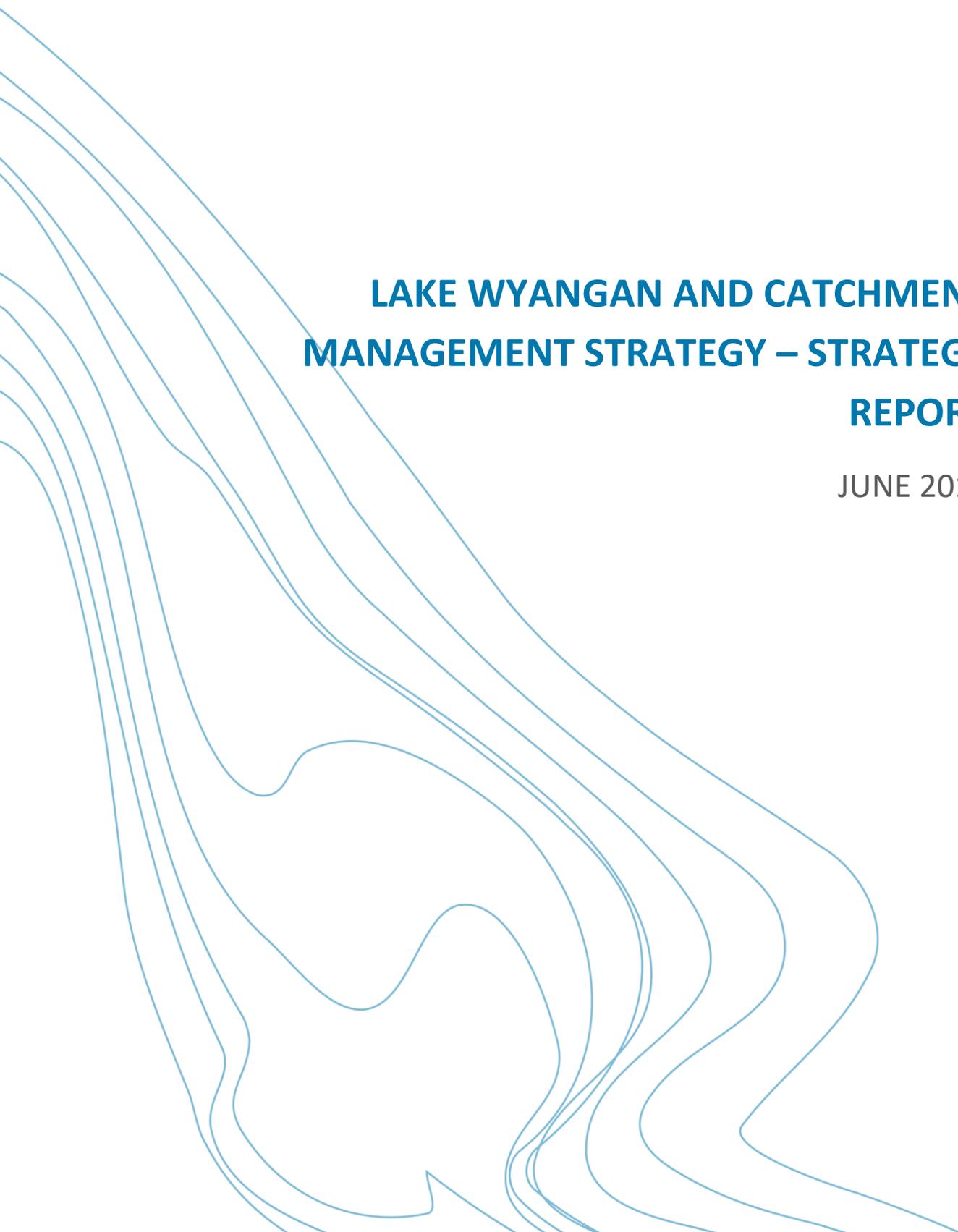




# **LAKE WYANGAN AND CATCHMENT MANAGEMENT STRATEGY – STRATEGY REPORT**

JUNE 2017



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## GLOSSARY

Algal biovolume	Algal biovolume is commonly calculated to assess the relative abundance (as biomass or carbon) of co-occurring algae varying in shape and/or size
Bioretention	Bioretention is the process in which contaminants and sedimentation are removed from stormwater runoff. Stormwater is collected into the treatment area which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants.
Blue-green algae	A widely distributed grouping of cyanobacteria occurring singly or in colonies in diverse habitats. Some species can fix nitrogen.
Chlorophyll a	A green pigment, present in all green plants and in cyanobacteria, which is responsible for the absorption of light to provide energy for photosynthesis.
Cyanobacteria	Any of various photosynthetic bacteria of the phylum Cyanobacteria that are generally blue-green in colour.
Diurnally	Occurring in a 24 hour period
Eutrophication	Excessive abundance of nutrients in a lake or other body of water, which causes a dense growth of plant life
Gross pollutants	Gross Pollutants are anything larger than sediment.
HAB	Harmful Algal Bloom
Infiltration	Infiltration is the process by which water on the ground surface enters the soil.
Macrophyte	A macrophyte is an aquatic plant that grows in or near water and is either emergent (above surface), submergent (below surface), or floating. In lakes and rivers macrophytes provide cover for fish and substrate for aquatic invertebrates, produce oxygen, and act as food for some fish and wildlife.
NTU	Nephelometric Turbidity Units (NTU) is a unit of measurement for turbidity
Pathogens	A bacterium, virus, or other microorganism that can cause disease.
Residence time	The average length of time during which a substance, a portion of material, or an object is in each location or condition, such as adsorption or suspension.
Lake stratification	Lake stratification is the separation of lakes into three layers: Epilimnion - top of the lake. Metalimnion (or thermocline) - middle layer that may change depth throughout the day. Hypolimnion - the bottom layer.
Thermocline	An abrupt temperature gradient in a body of water such as a lake, marked by a layer above and below which the water is at different temperatures.

Turbidity	Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity.
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# 1. INTRODUCTION

## 1.1 Background

Griffith City Council (GCC) in partnership with Murrumbidgee Irrigation (MI) commissioned Water Technology and Professors Perran Cook and John Beardall of Monash University to undertake the Lake Wyangan and Catchment Management Strategy project.

Lake Wyangan is situated 6 km's northwest of the Griffith CBD and is the epi-centre for a diverse range of land uses and recreational uses. The Lake Wyangan catchment is relatively small, totalling around 121 km<sup>2</sup>, including diverted catchment runoff through the irrigation supply and drainage infrastructure (Lake Wyangan's natural catchment is around 75km<sup>2</sup>) (BMT WBM, 2013). The Lake View Branch Canal supplies irrigation water to local agriculture and is a major feature of the catchment as it intersects most catchment runoff. The recent Lake Wyangan modernisation project by Murrumbidgee Irrigation (MI) included the replacement of 13.7km of degraded open channels with sub-surface gravity pipelines, significantly enhancing volumetric water delivery on-farm while reducing delivery water losses as accessions to groundwater flows draining into Lake Wyangan.

The immediate area surrounding Lake Wyangan comprises the villages of Lake Wyangan and Nericon, several Rural Residential developments, intensive horticultural farms (Citrus, Viticulture), grazing land and broadacre farming including almonds, melons, Winter cropping, rice and livestock and recreational areas. Within Griffith City Council's Land Use Strategy: Beyond 2030, there is also planned future development in areas surrounding Lake Wyangan, which includes land release for some 800 residential and rural residential lots over the next 20 years.

North Lake itself is a very popular recreational facility with several clubs using the area for boating, water-skiing, sailing, rowing, fishing, picnicking, barbequing, and wildlife observation. South Lake operates as drainage basin for rainfall runoff and minimal off farm drainage.

