management and pollution control systems involves reviewing how water quality management, both within and between organisations, is approached. It focuses on establishing checking and review loops in key areas, such as compliance with conditions of consent, and sediment and erosion control. The program also highlights the need to embed water quality improvement actions in organisational plans to ensure the WQIP is implemented. It highlights the need to review a range of existing systems such as the fee structure for on-site sewage management, and recommends exploring alternative ways to formalise the response to complex pollution cases and strengthen cross-agency relationships and delegation.	Wallis Smiths Myall	3.7
Management support actions			
Adaptive Management Strategy / Ecological monitoring program	The Adaptive Management Strategy underpins the implementation of the WQIP. It highlights the ecological, political and social uncertainties surrounding the WQIP, and identifies ways to track these and make informed management decisions during plan implementation. The ecological monitoring program outlined in the strategy involves the collection of data on ecological indicators such as chlorophyll-a, water clarity, habitat assessments on river reaches and fish sampling. The strategy also recommends a public reporting regime for the WQIP.	Wallis Smiths Myall	3.9
Future investigation relating to the Farm Scale Action Plan[DG5]	Areas for investigation include riparian management, wetland management, groundcover management, farm infrastructure management, nutrient management and ways to encourage uptake of improved management practices. The findings from this research are applicable across all three catchments.	Wallis Smiths Myall	3.3.2

Predicted ecological improvements resulting from management actions

Wallis Lake

Substantial reduction in chlorophyll-a concentrations would be achieved in the Pipers Bay area with full implementation of the identified actions. Chlorophyll-a concentrations can be reduced, on average, by 13% and up [DG6]to 26% for Pipers Bay; and, on average, by 3%, and up to 7% for [pt7]the upper, mid and lower estuary zones. Although substantial, these changes do not reach the target 50% reduction in chlorophyll-a identified for Pipers Bay, or the reductions identified for the upper and mid estuary.

Smiths Lake

The estimated feasible change in chlorophyll-a concentrations in Smiths Lake are in the order of 3.6%. This result achieves the identified target of no decline in ecological condition.

Myall Lakes

Reductions in chlorophyll-a concentrations of 2.4% would be achieved in the Bombah Broadwater with full implementation of the management actions identified. Smaller reductions would be achieved for the Boolambayte Lake (1.9%) and Myall Lake (1.6%). Changes do not reach the 14% reduction identified as the long-term target for Bombah Broadwater, but do achieve the target of no further decline for the Myall and Boolambayte systems.

In conclusion, these changes do not fully achieve the identified long-term targets for Pipers Bay, the upper and mid estuary of Wallis Lake, and Bombah Broadwater in the Myall Lakes.

They are, however, an important step in moving towards these outcomes and are highly important for the adoption of longer-term adaptive management. Importantly, the WQIP recommends that there be no further decline in lake condition. This objective would be achieved in all areas of Wallis, Myall and Smiths lakes through the implementation of the WQIP.

Costs and future funding

Funding for the WQIP urban, rural and lake use actions is critical to the success of the Plan. Sourcing funds is identified as one of the major challenges confronting the organisations and community members who are committed to implementing WQIP actions. The costs of funding the actions identified in the WQIP for each lake are summarised below.

Table 0.4. Summary of costs associated with implementing the Water Quality Improvement Plan after seven years.

Lake	Total cost of WQIP implementation	Average annual cost over seven years
Wallis Lake	$54,801,000	$7,687,000
Smiths Lake	$1,221,200	$174,000
Myall Lakes	$7,153,000	$954,000

Economic analysis undertaken as part of this project has shown that the benefit-cost ratio for implementing the Wallis and Myall Lakes actions is economically viable. Smiths Lake, however, did not demonstrate such a convincing response, with a benefit-cost ratio that showed the Plan is difficult to justify on the grounds of economic efficiency alone. This result is largely because Smiths Lake is currently in a *High conservation value* condition, and predicted changes in water quality under the Plan actions do not lead to benefits that are able to be feasibly estimated. Given the limitations of this analysis and the environmental values identified by the local community, it is still recommended that the WQIP actions be implemented for Smiths Lake.

