Draft Goulburn Broken Catchment Water Quality Strategy

Goulburn Broken Water Quality Working Group

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Forward

I am pleased to release this draft strategy for public comment. Water quality within the Goulburn Broken catchment is of vital importance to the regional community and the downstream communities which depend on the Goulburn Broken for their supply of water. The catchment is of national significance and it is imperative we maintain our water in prime condition.

This strategy represents over four years work by the Goulburn Broken Water Quality Working Group. The Group has worked hard to grapple with complex issues to come up with a strategy which I believe is achievable and meets our objectives. The Group has brought together a diverse range of stakeholders, sometimes with diverse opinions, but always working together to achieve the outcome which will give the best result for the catchment.

Development of the strategy has already focussed community attention on nutrient management and blue green algal issues. Many actions proposed in the draft strategy are already being picked up and implemented. This is a very good result, but we cannot now afford to sit back and wait for things to happen. We have to make them happen. The Catchment Board will be working hard to secure funding to assist implementation activities.

The strategy is based on the best (often imperfect) knowledge we have at present; as time goes by and more is learnt about nutrients, their management and their interaction with blue green algae, I am sure the strategy will change and adapt.

The strategy clearly focuses action on the major nutrient sources in the catchment, especially irrigation drainage.

We have set ourselves some ambitious targets, especially in irrigation areas. The challenge is for the catchment community to work together to meet these targets, which may change as knowledge improves. However, because we have never had to consider nutrient issues in our management thinking I believe we can make quick improvements. Indeed, downstream communities along the River Murray, are looking for us to make these improvements and will watch strategy implementation closely. These communities benefit greatly from our efforts, and will be asked to contribute to our program via cost sharing arrangements with Government.

As well as setting out a program of activities, this strategy provides a clear framework for coordination, monitoring, reporting and accountability. The Goulburn Broken Catchment and Land Protection Board, and its River and Water Committee, will oversee strategy implementation. Responsibility for activities is clearly assigned.

I congratulate all those involved in preparation of this document and especially acknowledge the funding contribution of the National Landcare Program.

You now have the opportunity to comment on the strategy. Your comment is welcomed and each response will be addressed by the River and Water Committee as it prepares the final version of the strategy for preparation to Government.

John Dainton
Chairman

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Glossary

Common Acronyms

AEAM	Adaptive Environment and Assessment Management (model)
BGA	Blue green algae
BMP	Best management practice
BNR	Biological nutrient removal
Board or Catchment Board	Goulburn Broken Catchment and Land Protection Board
CMSS	Catchment Management Support System (model)
CNR	Department of Conservation and Natural Resources
DAEM	Department of Agriculture, Energy and Minerals
DC	Dryland Committee (of the Catchment Board)
EPA	Environment Protection Authority
GB	Goulburn Broken
G-MW	Goulburn Murray Rural Water Authority
GVW	Goulburn Valley Urban Water Authority
IAI	Intensive animal industries
IC	Irrigation Committee (of the Catchment Board)
IP	Issues Paper
LWRRDC	Land and Water Resources Research and Development Corporation
MDBC	Murray Darling Basin Commission
ML	Megalitre
NLP	National Landcare Program
NRMS	Natural Resource Management Strategy (of MDBC)
O&M	Operations and Maintenance
OCE	Office of the Commissioner for the Environment
REWQC	River Environment and Water Quality Committee (of the Catchment Board)
SEPP	State Environment Protection Policy
SIR	Shepparton Irrigation Region
SIRLWSMP	Shepparton Irrigation Region Land and Water Salinity Management Plan
STP	Sewage treatment plant
The Strategy	The Goulburn Broken Water Quality Strategy.
TN	Total nitrogen
TP	Total phosphorus
UDV	United Dairy Farmers Victoria
VFF	Victorian Farmers Federation
VFF	Victorian Farmers Federation
VNMSIC	Victorian Nutrient Management Strategy Implementation Committee
VWQMN	Victorian Water Quality Monitoring Network
WQWG	Water Quality Working Group

Note: The Department of Conservation and Natural Environment (CNR) and the Department of Agriculture Energy and Minerals have been amalgamated to form the Department of Natural Resources and Environment.

Introduction

The Goulburn Broken catchment is one of three high priority catchments targeted by the Murray Darling Basin Ministerial Council's Algal Management Strategy to develop and implement catchment management strategies addressing algal and nutrient problems.

Both the MDBC Algal Management Strategy and Victorian Nutrient Management Strategy call for the development of catchment based nutrient management strategies.

Over the past three years the Goulburn Broken Water Quality Working Group (WQWG) has coordinated the development of this water quality management strategy (the Strategy) for the Goulburn Broken Catchment.