This diverse land use and lake use mix now presents significant water management challenges, particularly as community expectations regarding both water quantity and quality in Lake Wyangan have risen significantly. Of concern is the reoccurring incidence of Blue-Green Algae (B-GA) in the lakes. Lake Wyangan regularly attains the NHMRC 2008 Recreational Guideline 'Red Alert' status with total B-GA biovolume readings  $\geq 10\text{mm}^3/\text{L}$  subsequently restricting all access to the lake.

The Lake Wynagan and Catchment Strategy Management project has looked at the drivers of water quality and ecological condition in Lake Wyangan and how catchment conditions, and in particularly land use, impacts upon this. This information has been used to develop an integrated management strategy for Lake Wyangan and its Catchment to guide future actions to address water quality concerns.

## 1.2 Purpose

This document is a strategic plan that builds upon the accompanying technical investigation. It aims to provide a clear vision and direction for Council in terms of future Lake and Catchment management to improve water quality in Lake Wyangan and reduce the incidence of B-GA blooms. Management objectives and actions are clearly defined and prioritised and guidelines for measurement of success have been identified.

All management actions relate to specific desired outcomes for the lake and are ranked per their recommended priority for implementation. Where possible targets or timelines have been included however in many instances these will be dependent upon suitable funding being made available.

### 1.3 Supporting Documentation

This document can be read in conjunction with the accompanying technical report. The technical investigation focussed on quantifying the water quality conditions in Lake Wyangan, particularly in relation to B-GA and how lake conditions were affected by the surrounding catchment. As the irrigation supply and drainage network is an important component of the water balance for the Lake the assessment included both water quality measurements and modelling in the Lake and the inflowing drains.

Following the assessment of the lake and catchment water quality conditions, a Management Options analysis was undertaken. This was a comprehensive review of in-lake and catchment options for improving water quality conditions to reduce or eliminate the occurrence of B-GA. A range of short and long term options were considered and recommendations provided as to the most effective in-lake and catchment options available.

### 1.4 Report Structure

This document is a strategic plan that will provide Griffith City Council with direction regarding water management practices in Lake Wyangan and its Catchment. It sets a Vision, clear Management Objectives, and outlines Management Actions both now and in the future. The overall report structure is outlined in Figure 1-1.



Figure 1-1 Report Structure

For each Management Action a Road Map has been provided indicating the various tasks that should be addressed, the suggested timeframe of the task, and the likely impact of the action upon improving water quality conditions within Lake Wyangan and the catchment drains.

Funding for the actions listed within the Road Maps will be able to be either budgeted for internally within Council or otherwise, where external input is required, external funding could be sought, e.g. Federal and/or NSW State Government, Riverina Local Land Services.

## **1.5 Public Exhibition and Feedback**

Public exhibition of the Lake Wyangan and Catchment Management Strategy occurred in December 2016 and feedback was received via several written submissions. These submissions were reviewed by Council and the final Strategy Report (this document) along with the accompanying Technical Report incorporate the relevant feedback.

## 2. VALUES

People of our community value Lake Wyangan and its catchment for many reasons, including the aesthetic and recreational value of the area, its environment and the economic values for local businesses, and the lifestyle that living near the Lake provides.

### 2.1 Threats

The following are the key issues threatening the attributes of Lake Wyangan and its Catchment that the community most highly value. These threats primarily come about through the ways in which water is used and distributed across a range of land uses and activities throughout the catchment.

- Elevated nutrient and sediment levels in the drains and into Lake Wyangan leading to B- GA blooms,
- Reduced drain inflows to the Lake through both more efficient irrigation practices, improved asset management of irrigation delivery infrastructure, and climate variability,
- Other pollutants (including pathogens and chemicals),
- Loss of ecosystem function and associated services within the Lake, and
- Increasing peri-urban and intensive horticulture development pressures within the catchment,

The intent of this plan is to assist all stakeholders in dealing with these issues and protecting and improving what is valued.

### 2.2 Principles

The water quality conditions of Lake Wyangan and its Catchment are to be maintained and improved in line with the following principles:

- The ecological needs of the Lake and Catchment are to be met whilst balancing recreational, aesthetic and commercial uses.
- People are to be informed and empowered to work together for a healthy Lake and Catchment and a strong, healthy community.
- The management of the Lake and Catchment must aim to maintain and enhance the resilience of natural systems.
- The management of the Lake and Catchment is to be best practice, adaptive and based on the best available scientific information.
- Knowledge gaps are to be identified and addressed to continually improve management of Lake Wyangan and its Catchment.

### 2.3 Vision

Our vision for Lake Wyangan and its Catchment is:

***Community, business including Agri-business, and Council working together for a healthy, productive and attractive Lake Wyangan and Catchment both now and into the future.***

These Values, Threats, Principles and Vision have been developed based on the outcomes of the technical assessment for this project, which involved consultation with Griffith City Council, Murrumbidgee Irrigation and the community through a series of Project (Expert Panel and Steering Group) Meetings and Community Stakeholder Meetings. A community survey was undertaken at the Community Stakeholder Meetings and the response received helped to inform this plan. These are detailed in Appendix E of the accompanying Technical Report.

## 3. MANAGEMENT OBJECTIVES

### 3.1 Overview

The suitability of water quality has long been recognised as an important issue for both North and South Lake Wyangan. The on-going outbreaks of blue-green algal blooms (B-GA) have brought the issue of lake water quality into the public arena, specifically highlighting the impacts nutrients and sediments can have on the suitability of the lake waters. The primary sources of these nutrients and sediments are from the range of agricultural activities in the catchment rather than individual point sources. Additional sources of nutrients and sediments also include the existing on-site (septic tank) wastewater treatment systems, and runoff from peri-urban development areas. Historic as well as current sediment and nutrient contributions to the Lake are also important.

Therefore, to achieve the vision of Community, Business and Council working together for a healthy, productive, and attractive Lake Wyangan and Catchment, both now and into the future, a series of management objectives (see Table 3-1) has been developed.

These objectives are underpinned by a detailed set of Management Actions linked to stakeholder(s) responsible for their implementation. For ease of use, these objectives have been divided into themed management areas labelled: Water Quality, Ecosystem Health, and Community Wellbeing.

It is recognised that the Lake and the Catchment cannot be considered in isolation and that the health of the lake is fundamentally linked to the health of the entire catchment. Although treated separately within some Management Actions, these objectives clearly highlight the interconnectedness of Lake and Catchment health, and the wellbeing of the Community.

*Table 3-1 Management Objectives*

Water Quality (WQ)	
WQ1	Reduce the frequency and severity of algal blooms in Lake Wyangan
WQ2	Reduce nutrient and sediment loads to waterways
WQ3	Reduce the risk of septic waste entering Lake Wyangan
Ecosystem Health (EH)	
EH1	Maintain and improve areas of locally significant native riparian and wetland vegetation as well as linkages between habitat areas
EH2	Address the threats to local ecosystems from climate variability
Community Wellbeing (CW)	
CW1	Facilitate safe and sustainable usage of Lake Wyangan
CW2	Protect and enhance the aesthetic and recreational values of Lake Wyangan and its Catchment
CW3	Provision of a range of quality recreational opportunities

Sections 4, 5 and 6 describe the main Management Actions required to achieve the objectives in Table 3-1. The main Actions are described in detail and are followed by Road Maps. Road maps identify and prioritise the works needing to be completed in order to provide cost effective and thoroughly scoped projects.

## 3.2 Guidelines to Measure Success

Long-term success of the management objectives through the Management Actions should be measured by monitoring the progress of their implementation over time. Performance monitoring and review is therefore an integral part of the overall Lake and Catchment Management Strategy.

Key Performance Indicators (KPIs) or similar measurement tools can be used as an indicator of the measure of success of each objective that has been developed. These were included in the Road Maps. The Roads maps present specific milestones, objectives and outcomes that have been identified to enable monitoring and review of the implementation process.