Given the value of funding required to achieve the improvements in ecological condition identified in this Plan, there would need to be a collective focus on seeking funding to implement the WQIP through the development of a business plan. As funding becomes available, the approach to implementation will need to be flexible and adaptable. The potential sources of funds, their relative importance for implementing the plan and the security of funding for the particular actions have been identified and are discussed within the WQIP.

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GLOSSARY OF TERMS

AnnAGNPS	The Annualised Agricultural Non-Point Source (AnnAGNPS) model simulates quantities of surface water, sediment, nutrients and pesticides leaving the land areas and their subsequent travel through the watershed. More information on this model can be accessed from the Decision Support System (DSS) Overview window.
Benthic	The benthic zone is the ecological region at the bottom of a water body, such as a lake, and includes the surface and some sub-surface layers. The organisms that live in this zone are called benthos.
Catchment Action Plan	A Catchment Action Plan is used to guide investment to protect and improve the natural resources of a region over a given period. The Hunter-Central Rivers Catchment Action Plan is a 10-year plan (2006 to 2016) for better coordinated and more sustainable management of the regions natural resources. It identifies the key natural resource features that require protection and improvement, and outlines the best ways to do this.
Catchment load	The amount of nutrient or sediment that the estuary model predicts will not cause exceedance of Ecological Condition Targets.
Chlorophyll-a	Chlorophyll-a is one type of the green pigment found in plants known as chlorophyll. Measurements of chlorophyll-a concentrations in a waterbody are used to estimate algal biomass and to assess biological productivity.
Conceptual framework	Conceptual frameworks in the Great Lakes DSS show the relationship between land use and management actions, and community values. An initial framework, developed during the review phase, was presented to stakeholders for discussion, and to ensure that management actions and community values associated with the lake and its catchment were included. The participatory activities were used to refine the conceptual framework and to clarify the types of actions to be included in the DSS.

DCP	Development Control Plans (DCPs) supplement LEPs and are detailed guidelines that define controls that apply to a particular type of development or in a particular area.
DSS	There is no universally accepted definition of Decision Support System (DSS), although in its most general form a DSS is a tool to support decision-making. They are often computer-based tools that allow users to explore current and alternative options for managing the system of interest. DSS developed at iCAM tend to feature three main components: Data base – numerical and/or qualitative information that helps users familiarise themselves with the study system and to explore the impacts of different options. Model base – the models used to manipulate data and generate output from user-defined actions. Data stored in the data base are input to, or created by, the model base. Interface – the DSS interface allows user to navigate through the tool, run the models and view outputs. The interface is kept separate from the model base to facilitate the use of the DSS by users who are not familiar with programming and computer models. More information on the Great Lakes DSS can be accessed from the DSS Overview window.
Ecological Condition Targets	Numerical levels or descriptive statements that must be met to maintain environmental values. In the Great Lakes CCI, project condition targets have been set for chlorophyll-a and turbidity.
Environmental value	The value or use of the water that we wish to protect.
Hydrodynamic model	In the CCI project, a computer-based hydrodynamic model was developed for each lake system. The model shows where water (and water-borne, catchment-derived matter) goes, and how long it stays there. The model is driven by the physics of the system and considers wind, tides and catchment inflows.