This strategy focuses initially on managing the nutrients phosphorus (P) and nitrogen (N) to reduce the incidence of blue green algal blooms. Other water quality issues will be tackled over time.

There are three parts to this strategy:

Part A	Developing the Strategy - brief catchment description, policy background and description of the strategy development process.
Part B	The strategy
Part C	Relevant, more detailed background information.

Detailed background information is contained in a series of background papers which are summarised in Part C.

Comment, and input to further strategy development is invited.

PART A

1. PART A - Developing the Strategy

1.1. About the Catchment.

The Goulburn Broken catchment comprises the catchments of the Goulburn and Broken Rivers and a small part of the Murray Valley, downstream of Bundalong. (Map 1). The catchment covers a total of 2 391 544 ha, or 10.5% of Victoria's total land area. Land use is shown in Table 1 and Map 2.

The catchment is part of the Murray Darling Basin. Although it covers only 2% of the basin it provides 11% of its stream flow.

Approximately 250 000 people live in the catchment.

1.1.1. Catchment Description

Goulburn Catchment

The Goulburn River catchment is the largest in Victoria and covers 1 619 158 ha. A number of the Goulburn's major tributaries rise on the northern slopes of the Great Dividing Range. These include the Big, Delatite, Howqua and Jamieson. The catchment covers 7.1 % of the state's total area and has a mean annual water discharge of 3 040 000 ML, which is 13.7% of the total state discharge. It produces on average, 1.8 ML/ha.

Terrain varies from the high ranges to the Murray Plain. The northern half of the catchment is relatively flat.

Rainfall varies substantially. The high country in the south east experiences cool winters with persistent snow and an average annual rainfall greater than 1600 mm, Rainfall decreases northward and in the far north of the catchment is less than 450 mm per year, only one third of the annual evaporation in that area.

The catchment was once forested over its entire area. While native vegetation has been retained in the mountainous far south, where slopes are steepest, clearing for agriculture has been extensive in its valleys and plains.

Streamflow along the Goulburn River has been modified by two major features, Lake Eildon and Goulburn Weir. Operation of Eildon Reservoir has reduced the July to September flows passing Eildon to 33% of the total annual flow, allowing an increase of the January to March flows to 23% of the annual flow. The Goulburn Weir near Nagambie and associated diversion channels to the east and west, have reduced the average annual down river flow there to 1 340 000 ML, less than half the pre-regulated flow. Lake Eildon has a capacity of 3 390 000 ML and supplies more than half of the water used in the Shepparton Irrigation Region.

There are several large rural cities - Shepparton, Mooroopna, Seymour and Kyabram, and another 8 with populations over 1500.

Map 1 Catchment Map

Map 2 Land Use

Broken Catchment.

The Broken River is a tributary of the Goulburn River. It joins the Goulburn River just south of Shepparton. The basin also includes the catchment of the Broken Creek which diverges from the Broken River just west of Lake Mokoan and flows in a north westerly direction to the River Murray. It also includes small areas of the Murray catchment, south of the River Murray.

The catchment covers 772 386 ha or 3.4% of Victoria's total area and has a mean annual flow of 325 000 ML (0.42 ML/ha).

As with the Goulburn catchment, climate varies considerably. In the south average annual rainfall about 1270 mm. Rainfall decreases to about 700 mm near Benalla, 550 mm at Dookie and 470 mm at Cobram. Across the northern section rainfall generally decreases to the west.

Streamflow is extremely variable between seasons and between years. The three months July to September account for over half the annual stream flow. Annual flow has varied from a minimum of 5000 ML in the drought year of 1943 to maxima of more than 1 000 000 ML in the flood years of 1917 and 1956.

Most of the catchment has been cleared for agriculture which supports grazing in the south, and mixed cereal and dryland grazing in the central region. A large part of the northern section is within the Murray Valley irrigation district, with production for fruit growing, dairying and livestock production.

There are two major water storages and two smaller storages. Lake Nillahcootie was constructed in 1967 and has a capacity of 40 000 ML. Lake Mokoan, constructed in 1971, has a capacity of 365 000 ML. These reservoirs provide reliable water supply for stock domestic and irrigation supplies. On Ryans Creek two small reservoirs, operated by Ovens Water provide water to the town of Benalla.

Benalla is the largest urban area. There are numerous smaller towns including Cobram, Nathalia, Yarrawonga and Numurkah. Part of Shepparton is within the catchment.

Table 1: Land Use in the Goulburn Broken Catchment (after OCE 1991).