In general, the following should be monitored:

- If actions have been implemented.
- Changes in water management practices.
- Reductions in nutrients or other threats to water quality.
- Changes in the quality or health of Lake Wyangan.
- Changing or new priorities.

Actions should be reviewed to determine if they require alteration due to new information or recognition that the original actions were not entirely appropriate. The effectiveness of the strategy could then be assessed by asking the following evaluation questions:

- What worked in relation to helping achieve the objectives?
- What did not work?
- Did anything change because of the action?
- Were there any unexpected results from the strategy?
- What would be done differently next time?
- What evidence is there that the strategy implementation made a difference?
- Have people changed their management practices?
- Are the problem areas getting better?
- Have community values / expectations changed?

This strategy provides guidance on how to measure success by recommending a number of performance indicators to be monitored and reviewed over time. The specifics of the suggested measures should be clarified in a later stage depending on the feasibility of the actions at the time of implementation of this plan.

## 4. WATER QUALITY MANAGEMENT ACTIONS

The following sections set out the priority water quality management actions which form the core of the Lake Wyangan and Catchment Management Strategy. These actions have been developed based on detailed options assessments undertaken for this project.

### 4.1 WQ1 - Reduce the frequency and severity of algal blooms in Lake Wyangan

Shallow lakes are dynamic systems which change over time in response to internal and external inputs and processes. Eutrophication in these systems occurs when there is an excess of inorganic nutrients which often leads to excessive growth of algae, termed an algal bloom.

The three main factors controlling an algal bloom are the residence time of the water, nutrients, and the availability of light in the water column.

- **Residence time** - Water within Lake Wyangan has a long residence time as there is no natural outlet. This limits the ability for mixing of the water to occur and the only exchange of water is through evaporation. The volume of water entering the Lake through the drains has also reduced over time. The longer the residence time the greater the chance of an algal bloom occurring. Reducing the residence time means the algal biomass becomes regulated by the rate it is removed from the lake by evaporation.
- **Nutrients** – Nitrogen and phosphorus are the key nutrients in B-GA bloom development. Historic nutrient loads to the Lake through the drainage network have resulted in a significant store of phosphorus in the Lake sediments. There is also continued input of high levels of sediments, nitrogen and phosphorus through the drainage network.
- **Light** – the turbidity and mixing conditions in a lake can limit the algal biomass, however the depth of light penetration can also limit the growth of submerged aquatic plants. Monitoring data indicates that turbidity in the Lake is generally low although plumes of suspended sediment have been observed coming from the inflow drains following rainfall events. Phosphorus also attaches to these sediments.

The focus of management options described below was on actions that can be undertaken to reduce the frequency and severity of algal blooms by addressing these three controlling factors.

#### 4.1.1 *Management Options Review Summary*

To develop management actions for the Lake, an assessment of over 20 in-lake management options was undertaken. Both short and long term options were considered as well as linkages to catchment management actions. A detailed summary of all the in-lake options assessed and their relevance to Lake Wyangan is provided in the accompanying technical report. Because of the assessment, the recommended short- and long-term options are:

- **Aeration/Mixing Systems** - The release of phosphorus stored in the sediment into the water column is likely an important factor in blue-green algae bloom generation. Although not confirmed by the available data, this is thought likely to occur diurnally with conditions most conducive to stratification in late Spring through to late Summer. Further monitoring is recommended to confirm this. The lack of mixing of the lake waters in turn exacerbates this process. Mixing and/or aeration of the lake waters, limits stratification from occurring and promotes cycling and growth of the Green (Chlorophyta) group of algae in preference to the blue-green (cyanobacteria) algae.

The option of mixing/aeration within the bottom waters **does not directly manage the summer surface water algal growth**. It will, however, reduce the risk of algal blooms occurring following autumn mixing of the bottom and surface waters, and the amount of phosphorus available at the commencement of the next growing season.

It is recommended that a “pilot” project be implemented in North Lake Wyangan to test the effectiveness of an aeration/mixer system to reduce or limit the occurrence of algal blooms. This would be linked to the recommended water quality monitoring program and would be focussed on the “hot spots” within North Lake Wyangan.

The recommended on-going water quality monitoring includes continuous monitoring of water quality conditions in Lake Wyangan at monitoring sites within North and South Lake as well as regular spot sampling at the existing monitoring sites. It is also recommended that the physical monitoring be combined with satellite mapping of water quality to provide an accurate and detailed picture of conditions across the whole of Lake Wyangan on a regular basis. This approach would allow “hot spots” of potential B-GA blooms to be readily identified to inform the operational locating of aeration/mixing equipment. Initial costs have been sourced from suitable manufacturers.

- **Hydrologic Manipulation** – this is the enhancement of the inflows, outflows and mixing regime within the Lakes. The aim is to reduce the residence time of the waters and therefore the algae and phosphorus concentrations in the water column. Discussions are on-going as to the feasibility and costs of options for hydrologic manipulation, which includes:
  - Environmental flow allocations – provided through the existing MI network. To obtain an environmental flow allocation within the Murrumbidgee catchment further discussion with the Murrumbidgee Environmental Water Allowance Reference Group is required. To support any application, information must be provided on any water dependent ecosystems and services or sites of ecological significance at Lake Wyangan.
  - GCC “fills” – provided through the existing MI network. GCC holds a Water Access License. It can trade this water on the open market at a value determined year to year by the open market. GCC can utilise this license for filling North Lake Wyangan, foregoing the Water Market opportunities, and subsequent income. This water is supplied to the lake via the existing MI drainage network.
  - Modification of existing extraction licenses from Lake Wyangan to allow the lake to operate as an irrigation storage. It was identified in discussions with stakeholders during the project that there are existing extraction licenses associated with Lake Wyangan. At present these licenses are only triggered under high lake levels typically associated with flood events. However, the question was asked as to whether these licenses could be modified to enable extraction from North Lake Wyangan under non-flood conditions if the supply water was provided via the drainage network and stored in the lake.
  - Changes to existing MI/GCC infrastructure to facilitate enhanced delivery or extraction of water from the lake either for environmental allocations, GCC “fill events”, or irrigation water delivery. MI have provided an indication of the possible flow routes and volumes that could be implemented for North and South Lake Wyangan to improve water circulation and mixing conditions. Initial testing of the proposed flow route and volume options showed there was an

improvement in mixing conditions across the Lake when undertaking a Council fill event compared to a GCC “fill event” using the existing infrastructure alone.

It is recommended that “fill events” continue to be undertaken. The fill volume should be at least 25% of the lake volume (i.e. 25% of the volume of North Lake Wyangan if the water is delivered to North Lake) to enhance the dilution effect and the preferred timing for fill events is late Spring, and Summer. Longer term opportunities to enhance circulation in the lakes should continue to be investigated.

Other recommended in-lake options are:

- **Macrophyte Restoration** - This management option would involve the re-establishment of emergent and submerged macroplants. The purpose of the action would be to enhance the natural take-up of nutrients within the lake. As noted in Lawrence (2012) for Lake Burley Griffin, the re-establishment of macrophyte habitats in lakes and reservoirs has had a mixed success rate often due to the already elevated suspended sediments, limiting light necessary for their re-establishment.

A staged or phased approach to a “macrophyte restoration” program is recommended. This could be targeted to specific locations on North and/or South Lake, and timed to coincide with periods where the lake water level can be reduced (such as during winter).

- **Carp Management** – Monitoring to determine the existing carp numbers within Lake Wyangan. Dependent on the outcomes of the monitoring, targeted carp removal could be undertaken in identified hotspots where the fish congregate for spawning or where water temperatures are favourable.

Monitoring of carp numbers within the Lake is required to quantify the potential need and then effectiveness of this option. A Fish Survey of Lake Wyangan should be undertaken by NSW DPI (Fisheries) to establish the actual population and the numbers of various species in the lake.