Indicator	A characteristic used to provide a measure of the condition of ecosystem or quality of water.
LEP	Local Environmental Plans (LEPs) are the principal legal document at the council level for controlling the use and development of land. LEPs are prepared by councils and approved by the Minister after public exhibition of the plan.
Light attenuation	Light attenuation determines how fast the light intensity decreases with distance from objects and is measured as an exponential loss rate per metre. It quantifies the amount of light that is available for photosynthesis.
Littoral rainforest	A type of rainforest that occurs within the influence of the sea or a large coastal water body (e.g. lake or estuary). This vegetation type is protected in New South Wales under SEPP 26.
Macroalgae	Algae that are not microscopic. The body of the plant can be seen easily with the eye.
Macrophyte	An aquatic plant that grows in or on the water and can be free-floating, submergent or emergent.
MUSIC	MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is designed to simulate urban stormwater systems operating across a range of temporal (minutes to daily) and spatial (0.01 km^2 to 100 km^2) scales, and was developed by the Cooperative Research Centre for Catchment Hydrology – Urban Stormwater Quality Program. The model has been designed for urban stormwater engineers, planners, policy staff and managers in consultancies and state, regional and local government agencies. More information on the use of MUSIC in the CCI project can be accessed from the DSS Overview window.
Potential for eutrophication (PE)	The potential for excessive plant growth to occur in a water body. It provides a measure of the risk of negative outcomes such as nuisance algal blooms, transition to phytoplankton dominance, more turbid waters and muddy foreshores. The concentration of material in the water column that might, at some time, be used for primary

	production is a reasonable indicator of PE. In the estuary models developed for the Great Lakes CCI project, nitrogen concentration in the water column is considered to be a measure of PE.
Riparian vegetation	Riparian vegetation is the vegetation on land adjoining, directly influencing or influenced by a stream.
Secchi depth	The depth that a 20 cm weighted black-and-white disk can be seen into a water column, and is a measure of water clarity.
SEPP	State Environment Planning Policies (SEPP) are policies proposed by the Minister and approved by the Governor. SEPPs address matters of state significance.
Total Nitrogen	A measure of all forms of nitrogen (e.g. nitrate, nitrite, ammonia-N and organic forms) exported from lands or present in a water body.
Total Phosphorus	A measure of all forms of phosphorus (e.g. dissolved, particulate) exported from lands or present in a water body.
Total Suspended Sediment	Total amount of suspended material in a water column, and is a measure of water clarity.

ABBREVIATIONS

AHD	Australian Height Datum
ALUM	Australian Land Use and Management
AnnAGNPS	Annualised Agricultural Non-Point Source Pollution model
ARI[DG9]	Average return interval
ASRIS	Australian Soil Resource Information System
AUSRIVAS	Australian River Assessment System
BASIX	NSW Building Sustainability Index
BMP	Best management practice
BOD	Biological oxygen demand
CCI	Coastal Catchments Initiative
CMA	Catchment Management Authority
CRCCH	Cooperative Research Centre for Catchment Hydrology
CRP	Current recommended practice
DAGS	Mid Coast Dairy Advancement Group
DCP	Development Control Plan
DECC	Department of Environment and Climate Change
DIN	Dissolved inorganic nitrogen
DIPNR	Department of Infrastructure, Planning and Natural Resources (no longer current)
DNR[DG10]	Department of Natural Resources
DON	Dissolved organic nitrogen
DoP	Department of Planning
DPI	Department of Primary Industries
DSS	Decision Support System
DWE	Department of Water and the Environment
EPA	Environmental Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
GIS	Geographical information system
GLC	Great Lakes Council
GLLEP	Great Lakes Local Environmental Plan
GSC	Gloucester Shire Council
GTCC	Greater Taree City Council
HCRCMA	Hunter-Central Rivers Catchment Management Authority
ICOLL	Intermittently closed and opened lake or lagoon
ISO	International Standards Organisation
km	Kilometres
LEP	Local Environmental Plan
m	Metres
MCW	MidCoast Water
MoU	Memorandum of Understanding
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
N	Nitrogen
NHT	Natural Heritage Trust
NPWS	National Parks and Wildlife Service (NSW)
NRM	Natural resource management
NSW	New South Wales
NTU	Nephelometric turbidity units
OAQC	Oyster Assurance Quality Control

OSM	On-site Sewage Management
P	Phosphorus
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
REP	Regional Environmental Plan
SALIS	Soil and Landscape Information System
SEPP	State Environmental Planning Policy
SOE	State of the Environment
SoJI	Statements of Joint Intent
SPADE Pro	Soil Profile Attribute Data Environment Professional
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
µg/L	Micrograms per litre
WQIP	Water Quality Improvement Plan
WSUD	Water Sensitive Urban Design