Land use type (ha)	Goulburn	Broken	Total
Native Vegetation (forested)	544000	111650	655650
General agriculture (dryland)	916800	532070	1448870
Intensive agriculture (irrigation)	110400	99330	209730
Plantation (pines)	6400	16940	23340
Urban	1600	770	2370
Total (ha)	1579200	760760	2339960

1.1.2. National Importance of the catchment.

Extensive food processing industries in the region produce some 25 percent of Victoria's rural output. The network of industries is recognised as one of the nation's "food bowl" centres and these industries collectively have invested hundreds of millions of dollars in the introduction of world class technology and international best practice to their operations to maximise their export opportunities.

Eighteen industries (four of which are just out of the catchment) directly employ some 6000 staff and support a significant proportion of the region's population. Annual export income from these industries currently total $765 million with seven firms being included in the top 200 export earners. (CMPS&F (a)1995). Domestic income equals this. Using accepted multipliers, estimated economic activity resulting from this sector alone is $3 billion per year.

The continued well being of the region relies on supply of good quality water to primary producers and food processing industry.

Irrigation areas to the west also rely on water supplied from the Goulburn Broken catchment. Infrastructure investment by Goulburn Murray Water alone totals $2.6 billion. This relies heavily on the water resources in the Goulburn Broken catchment.

1.2. Policy Background

A number of organisations have water quality policies and objectives which are relevant to the Goulburn Broken Water Quality Strategy. These are detailed below.

1.2.1. National Water Quality Management Strategy

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Australian Water Resources Council (AWRC) are developing a national water quality strategy that seeks to manage the nation's water resources on a sustainable basis. The overall objective of the water quality management strategy is to:

...achieve the sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

The objective will be achieved by applying a number of principles to water quality management, including:

- ecologically sustainable development
- an integrated approach to water quality management
- community involvement in setting water quality objectives and developing management plans
- government endorsement of the water quality objectives.

The strategy calls for the preparation of catchment based water quality management plans.

1.2.2. MDBC Water Quality Policy

The Murray Darling Basin Commission (MDBC) has a water quality policy which aims:

"To maintain and, where necessary, improve existing water quality in the rivers of the Murray Darling Basin for all beneficial uses - agricultural, environmental, urban, industrial and recreational.

In the case of those parameters such as salinity and nutrients which are already recognised as causing problems, the policy is to improve water quality..."

This was formally adopted as a policy by the Murray Darling Ministerial Council in August 1990.

1.2.3. MDBC Algal Management Strategy

The goal of the MDBC Strategy Algal Management Strategy is to

"reduce the frequency and intensity of algal blooms and other water quality problems associated with nutrient pollution in the Murray Darling Basin through a framework of coordinated planning and management actions."

To meet its goal the strategy has four key objectives:

- reduce nutrient concentrations in the streams and storages of the basin
- improve stream flow regimes and flow management
- increase the communities awareness of the blue green algal problem
- obtain better information and scientific knowledge of blue green algae

The strategy is founded on three specific principles

- the community's acceptance and "ownership of the problem and the action necessary to solve it at the local level
- minimising the amount of nutrients requiring treatment and disposal or re-use at source
- wherever possible, wastewaters should be reused for practical purposes such as irrigation.

1.2.4. Victorian State Environment Protection Policy - Waters of Victoria

This policy, declared under the Environment Protection Act, has the policy goal

"to attain and maintain levels of water quality which are sufficient to protect the specified beneficial uses of the surface waters of the policy area".

No specific policy has been declared for the Goulburn Broken catchment.

1.2.5. Victorian Nutrient Management Strategy for Inland Waters

The objective **"is to provide a policy and planning framework to assist local communities and the state government manage nutrient levels in water bodies to minimise the potential for the development of algal blooms, particularly blue green algae."** The strategy consists broadly of two components:

- a range of initiatives across the state which reduce or have the potential to reduce nutrient levels and provide net benefits to the community. Developing and

implementing these initiatives will involve both the state government and local communities; and
- specific nutrient management options to deal with particular local nutrient problems. These actions will need to be undertaken by local communities, in consultation with the state government.

2. Strategy Development Process

2.1. Community consultation and involvement

Development of this strategy has involved a wide range of key stakeholders. The Goulburn Broken Water Quality Working Group has overseen overall strategy development. Preparation of the strategy has involved

- establishment of a Water Quality Working Group
- implementation of an extension program
- audit of existing water quality information
- identification and prioritising of major sources of nutrients
- identification of best management practices.

The process has been supported by a technically based Planning Support Group. Further community and stakeholder involvement has been made possible by:

- involvement in the AEAM modelling process.
- publication of an Inception Report.
- issues paper presentations by consultants at workshops.
- newsletters and annual reports published by the WQWG.
- preparation, and wide distribution, of the issues papers and the opportunity for comment on these.
- numerous newspaper and radio articles.
- briefings and workshops on the state of strategy development.
- cost sharing workshop.
- the opportunity to contribute to development of this draft strategy.
- the opportunity to comment on the draft strategy.