In relation to Carp Herpes, if it is determined that Carp numbers are of concern for water quality in Lake Wyangan, GCC would likely enlist the further expertise of NSW DPI (Fisheries) and the Invasive Animals CRC to undertake a planning and modelling exercise to ensure a managed Carp kill and clean-up because of releasing the Carp Herpes Virus.

- **Monitoring and Communications Protocol** – currently GCC and MI undertake separate monitoring programs and B-GA alert protocols for North and South Lake Wyangan. A combined monitoring and communication protocol for the lake should be developed. The monitoring program should be reviewed every 2 years to consider latest monitoring techniques and requirements.

Develop and implement a combined GCC and MI monitoring and communication protocol for Lake Wyangan.

#### **4.1.2 Road Map**

Management actions and the road map to address WQ1 - Reducing the Frequency and Severity of Algal Blooms in Lake Wyangan are described in Table 4-1.

Longer term management actions to reduce on-going nutrient loads into Lake Wyangan from the catchment are treated separately in Section 4.2.

## Road Map for WQ1 - Reducing the Frequency and Severity of Algal Blooms in Lake Wyangan

Table 4-1 Water Quality Management Actions – Frequency & Severity of Algal Blooms

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
<b>WQ1.1</b> <b>Coordination of Catchment and Lake Management Governance</b>	Setup a Lake Wyangan & Catchment Management Committee comprising representatives from management agencies as well as residents and stakeholders.	Continue the operation of the Lake Wyangan & Catchment Management Committee as a coordinating mechanism for implementation of the plan.	Continue the operation of the Lake Wyangan & Catchment Management Committee as a coordinating mechanism for implementation of the plan.	High	Lake Wyangan & Catchment Management Committee was created within the first two years of signing the strategy and actively operating.
	Allocation of a person within GCC to be responsible for this committee and coordination of the implementation of the management actions will ensure actions and tasks can be implemented. This will require time and budget allowance.	Continue the allocation of person to support the committee and action implementation.	Continue the allocation of person to support the committee and action implementation.	High	The Lake Wyangan & Catchment Management Committee has a person who oversees and reports on the matters related to Lake Wyangan.
	Identify potential collaborations and funding sources/arrangements for implementing Management Actions. Document the potential collaboration as well as the successful ones.	Annually review the potential collaboration and funding sources/arrangements.	Annually review the potential collaboration and funding sources/arrangements.	High	Several potential collaboration and funding sources were identified.  Several projects have been developed through external

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
					<p>collaboration and funding.</p> <p>It is suggested that a target number of proposals/projects per year should be established.</p>

<p><b>WQ1.2 - Water Quality Monitoring Program</b></p>	<p>Establish and implement flow and water quality monitoring program – lake focus (to be combined with WQ2.1). This should be done through a combined monitoring and communication protocol between GCC and MI.</p> <ul style="list-style-type: none"> <li>• Review and adapt the monitoring program based on monitoring outcomes to date.</li> <li>• Setup real-time monitoring of DO/temp levels in the lakes. This will allow for forecasting of potential periods of risk for algal bloom occurrence.</li> <li>• Conduct nutrient and algal monitoring on a regular basis to obtain a comprehensive background dataset.</li> </ul>	<p>Report annually on the outcomes of the monitoring program.</p> <p>Undertake yearly review of the monitoring program and (if required) update of the monitoring program.</p> <p>Use the data to create a consolidated database of the current physical conditions in the lake which affect algal bloom development, including DO levels and nutrient concentrations.</p>	<p>Continue to update the database of monitoring data.</p>	<p>High</p>	<p>A monitoring program is in place and is reviewed every year ensuring that the key parameters have been monitored.</p>
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Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
		Update and calibrate the existing Source model (eWater) of the Lake and catchment and assess the impacts of proposed future changes.	Update the modelling as necessary to test the potential impacts of changes to catchment landuses or implementation of management options prior to and following implementation.	Medium	A catchment model has been calibrated and is being used to aid assessment of future changes.
	Establish trigger levels for undertaking management actions such as “fill events”. Fill events should be undertaken in late Spring to Summer and should aim to provide at least 25% of the lake volume if instigated for algal bloom management (i.e. 25% of the volume of North Lake Wyangan if the water is delivered to North Lake Wyangan).	Review and revise trigger levels.	Review and revise trigger levels	High	Trigger levels for management actions were established and are being used to determine the fill events.
<b>WQ1.3 In-Lake Management</b>	Identify the presence of “hot spots” of B-GA blooms across Lake Wyangan using the on-going physical water quality monitoring combined with the satellite imagery analysis.	Undertake trials of mixing of the water column in North Lake - aiming for Spring/Summer period. Should be combined with in-lake monitoring. Focus on “hot spot” locations.	Continue (and possibly expand) trial dependent on review of performance to determine if system shows impact on water quality.  Review costs of trial.	High	Trials of mixing of the water column in North Lake were performed. If the trials were found to be useful and cost-beneficial, an expansion plan was developed and is in place.

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
		Review at the end of the irrigation season in autumn 2017.			
	<p>Implement a GCC “fill event” into the lake to address water shortfalls and improve mixing conditions.</p> <p>Confirm if the allocation of environment flows is possible for Lake Wyangan.</p>	<p>Implement works to improve recirculation of water in the lake and improved mixing of any flow releases or fill events.</p> <p>Further modelling of the impact of different release volumes on mixing to determine appropriate volumes.</p>	Continued implementation of works to improve recirculation of water in the lake.		Water circulation is in practice and advancing towards improved Lake conditions through reduced frequency and severity of B-GA blooms compared to the previous season.
	<p>Undertake pilot projects for macrophyte restoration in North and South Lake. This could be combined with stormwater management actions (detailed in the following section) which include:</p> <ul style="list-style-type: none"> <li>• Construction of a sediment basin and wetland at the outlet of Drain No. D2LVDR030E into North Lake Wyangan.</li> <li>• Restoration of macrophyte beds in and</li> </ul>	<p>Continued trials including:</p> <ul style="list-style-type: none"> <li>• Construction of a sediment basin and wetland at the outlet of drain at the location of sampling point SLW-3.</li> <li>• Restoration of macrophyte beds in and around South Lake.</li> </ul> <p>Bi-annual review of performance and identification of any design improvements.</p>	Extend the trials to all inflowing drains.	Medium	<p>The pilot project was undertaken and the lesson learnt were documented.</p> <p>Several other projects are being carried out based on the learnings obtained with the pilot project.</p> <p>Measureable reduction in sediment load within 12 months of implementation of a sediment basin.</p>

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
	around the recreation area.				
	In-lake carp survey to determine carp numbers in the Lake.	On-going survey of carp and fish levels. Implement carp management actions if carp numbers indicate they may be an issue within the lake.	On-going survey of carp levels.		Surveys are regularly undertaken and carp levels are under control.  Increase in macrophyte growth in the lake.

## 4.2 WQ2 -Reduce nutrient and sediment loads to waterways

The North Lake receives most its runoff from agricultural land (predominantly citrus, almonds, grapes, vegetables and rice) through the MI drain network. This runoff contributes high levels of nutrients and sediment to the Lake. At present, there are no significant urban or peri-urban development's contributing runoff directly to the North Lake. Agricultural land uses are likely to continue, however there is also increasing pressure for peri-urban development around the eastern margins of the lake. Without management interventions, the nutrient and sediment load to the North Lake will remain high.

The South Lake currently receives most runoff from the existing peri-urban/urban areas of Lake Wyangan village, Mallinson Drive as well as from significant areas of intensive (predominantly horticulture) farming. This runoff, combined with tile drainage from the agricultural areas, contributes nutrients and sediments into South Lake. The continued intensive agriculture along with potential increases in peri-urban development is likely to further increase stormwater runoff volumes into South Lake. Overall, without management interventions the nutrient and sediment load to the South Lake will remain high.

### 4.2.1 *Agricultural Areas*

Agriculture activities have the potential to generate excess amounts of nutrients and sediments if inappropriately managed, and can expose soil to erosion, resulting in large amounts of sediment and attached nutrients that can be transported into the MI drain network and any local waterways.

Treating the agricultural runoff before it reaches the waterways has a positive effect on the waterway health, increasing water clarity and the abundance of aquatic fauna and flora. Reducing the impacts of runoff from agricultural land use on water quality in the drains and ultimately Lake Wyangan therefore focuses on land management practices and education. The actions under this objective can be readily linked to other Griffith City Council management plans.

Agricultural runoff can be managed by:

- maintaining healthy vegetation around waterways such as the MI drain network, and potentially implementing features such as swales and vegetated buffer strips,
- maintaining healthy and appropriate vegetation within the drain network and managing this vegetation with appropriate maintenance practices,
- capturing and treating runoff in sediment ponds either on farm or with the MI drain network,
- covering or enclosing fertiliser storages,
- reducing fertiliser use through better targeting,
- upgrading to more efficient irrigation systems,
- reducing runoff from dryland and irrigated farming land.

It should be noted that the period between the implementation of improved management practices and subsequent improvements in water quality varies. Erosion control measures tend to have a fairly rapid effect on soil loss from a crop field whereas for agricultural nutrients the lag between implementation and measurable results is generally accepted to be in the order of years to decades (Meals et al, 2010).

## 4.2.2 Peri-Urban and Urban Areas

In natural catchments around 25% of the rain infiltrates and 10% end up as runoff (FISRWG, 1998). As urbanisation increases, less rainfall is infiltrated and more becomes runoff, Figure 4-1. At Lake Wyangan this means that in the peri-urban and urban areas rainfall that once infiltrated the ground through vegetation now meets impervious surfaces such as roofs, roads, and footpaths, runs directly into the drain network and ends up in the Lake. This runoff carries with it pollutants such as sediments and nutrients from houses, roads, lawns, livestock, and pets (GLC, 2012b).

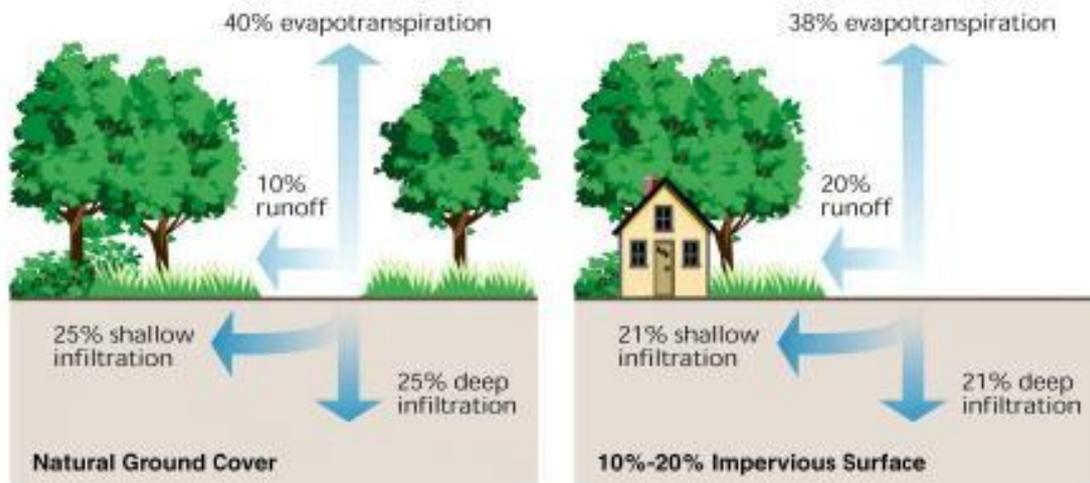


Figure 4-1 Changes to water flows with urbanisation (FISRWG, 1998)

Reducing the impacts of runoff from peri-urban and urban land use on water quality in the drains and ultimately Lake Wyangan therefore focuses on water management practices and education. The actions under this objective can be readily linked to other GCC management plans.

Peri-urban and urban runoff can be managed by a range of treatment measures including:

- Swales and vegetated buffer strips along roadways and/or the MI drain network,
- Sediment ponds, wetlands and bioretention systems located at the stormwater outlet from a development or at the inlets to Lake Wyangan, and
- Bioretention on individual properties.

As for agricultural management practises, in a peri-urban or urban setting there is a lag between implementation of the treatment measures and improvements in water quality downstream. However, small treatments close to the source of the sediments or nutrients typically result in more rapid improvements.

## 4.2.3 Management Options Review Summary

Rural and peri-urban/urban water management approaches and features can be implemented across a range of locations and at various scales – from individual farms or properties to the full drainage network.

To reduce sediment and nutrient loads to waterways within the Lake Wyangan catchment a range of options were considered with several them linked to in-lake management actions. A detailed summary of all the rural and peri-urban water management options assessed and their

relevance to Lake Wyangan is provided in the accompanying technical report. Based on the outcomes of the review, the recommended options are:

- **Implement on-going monitoring program in the drains** – this builds upon the existing monitoring program through inclusion of flow monitoring of the incoming drains to allow improved determination of sediment and nutrient loads into the lake.

It is recommended that flow monitoring combined with total suspended solids or turbidity monitoring for all the inflowing drains. Ideally the flow monitoring would be telemetered. Further details of the recommended monitoring program are provided in the accompanying technical report.

- **Promote changes to on-farm soil and water management practices** – this focusses on on-farm changes to fertiliser application and irrigation practises, ground cover including vegetation types, as well as areas adjacent to the MI drainage network.

It is recommended that GCC continue to promote the benefits of such changes for the water quality of Lake Wyangan in collaboration with Riverina Local Land Services.

It is recommended that GCC work with Riverina Local Land Service to develop guidelines for managing land adjacent to drains such as allowing for vegetated buffer strips. These buffers act as both a sediment trap and for nutrient reduction. A pilot project should be developed to assess appropriate options for different crop/farm types.

- **Modify current MI / GCC drain design and maintenance practises in the catchment and implement program of “vegetated drains”** – the quality of the water in the drains is important to the long term health of Lake Wyangan. Allowing appropriate vegetation in the base and banks of the drains would assist in reducing the sediment and nutrient load to the Lake.

It is recommended that GCC work with MI to develop guidelines for design and management of drains in the Lake Wyangan catchment. A pilot project should be developed on Drain No.D2LVDRR030E for this process. This would then be expanded to other drains, prioritised based on the sediment and nutrient loads determined through the monitoring program.

- **Implement sediment basins, bioretention features, and/or wetlands on each drain at the inlet to Lake Wyangan** - Nutrients and fine sediments, require several measures used in sequence for treatment to be most effective. The drain inlets to Lake Wyangan would be appropriate locations for these features. Land availability may be a constraint for some of the features. Very high sediment loads could also damage and ultimately shorten the life span of the systems. Any system would need to accommodate delivery of environmental or “fill” water to the Lake.

Wetlands are usually preferred by the community as they provide aesthetic and amenity benefits. In addition, they provide downstream waterway health and significant temperature cooling benefits.

On the other hand, bioretention features are very efficient in removing nutrients and can provide high levels of treatment in significantly small systems.

It is advised that either of the systems should follow a sediment pond that will work on settling the coarse sediments and ensure a longer life of the secondary system (i.e. wetland or bioretention).