2.1.1. Goulburn Broken Catchment Board.

The Goulburn Broken Catchment and Land Protection Board (the Catchment Board) was set up in 1995. The Board provides overall coordination of catchment and land protection issues in the catchment. It has set up committees to provide coordination of specific issues, including water and river environment. The River Environment and Water Quality Committee has worked closely with the Water Quality Working Group to ensure a smooth transition from water quality strategy development to implementation.

2.2. Identifying Nutrient Sources

Key nutrient sources were identified in the catchment by four major means.

2.2.1. AEAM (Adaptive Environmental Assessment and Management).

The AEAM process provided resource managers with a tool to evaluate management and policy options. Workshops were used to collate and coordinate the knowledge from a diverse range of people and develop a simple computer model of the catchment.

2.2.2. Nutrient Audit.

Work carried out by State Water Laboratory (now Water EcoScience) investigating water quality, blue green algal blooms and nutrient sources in the catchment was incorporated in the AEAM process and the Inception Report.

2.2.3. Detailed issues papers

Consultants were engaged to prepare detailed issues papers investigating key nutrient sources identified in the AEAM process. Papers were prepared covering issues associated with nutrients from:

- irrigation drainage
- dryland diffuse sources
- intensive animals
- sewage treatment plants
- urban stormwater and local water quality issues

These investigated, in some detail, nutrient sources, nutrient management options and the costs of these management options. The overview in Section 6 briefly summarises the issues papers and other relevant information.

2.2.4. CMSS (Catchment Management Support System).

A CMSS model has been developed for the Goulburn Broken as part of a project assessing the relative merits of the AEAM and CMSS nutrient management models. The Goulburn Broken CMSS model has been used to assess the impacts of various management scenarios on nutrient loads and concentrations.

2.3. Background papers

In the course of strategy preparation a number of background papers were prepared (see Part C) These provide much more information about water quality, nutrient issues and nutrient management options than can be presented in this strategy. Many of these papers have been widely circulated, for example the inception report and issues papers, while others have had limited circulation.

3. Water Quality in the Catchment - the need for a Strategy.

Assessment of water quality in the catchment has shown all is not well with the state of the water in the Goulburn Broken catchment. A number of water quality parameters are above recommended levels. Symptomatic of this is the occurrence of blue green, and other nuisance, algal blooms.

Investigation of nutrient inputs to the Murray Darling River system has shown that activities in the Goulburn Broken contribute significant nutrient loads to surface waters, both within the catchment and to the River Murray. The problems associated with blooms of potentially toxic blue green algae in Victorian surface waters has been widely recognised by both resource managers and the general public. A number of water reservoirs have been temporarily closed in recent years, due to the possible presence of toxins associated with blue green algae in the water.

3.1. Blue Green Algae

The occurrence of toxic blue green algal blooms in inland surface waters has a wide range of social, economic and environmental impacts. The major problems include:

- public health risk (toxins)
- aesthetic effects (discolouration and scum formation, tastes and odours)
- animal health risk (livestock death, production losses)
- ecological effects (native animal deaths, disruption to the ecological balance)
- economic effects (damage to recreation, tourism, agriculture and industry)
- disruption to water supply (alteration to the physical and chemical properties of water which can influence water treatment and distribution).

Research in Australia and overseas has recognised nutrient enrichment of surface waters as a major factor in the development of algal blooms. Other factors influencing the development of blooms include:

- **physical factors**
    - turbidity
    - turbulence
    - temperature
    - water morphology
- **biological factors**
    - competition
    - predation
- **chemical factors**
    - micronutrients
    - macronutrients.

The relative importance of each of these factors is still being debated. There are significant uncertainties regarding the processes that result in the occurrence of algal blooms. It is known that phosphorus is the dominant limiting factor in their development and maintenance. ***At this stage the WQWG is concentrating on***

reducing the supply of the nutrients phosphorus and nitrogen to waterways, with particular emphasis on *phosphorus.* The WQWG accepts the view of Harris (1996): "All the evidence points to the fact that by far the best course is to reduce external P loadings (and increase the TN:TP ratio by that means) rather than attempt to change N loadings ...").

The Goulburn Broken strategy specifically does not address stream flow and flow management issues. The Bulk Water Entitlement process in the Goulburn Broken catchment addresses environmental flows. In addition it appears that flows in the major streams are of sufficient magnitude to prevent stratification and accelerated release of phosphorus from sediments. The use of environmental flows to "flush" algal blooms simply transfers the problem to another location.

Up to mid 1995, 61 major algal blooms had been recorded in the Goulburn Broken catchment (Map 3). Not all of these were blue green algal blooms. Some were blooms of nuisance algae. Blue green algal in Lake Mokoan, near Benalla, have received wide publicity. Other blooms have been recorded in major irrigation storages and urban water storages. A number of blooms, for example on farm dams and sewage treatment plant lagoons are often not recorded.

The blue green alga *Anabaena* and *Microcystis* account for most of the recorded blooms. Most occurred in storage reservoirs of the mid and lower reaches of the Goulburn River and in Lake Mokoan and Lake Nillahcootie. Blooms have been recorded in Lake Eildon and also in the River Murray at Yarrawonga.

Map 3 Algal Blooms - location

3.2. nutrients

Data on nutrients in water bodies in the catchment is available from a number of sources, including:

- Victorian Water Quality Monitoring Network (VWQMN)
- MDBC
- Major storages monitoring
- monitoring of irrigation drains as part of salinity projects

The EPA also collects some information. Location of monitoring points is shown in Map 4.

The length of data record varies from just over one year for some VWQMN sites to greater than 10 years for the MDBC sites. At VWQMN sites, data has been collected monthly since 1990. Data has been collected weekly at MDBC sites since 1989. Samples are collected and analysed in accord with standard recognised procedures.

At a number of locations across the catchment, landcare and school groups are collecting water quality information as part of the Waterwatch program. The information gathered helps in the understanding of local water quality issues and the development of local solutions to these issues and in the longer term assessment of the impacts of management actions.

3.2.1. Nutrient Concentration

To assist in assessing water quality in the catchment available nutrient concentration data from VWQMN and MDBC have been assessed against the ANZECC and OCE guidelines and the recently published EPA Guidelines. This assessment is not intended to be used to set water quality targets.

Map 4 water quality monitoring locations

3.2.1.1.Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC Guidelines).

The Australian and New Zealand Environment and Conservation Council (ANZECC), as part of the National Water Quality Management Strategy has published Australian Water Quality Guidelines for Fresh and Marine Waters. (Referred to as the ANZECC Guidelines). These guidelines provide numerical and narrative criteria to assist in managing water resources in a sustainable manner.

For phosphorus and nitrogen
The following nutrient values or concentration ranges are provided as an indication of levels at or above which problems have been known to occur, depending on a range of other factors. It is expected that , following site specific studies, guideline values for nitrogen and phosphorus may be determined for specific waterbodies that are higher or lower than the values indicated. For rivers and streams indicative concentrations values of ranges are:

TP 0.01 - 0.1 mg/L
TN 0.1 - 0.75 mg/L

Available concentration data has been assessed against the upper limits of the ANZECC Guidelines for rivers and streams. The percentage of records greater than the guideline figure for TP is shown in Table 2 and TN in Table 3:

Table 2: Exceedance of ANZECC Guideline for TP.

Site	**% of records with TP greater than 0.1 mg/L**
Broken Ck at Rices Weir	100
Castle Ck at Arcadia	100
Broken Ck at Katamatite	88
Goulburn River at McCoys Bridge	55
Broken River at Goorambat (Caseys Weir)	34
Goulburn River at Shepparton	11
Broken River at Gowangardie	9
Hollands Ck at Kelfeera	5
Goulburn River at Seymour	4
Delatite River	4
Goulburn River at Murchison	1

Table 3: Exceedance of ANZECC Guideline for TN.

Site	% of records with TN greater than 0.75 mg/L
Seven Cks at Polly McQuinns	100
Castle Ck at Arcadia	100
Seven Cks at Euroa	95
Broken Ck at Rices Weir	94
Broken Ck at Katamatite	92
Broken River at Moorngag	78
Goulburn River at McCoys Bridge	77
Broken River at Goorambat	64
Goulburn River at Shepparton	55
Brankeet Ck	37
Hollands Ck at Kelfeera	30
Goulburn River at Murchison	29
Broken River at Gowangardie	27
Goulburn River at Seymour	22
Delatite River	12

Only the Goulburn River at Eildon, Acheron River at Taggerty, Sunday Ck at Tallarook and Big River meet the guideline limit 100% of the time.

*3.2.1.2.**OCE Guidelines Classification***

The Office of the Commission of the Environment (OCE) in its 1988 State of the Environment Report on Victoria's Inland Waters classified nutrient levels using a qualitative index. This index has five levels ranging from 'Excellent to 'Degraded'. These levels relate to a comparison between the observed data for a particular site and water quality characteristics for a known or assumed natural state for a particular aquatic ecosystem. Data collected from monitoring sites have been used to classify water quality data using this index and the criteria set out for each of the parameters in the OCE Report (see Tables 4,5 and 6. (Cottingham 1994).