It is recommended that GCC work with MI to implement a staged program of sediment basins, biorention systems and/or wetlands on all the drain inlets to Lake Wyangan. It is recommended that Drain No. D2LVDR030E which enters North Lake Wyangan via the Recreation Area be prioritised as this could be combined with vegetation management in the drain upstream and macrophyte restoration round the lake margin. The location also provides for enhanced aesthetic and amenity benefits. Prioritisation of other treatments should be based on sediment and nutrient loads determined through the monitoring program.

- **Set sediment and nutrient removal targets for the treatment of runoff for new developments** - In New South Wales, these targets are set by local Councils. It is suggested that the removal targets presented in Table 4-2 could be considered as a baseline in which to derive more specific values for Griffith. Stormwater targets should be specific to land use type (e.g. rural, new peri-urban, established per-urban areas, growth areas, car parks and roads) as appropriate.

*Table 4-2 Runoff water quality management design objectives in terms of pollutant removal*

State	Suspended solids	Total phosphorus	Total nitrogen	Gross pollutants
Victoria	85%	45%	45%	90%
Queensland	80%	60%	45%	90%

- **Incorporate water management practises into current practices** - There are several ways in which GCC can include the principles of distributed onsite water management initiatives into the current practices, such as:
  - Integrating water management principles into the planning process;
  - Including water management best practice in the new infrastructure projects (where practical and possible);
  - Establishing an on-going retrofit program for existing areas after identifying and prioritising areas most suited and most in need of water management features; and,
  - Setting an annual water management features implementation target and undertaking regular progress reporting towards meeting this target.

Defining an implementation target and a target treatment for all water management features would allow GCC to work towards an actual, measurable goal and provide a benchmark across which actions and performance could be assessed. This means setting the level of suspended sediment, phosphorus and nitrogen reduction GCC would like to achieve through the implementation of water management practices.

#### **4.2.4 Management Options Estimated Costs**

Table 4-3 presents the estimated costs associated with various runoff water treatment options proposed in this strategy, including planning during the design, construction, establishment (i.e. first 2 years), maintenance, renewal and decommissioning phases.

**Table 4-3** *Indicative costs associated with the suggested runoff water quality management strategies*

<b>Feature</b>	<b>Construction (m<sup>2</sup>)</b>	<b>Maintenance First 2 Years (m<sup>2</sup>/year)</b>	<b>Ongoing Maintenance After the First 2 Years (per m<sup>2</sup>/year)</b>	<b>Renewal (m<sup>2</sup>/25 year)</b>	<b>Decommission (m<sup>2</sup>)</b>
Sediment Basin	\$200	\$16.5	\$11	\$56	\$76
Bioretention Basin	\$108	\$3	\$2	\$75	\$41
Wetland	\$550	\$5	\$5	\$285	\$214
Grassed Swale/Drain	\$20	\$3	\$3	\$13	n/a

### **4.2.5 Road Map**

Management actions and the road map to address WQ2 – Reduce sediment and nutrient loads to waterways in the Lake Wyangan catchment are described in Table 4-4. Many of these actions link to the longer term management in-lake actions detailed in the preceding section.

## Road Map for WQ2 - Reducing Nutrient and Sediment Loads to Waterways

Table 4-4 Water Quality Management Actions – Reducing sediment and nutrient loads

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
<b>WQ2.1</b> <b>Water Quality Monitoring Program</b>	Establish and implement flow and water quality monitoring program – catchment focus (to be combined with WQ1.2). <ul style="list-style-type: none"> <li>From this data GCC will be able to determine which type of management options are more suited to the conditions of the local government area.</li> <li>This data will inform future catchment modelling.</li> </ul>	Report annually on the outcomes of the monitoring program.  Use the data to create a consolidated database of the current physical conditions in the catchment and levels of main pollutants from different land uses.	Undertake a 5 year review of the monitoring program and (if required) update of the monitoring program.  Continue to update the database of monitoring data.	High	A flow and water quality program was established and the results are reported annually to the Lake Wyangan & Catchment Management Committee.

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
		Update and calibrate the existing catchment WQ models and assess the impacts of proposed future changes.	Update the modelling as necessary to test the potential impacts of changes to catchment landuses or implementation of management options prior to and following implementation.	Medium	Flow data has been used to calibrate the catchment modelling.
		Review and revise sediment and nutrient reduction targets for treatment measures.	Review and revise target levels.	High	The target levels have been reviewed and the GCC is advancing to achieve best practice management levels.
<b>WQ2.2</b> <b>Changes to on-farm soil and water management</b>	Develop links to industry organisations or groups for farm management.  Develop an efficient and effective system for the capture and sharing of new land management practices. This may be linking from the GCC website directly to the Riverine LLS website or through other media.	Provide assistance to industry organisations or groups to develop best practice guidelines for land management practices application to catchment activities.	Work with landholders through the Riverina LLS to build their capacity to undertake sustainable farming activities that improve groundcover and reduce impacts on drains, including: <ul style="list-style-type: none"> <li>• Increase ground cover under permanent plantings.</li> <li>• Reduce runoff from fallow land.</li> <li>• Establish riparian buffer zones along drains,</li> </ul>	Medium	The Lake Wyangan & Catchment Management Committee and the land owner representatives undertook pilot projects to showcase the benefits of healthy riparian zones and soil.  Landholders are working together with The Lake Wyangan & Catchment Management

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
			<ul style="list-style-type: none"> <li>Identify and remediate priority soil erosion zones,</li> <li>Undertake optimal soil nutrient management,</li> <li>Promote efficient irrigation practice i.e. which seeks to apply only the amount (mm) required for crop water use (i.e. Crop factor) and minimise drainage (infiltration) past the root zone. Efficient irrigation practices i.e. ensure only the required amount is applied when the crop reaches refill point.</li> </ul> <p>This could be done through pilot projects with specific landowners.</p>		<p>Committee to protect the drains.</p> <p>Responsibilities for implementation of management actions have been agreed.</p> <p>A reduction in sediment loads in the drains. The water quality sampling program will provide the required information to determine this improvement over time.</p>
<b>WQ2.3</b> <b>Catchment Management</b> <b>– On-ground Actions</b>	Undertake development of design and maintenance guidelines for MI and GCC drains in the catchment.	Implement a pilot project on Drain No. D2LVDR030E in collaboration with MI.	Expand the use of drain vegetation across the catchment network.	High	Design and maintenance guidelines have been developed and are currently in place.

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
	Undertake an audit of the drains to identify those with the highest potential to deliver sediment to Lake Wyangan.		Bi-annual review of performance and identification of any design or maintenance improvements. Regular inspections and condition assessment of drains.		Pilot projects were undertaken and projects have been expanding where results indicate that this action is reducing sediment/nutrient loads.
	Undertake pilot projects for runoff water management (linked to macrophyte restoration detailed in the preceding section) which includes: <ul style="list-style-type: none"> <li>Construction of a sediment basin and a secondary treatment feature (i.e. bioretention or wetland) at the outlet of Drain No. D2LVDR030E into North lake Wyangan.</li> </ul> Link with restoration of macrophyte beds in and around the recreation area.	Continued trials including: <ul style="list-style-type: none"> <li>Construction of a sediment basin and a secondary treatment feature (i.e. bioretention or wetland) at the outlet of drain at the location of sampling point SLW-3.</li> <li>Restoration of macrophyte beds in and around South Lake.</li> </ul> Bi-annual review of performance and identification of any design improvements.	Extend the project implementation to all inflowing drains.	High	The pilot project was undertaken and the lesson learnt were documented.  Several further projects are being carried out based on the positive outcomes obtained with the pilot project, such as a measurable decrease in sediment loads.
<b>WQ2.4 Catchment Management – Planning Actions</b>	Develop stormwater sediment and nutrient reduction targets for the catchment, including treatment targets for specific areas.	Create an annual improvement target that new and existing water treatment measures can be assessed against.	Review and refine targets until it reaches best practices.	High	Pollutant reduction targets were developed and are increasing annually.