Table 4: OCE Nutrient Classification

Water Quality	Description
Excellent	Water quality corresponding to known or assumed natural state for aquatic ecosystems
Good	Water quality consistent with the maintenance of all native biota
Moderate	Water quality resulting in slight degrading of natural aquatic ecosystems.
Poor	Water quality resulting in marked deterioration in natural aquatic ecosystems
Degraded	Water quality resulting in serious decline of natural aquatic ecosystems.

Table 5: OCE Nutrient Guidelines (median concentrations).

	Excellent	Good	Moderate	Poor	Degraded

TP mg/L	<0.010	<0.025	<0.050	<0.100	>0.100
TN mg/L	<0.20	<0.35	<0.50	<1.00	>1.0

< less than; > greater than.

Table 6: Assessment against OCE criteria using median concentration (mg\L).

OCE Rating	**TP no of sites**	**TN no of sites**
Excellent	2	0
Good	8	6
Moderate	7	6
Poor	3	6
Degraded	4	6
Total	24	24

(includes storages).

Map 5 shows water quality ratings at stations in the catchment. Water quality in the upper catchment is generally good, but decreases down the catchment.

Map 5 Water Quality

3.2.1.3.EPA Guidelines

The EPA have prepared Preliminary Nutrient Guidelines for Victorian Streams. This outlines preliminary guidelines, for nitrogen and phosphorus concentrations, in seven river regions across the State with similar environmental attributes and stream systems. Within each river region, pertinent available biological and nutrient data were collated allowing an assessment of background, threshold and "major impact" nutrient concentrations.

For the Goulburn Broken catchment three regions, and preliminary nutrient guideline maxima recommended, are relevant (Table 7):

Table 7: EPA Nutrient Guideline Criteria.

Region	Location within catchment	guideline maxima mg/L	
		TP	TN
Highlands river region	Mountain streams eg Upper Goulburn, Howqua, Upper Delatite, etc.	0.02	0.15
Murray Foothills river region	Goulburn above Goulburn Weir to just above Eildon Reservoir. Broken above Caseys Weir	0.03	0.2
Murray Plains River region	Goulburn River downstream of Goulburn Weir. Broken downstream of Caseys Weir.	0.05	0.6

Water quality data has been assessed against the EPA Guideline criteria (Table 8).

Table 9: Summary assessment against EPA guidelines

	Number of sites complying with guideline	
% compliance	**TP**	**TN**
more than 90%	4	0
between 60 and 90%	8	3
between 30 and 60%	4	5
less than 30%	7	15

The WQWG believes these Guidelines should be further refined.

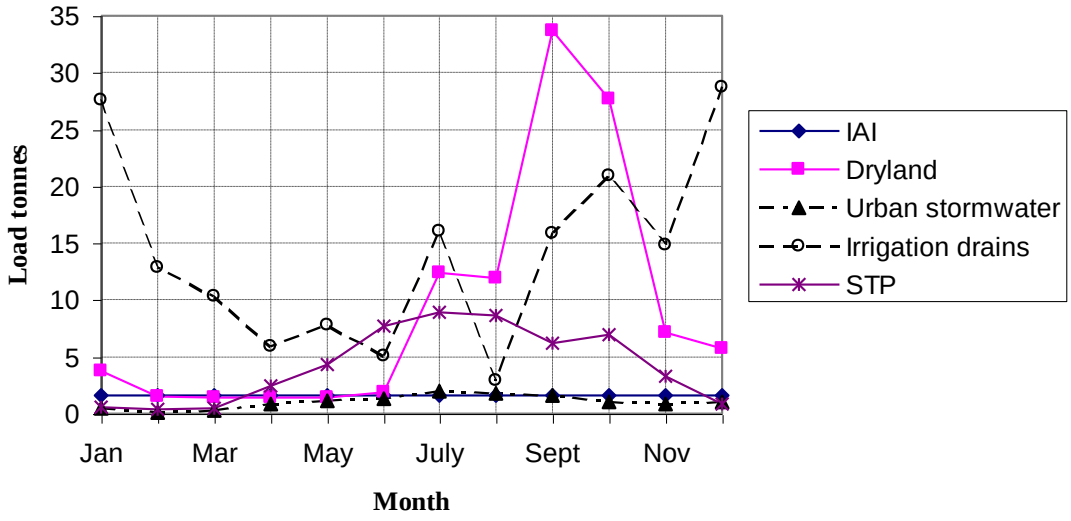
3.3. Nutrient Loads

The loads (tonnes or kilograms) of nutrients carried in streams is another indicator of the health of our catchment. These nutrient loads can become available at a later date,

at downstream locations, to drive nuisance algal growth, including blue green algal blooms, or affect the ecological components of a water body. Nutrient loads can be trapped in reservoirs to become problems at some later date and loads exported from our catchment can contribute to nutrient concentration problems and blue green algal blooms at downstream locations.

Large nutrient loads are often associated with high stream flow periods, over August, September and October. In this period nutrient concentrations can be low, but because of the large volumes of water involved, loads can be high. The seasonal distribution of loads is shown diagrammatically in Graph 1:

Graph 1 - Seasonal Distribution of TP load in Goulburn Broken



The total load of N and P leaving the Goulburn Broken catchment is shown in Table 9.

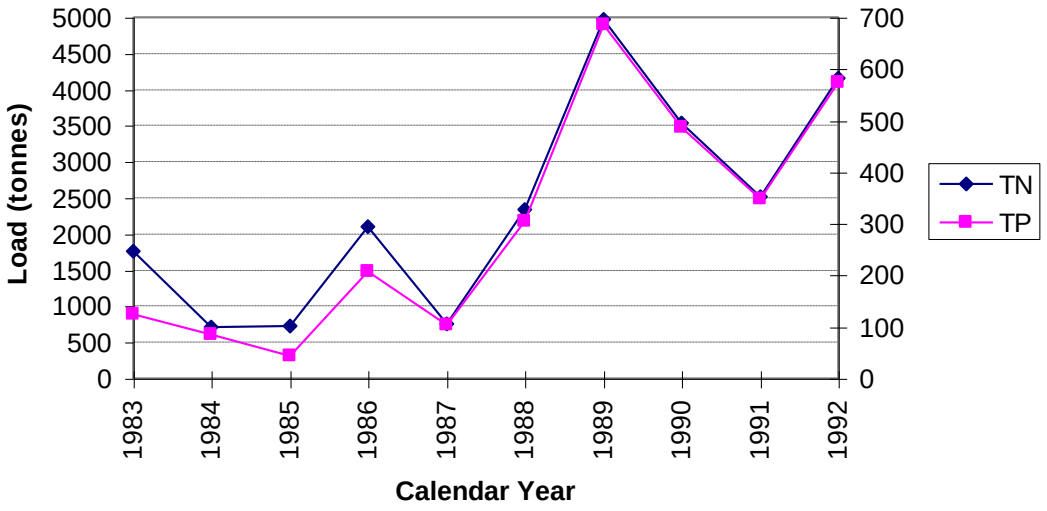
Table 9: Measured TP and TN loads.

Year	TP (tonnes) total catchment	TP tonnes - Goulburn at McCoys Bridge	TN (tonnes) total catchment	TN tonnes Goulburn at McCoys Bridge
1993/94	615	435	5121	4488
1994/95	256	108	1613	1100

Unfortunately this information is not available over a long period. However, information from Cottingham (1995) for the Goulburn at McCoys Bridge is shown below in Graph 2.

Graph 2

Nutrient Loads - Goulburn at McCoys Bridge 1983 - 1992



3.4. Nutrient trends.

Water quality data measured at monitoring sites in the Goulburn Broken catchment often has a large variance and in such cases only large trends in nutrient concentrations will be detected. A Seasonal Kendall Trend Analysis was performed for the parameters TP and TN at the VWQMN sites in the catchment at which the number of samples collected was greater than 52. (The sample size required to detect a trend greater than the standard deviation of the data at the 95% confidence level is 52). The results of the trend analysis are considered exploratory.

No trends in nutrient concentration were detected in either the Goulburn or Broken catchments.

3.5. Blue green algae Risk/Impact Assessment.

A multi criteria assessment of the risk of blue green algal blooms and their impacts has been undertaken. This evaluated:

- ***risks*** of a bloom (considers the factors predisposing a site to a bloom).
- ***impacts*** of a bloom (considers various water uses that may be impacted by a bloom)
- the contribution of sites or stream segments to the ***combined risk and impact*** at sites lower down the catchment.

Key sites were selected on the basis of perceived importance of impacts or risks of blooms, as well as the availability of data. In summary:

On an *overall risk/impact* basis sites that need special consideration for works include:

Lake Nillahcootie, Lower Goulburn River, River Murray, Broken River (Nillahcootie to Caseys Weir), Greens Lake/Lake Cooper, Broken Creek, Lake Mokoan, Lake Eildon, Lower Broken River and the Goulburn Weir Pool.

On a *risk* basis the following sites are important:

Lake Mokoan, urban lakes (eg Craigmuir Lake at Mooroopna), Greens Lake/lake Cooper, Lake Nillahcootie, Broken Ck, Lower Goulburn.

On an i*mpact* basis the following sites are important:

Murray River, Mid Goulburn River, Lake Eildon, Goulburn Weir Pool, Lower Goulburn River, Lower Broken River, Lake Nillahcootie and the mid Broken River.