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
	Incorporate runoff water management requirements including water quality targets for development applications.	Create an annual improvement target that new and existing water treatment measures can be assessed against.	Review and refine targets until it reaches best practice standards.	High	GCC has included treatment requirements for new developments.  Document of water management requirements for new developments have been created.
	<p>Develop education campaign for local landowners and residents.</p> <p>Residents meeting to discuss issues, concerns associated with proposed pilot projects.</p> <p>Working individually with any landowner directly affected by pilot projects in front of their property, perhaps by scheduling small group information sessions for certain residents at the GCC offices.</p>	<p>Develop a Water Management Strategy communication 'package' consisting of brochure materials to be distributed to the community.</p> <p>Letter drop for all local residents informing residents of the works that will take place, the theory behind the works and the maintenance needs of the runoff water treatment assets.</p> <p>Residents meeting to discuss issues, concerns and potential options.</p>	Continue dissemination of information on performance of existing treatment measures and any proposed new measures.	Medium	<p>The pilot projects have been used as demonstration for the community who understands the need to treat the pollutants in the catchment before reaching the Lake.</p> <p>Residents are aware of the works before they start.</p> <p>The Lake Wyangan &amp; Catchment Management Committee is fully engaged with key community members</p>

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
					who are passing on the learnings to the remainder of the community.  The number of educational projects undertaken during the first two years and the analysis of the number of participants and their feedback can be used to monitor the increase in the community engagement.
	<p>Establish a plan to roll out the runoff water treatment implementation works.</p> <p>A prioritised list will ensure systems are cost effective for the amounts of nutrients and sediment removed. Can be used to attract funding.</p>	<p>Develop a strategy for the roll out of water treatment assets within the catchment in collaboration with MI.</p>	<p>Update and review strategy every 5 years.</p>	<p>Medium</p>	<p>The roll out plan has been prepared.</p> <p>Responsibilities for implementation of management actions have been agreed.</p>
	<p>Include stormwater treatment systems as a requirement of all new subdivision.</p>	<p>Develop Guidelines for the design and construction of such assets. And continue to require these actions.</p>	<p>Continue to require these actions.</p>	<p>High</p>	<p>New developments are treating their generated runoff on site by</p>

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
					utilising sustainable treatment strategies.

## 4.3 WQ3 - Reduce the risk of septic waste entering Lake Wyangan

Inadequate sewage treatment and disposal can pose a significant threat to public and environmental health. There is currently no reticulated sewage system for the Lake Wyangan catchment.

Currently rural, urban and peri-urban areas rely on individual on-site sewage management systems (OSMS) for wastewater treatment. If these systems are inappropriately sited, or incorrectly managed and maintained, OSMS's can pose a significant risk of effluent entering nearby drains or seeping into groundwater.

### 4.3.1 Management Options Review

To reduce the risk of septic waste entering Lake Wyangan a range of options were considered. Based on the outcomes of the review, the recommended actions are:

- **Review and implement the Onsite Sewerage Management Plan** - Griffith City Council has an On-site Sewerage Management Plan. However, this plan will be reviewed and updated and will reflect the goals of the *Environment & Health Protection Guidelines: On-site Sewerage Management for Single Households and AS/NZ 1547:2000 (On-site Domestic Wastewater Management)*. As part of this review process, GCC will also carry out a review of its risk assessment program that it uses to assign risk levels to OSMS's. The allocated risk level determines the frequency in which inspections are carried out.
- **Implement Onsite Sewerage Management Development Assessment Framework** - Any on-site sewerage system proposed for new peri-urban developments in the catchment should be assessed using a risk-based approach which sets out GCC's level of investigation, acceptable solutions (deemed to satisfy) and minimum standards for sewerage management in unsewered areas. The responsibility for this would be with the GCC Environment, Health & Sustainability Unit.
- **Pursue funding for a reticulated wastewater treatment system** - Griffith City Council has submitted an Expression of Interest Application for the Restart NSW Water Security for Regions Regional Water and Waste Water Backlog Program. GCC has submitted three separate applications to fund reticulated sewerage systems for Lake Wyangan, Nericon and Tharbogang. The plan (if funding is received) is to have them all completed by 2020 (Lake Wyangan July 2016 – July 2017, Nericon July 2017 – July 2018 and Tharbogang July 2018 – July 2020). However, at this stage GCC has received no further contact in regards to the funding. The responsibility for this would be GCC Water & Sewerage Department.
- **Maintain toilet and pump out facilities at the recreation areas**, adapt to peak usage times and assess need for additional pump out sites – responsibility for this action is yet to be determined. The toilet blocks at Lake Wyangan Picnic Area, Camping Area, Boat Club and Sailing Club shall have a maintenance strategy that reflects the increased demand on the systems during peak usage times (boat club events, sailing club events, high camping use). The strategy should address how they will be dealing with the increased

use, measures in place to prevent any potential system overflows and who is responsible for monitoring the systems during this time.

### **4.3.2 Road Map**

Management actions and the road map to address WQ3 – Reduce the risk of septic waste entering Lake Wyangan are described in Table 4-5.

## Road Map for WQ3 - Reducing Risk of Septic Waste entering Lake Wyangan

Table 4-5 Water Quality Management Actions – Septic Waste Management

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
<b>WQ3.1 Onsite Sewerage Management</b>	<p>Review and update the existing Onsite Sewerage Management Strategy.</p> <p>Review of risk assessment program.</p> <p>Implement OSSM Development Assessment Framework.</p>	<p>5 year review of strategy.</p> <p>Bi-annual review of OSSM risk assessment.</p> <p>Annual risk assessment of new developments.</p>	Continued reporting on condition of OSSM systems.	Medium	<p>Educational outreach and training help was developed to avoid system failures.</p> <p>The OSSM framework has been developed and is adopted for maintenance of existing systems and planning for new developments.</p>
<b>WQ3.2 Implement reticulated sewerage system</b>	Pursue funding for reticulated sewerage system. Develop a business case to show case a cost-benefit analysis of advancing sewage management to protect Lake Wyangan.	Continue to pursue funding and undertake staged implementation as funding becomes available.	Implement reticulated sewerage system across the catchment.	Medium	A business case was developed and has been used for fund searching.
<b>WQ3.3 Lake Wyangan facilities management</b>	<p>Define responsibilities for OSSM facilities around Lake Lake Wyangan Picnic Area, Camping Area, Boat Club and Sailing Club.</p> <p>Develop maintenance strategy for each facility.</p>	<p>Fully implement maintenance strategy and monitoring performance.</p> <p>Include in OSSM risk assessment.</p>	Continued reporting on condition of OSSM systems.	Medium	<p>Responsibilities for implementation of management actions have been agreed.</p> <p>The local government area is advancing towards a coordinated OSSM system.</p>

## 5. ECOSYSTEM HEALTH MANAGEMENT ACTIONS

The land resources of the Lake Wyangan Catchment underpin the Catchment's health. Maintaining the quality of these land resources is therefore crucial to the maintenance of the services that these ecosystems provide. The loss or overexploitation of these services eventually results in decrease of the systems "resilience" which can lead to further and accelerating environmental decline.

### 5.1 EH1 & 2 - Maintaining and Improving Vegetation

Vegetation plays an essential role in maintaining healthy waterways. Besides being a key component for improved water quality, appropriated vegetation within the drains can improve the overall ecosystem health.

In urban and peri-urban catchments, drains and channels are often a last refuge for native fauna, however these corridors can offer important links to other habitats of greater size and diversity. In addition, introducing a shrub layer can potentially offer habitat to small birds. In the Lake Wyangan catchment, the MI drainage network provides this same opportunity.

#### 5.1.1 *Management Actions*

Available information on ecosystem components (e.g. vegetation, animals, birds and fish) has been reviewed and based on the outcomes of the review, the recommended options were:

- **Develop a revegetation plan for the catchment and the lake** – A coordinated revegetation plan for the catchment which links the existing vegetation corridors and wetlands and considers proposed new works at the lake and drains. This relates to the water quality objectives and actions around macrophyte restoration and sediment/nutrient reduction as well as enhancing the linkages to the existing riparian vegetation around the lake and the significant wetlands.

This plan should cover the plant selection as well the establishment of an ongoing program of weed control. In addition, it is important to engage the community in the early stages of the revegetation plan. It is necessary to educate the residents about the benefits of having vegetation, particularly in the drain network. The use of signs adjacent to drains explaining why vegetation is important is also recommended.

- **Develop management plans for drains and update existing management plans for wetlands** – The management plan for drains should link to the water quality objectives, particularly vegetation of the drains for reducing sediment and nutrient loads. The existing management plans for the Nericon and Campbells Swamp wetlands should be updated to ensure linkages to catchment actions and Lake Wyangan.
- **Undertake research to more clearly define environmental risks to local ecosystems associated with climate variability** – on-going climate variability poses a direct threat to biodiversity, including the direct impacts on habitat and ecosystem functioning. Many species are highly sensitive to changes in climate and weather-related patterns and events. These can disrupt seasonal food supplies and other resources, life cycle events, development, mortality, breeding and fertility, such that entire reproductive strategies

become less successful. At present, there is little specific information on how these changes affect systems such as Lake Wyangan.

Impacts on biodiversity will be complex and highly variable, therefore there is a need to develop best practice measures to address all the other environment stressors to minimise the impacts caused by climate variability. This may include plant selection, location etc.

### **5.1.2 Road Map**

To meet the management objectives for EH1 & 2 - Ecosystem Health Management, the following road map and actions have been developed. Actions associated with Objectives EH 1 and 2 have been combined in a single roadmap as the proposed actions are relevant to both objectives.

## Road Map for E1 & E2 - Maintaining and Improving Ecosystem Health

Table 5-1 Ecosystem Health Management Actions

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
<b>EH1.1 Maintaining and Improving Vegetation: Revegetation Plan</b>	<p>Develop a revegetation plan for the macrophyte restoration pilot project (as detailed in Section 4.1).</p> <p>Develop a revegetation plan for the drains (as detailed in Section 4.2).</p>	<p>Extend the revegetation plans to link with the existing significant wetlands in the catchment.</p> <p>Mapping of all riparian and drain vegetation to provide information to all stakeholders and agencies.</p>	Review and update the revegetation plan every 5 years. Link the plan to the implementation strategy for stormwater management features.	Medium	Revegetation plans were developed and have been adopted in the design of new water treatment assets as well as for the existing drains.
<b>EH1.2 Maintaining and Improving Vegetation: Management Plans</b>	Develop a management plan for the drains and review and update the existing management plans for Nericon and Campbell's Swamp wetlands.	Review and update the plans every 5 years.	Continue to review and update the plans.	Medium	The management plans and are being adopted to improve the health of the drains and swamps within the Local Government area.
<b>EH2.1 Address Threats from Climate Variability</b>	Model the water levels of Lake Wyangan under climate change scenarios.	Initiate linkages to research groups on projects related to environmental risks to local ecosystems from climate variability.	<p>Support on-going research programs.</p> <p>Update the catchment model to assess the impact of the future climate scenarios on the runoff generation.</p>	Low	The impact of altered rainfall has been modelled to understand potential changes in catchment runoff as well as the lake levels and this information is being used to plan for the future.

## 6. COMMUNITY WELLBEING MANAGEMENT ACTIONS

### 6.1 CW1 to CW3 - Ensuring Safety, Improving Aesthetics and Maintaining Recreation

The aesthetic and recreational use of Lake Wyangan supports a range of local businesses, from boat hire and fishing supplies to Murrumbidgee Irrigation and is a very popular recreational facility with several clubs using the area for boating, water-skiing, sailing, rowing, fishing, picnicking, barbequing and wildlife observation. It is important to balance these uses to ensure that the resources of the Lake are managed sustainably for now and the ongoing enjoyment of future generations.

#### 6.1.1 *Management Actions*

Available information on community wellbeing components (e.g. safety, sustainable use, aesthetics and recreation) has been reviewed and based on the outcomes of the review, the recommended options are:

- **Ensure community representation on the Lake Wyangan & Catchment Management Committee** – Encourage and welcome a range of community members to be actively involved in the Lake Wyangan & Catchment Management Committee. This may be a rotating position to ensure a range of community views are brought to the discussions.
- **Undertake regular community news updates and education programs** – linking to the Water Quality Actions it is important that the community understands the actions detailed in this strategy and their expected outcomes for Lake Wyangan.

Improved lake water quality will positively impact the local and broader community and provide recreational opportunities, employment, and income. A participatory management approach for Lake Wyangan is an important strategy to ensure a robust long term management plan. When community is closely involved, they begin to understand the main problems and the main barriers in the management process. It is important that local community understands the causes of the B-GA problems at Lake Wyangan and how the catchment impacts upon this.

#### 6.1.2 *Road Map*

In order to meet the management objectives CW1 to CW3 - Community Wellbeing, the following road map and actions have been developed. Actions associated with Objectives CW1 to 3 have been combined in a single roadmap as the proposed actions are relevant to all of the objectives.

## Road Map for CW1 to CW3 - Facilitating Safe and Sustainable Usage of Lake Wyangan, protect its Aesthetic and Recreational Values, and provide Enhanced Recreational Opportunities

Table 6-1 Community Wellbeing Management Actions

Proposed Actions	Short Term (<2 years)	Medium Term (>2 to 5 years)	Long Term (> 5 years)	Priority (L, M, H)	Guidelines to Measures of Success (Effectiveness)
<b>CW1 to 3 Coordination of Catchment and Lake Management Governance</b>	Links to Water Quality Action WQ1.1. Ensure a community representative on the Lake Wyangan & Catchment Management committee. Possibly on a rotational basis.	Continued representation of the Lake Wyangan & Catchment Management Committee	Continued representation on the Lake Wyangan & Catchment Management Committee	High	Members of the community are part of the Lake Wyangan & Catchment Management Committee and work effectively to disseminate the notion of best water management practices to improve the health of Lake Wyangan.
<b>CW1 to 3 Communication</b>	Provide an online portal for monitoring information to promote increased awareness and improved understanding of water quality monitoring at Lake Wyangan.  Provide information sheets or similar to explain the purposes of any pilot studies, or management actions being undertaken.	Continue to update and disseminate information.	Continue to update and disseminate information	High	An education program developed by the Lake Wyangan & Catchment Management Committee has been adopted to disseminate the notion of best water management practices to improve the health of Lake Wyangan.

## 7. REFERENCES

FISRWG (1998). Stream Corridor Restoration: Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group, 1998.

LWMP, 1998, MIA and Districts Community and Water Management Plan, compiled by Cummins, T. and numerous community and government organisations, Griffith

Melbourne Water, 2005. Constructed Shallow Lake Systems – Design Guidelines for Developers, Version 2. November 2005.

Melbourne Water (2005) .WSUD Engineering Procedures: Stormwater, CSIRO Publishing,

Sydney Metropolitan Catchment Management Authority (2010). Draft New South Wales MUSIC Modelling Guidelines. <http://www.wsud.org/wp-content/uploads/2012/07/Draft-MUSIC-Modelling-Guidelines-31-08-201011.pdf>. [Accessed 05/08/14].

Lawrence, I., Baldwin, S., Maher, B & Breen, P. (1998) Urban Pond Research Report. CRC for Freshwater Ecology

Lawrence, I. (2012). Investigation into the state of Lake Burley Griffith and Catchment Water Quality Assessment, Office of the Commissioner for Sustainability and the Environment



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