3.6. Impacts of poor water quality

The impacts of poor water quality are many and varied. They can be summarised as

Pollutant	**Impact**
Plant nutrients (phosphorus and nitrogen)	adversely affect ecosystem balances; decreased oxygen levels; increased levels of nuisance algae including blue greens; health risks from toxins.
organic matter	expansion of bacteria populations leading to oxygen depletion
Pathogens	disease in plants, animals and humans.
Toxic substances	inhibit important biological processes. Can have a cumulative impact in food chains or can be mutagenic or carcinogenic.
Litter	health and safety risk. reduction in aesthetic value of waterways.
Turbidity/sediment	Reduction in light availability to life, plants, fish and invertebrates, in water. smothering of stream beds.
Biocides	Health risks; cumulative impact in food chains.

3.7. Other water quality issues the catchment

While this strategy concentrates on nutrient issues there are a number of other existing or potential water quality issues in the catchment which the WQWG is aware of. Some of these issues are actively being addressed by the Goulburn Broken community, for example salinity. Other issues, such as biocides may be a recognised concern. Still other issues, such as acidity, are only just becoming recognised.

3.7.1. Salinity

Large areas of the catchment are at risk from salinity. A number of catchments produce high salt loads and some streams show impact of elevated salt concentrations. The dryland and irrigation salinity management plans address salinity issues in the catchment.

3.7.2. Acidity

Analysis of stream pH values at some sites in the catchment indicates a lowering of pH by one unit over the past ten years. This is likely to have adverse ecological impacts. The causes, at this stage are unknown, but may be related to development of acid soils across the catchment.

Phosphorus may be mobilised from sediments in low pH (high acidity) conditions (Cottingham 1995). Across the Goulburn Broken catchment, soil acidity is extreme on 28% of land used for broad acre cropping and 17% of pastures.

3.7.3. Biocides (pesticides and herbicides), heavy metals and other toxicants.

Large volumes of biocides are used in the catchment for agricultural and other purposes. Spot surveys do not indicate a problem in waterways , but no widescale, systematic, study has been carried out. Biocides and heavy metals in waterways, especially irrigation drains, is an issue frequently raised as a community concern.

Mercury contamination of the Upper Goulburn River is a known problem.

Toxicant and heavy metal pollution associated with urban stormwater runoff is an issue requiring investigation.

3.7.4. Turbidity

As recent study by Olive and Fredericks (1995) and Post et al (1995) investigating turbidity sources in the catchment of the River Murray have highlighted the Goulburn catchment as a significant source of turbidity and sediment to the River Murray. In Post et al's preliminary analysis, the Goulburn River is estimated to contribute 37% of the flow and 58% of the sediment relative to all streams entering the Murray upstream of the Murrumbidgee junction. Broken Ck contributes 2% of the flow and 8% of the sediment.

It is hoped further work will refine these figures, develop relationships between sediment and phosphorus and investigate sources of turbidity and sediment.

3.7.5. Viruses, bacteria, etc

Across the catchment E. coli contaminate many waterbodies. Sources of this contamination are many and varied, and include urban stormwater runoff, agricultural activities, recreational activities.

Irrigation drainage may carry disease organisms such as Salmonella, Mycobacterium (Johnes Disease), Campylobacter (enteritis), Leptospira, Brucella and Shigella. There has been almost no investigation on the pathogens carried by irrigation (and other) and how long they persist.

3.7.6. "Black Water events"

Major changes in water quality often occur with flooding and flood mitigation works have been implicated in causing fish kills through rapid deoxygenation of water after flooding. A fish kill occurred in the Broken Ck in 1993. It is suggested this kill was

due to hypoxic water conditions caused by the runoff from exceptionally large scale flooding in an area where native riparian and floodplain vegetation has been replaced by introduced pasture and crop species.

3.7.7. Pest Water Plants

Occurrence of Queensland water lily (*Nymphea mexicana*) have been recorded in the backwaters of the Goulburn Weir. Anecdotal evidence suggests these occurrences may impact on water quality and have the potential to become a major pest in the lower Goulburn and River Murray.

3.7.8. Carp

Anecdotal evidence, and research in progress, suggests carp may have an important role in causing nutrient and turbidity problems.

4. PART B -The Strategy

4.1. Overview

4.1.1. Water Quality Working Group Objectives:

The Water Quality Working Group has set the following objectives for this strategy:

- minimise blue green algae outbreaks in our catchment
- minimise/optimise water treatment costs
- minimise nutrient contributions to the Murray
- foster regional development (by ensuring quality water to industry, agriculture and the community) and
- enhance the riverine environment.

4.1.2. Principles

These objectives will be achieved by applying a number of principles to water quality management, including:

- **Implementation of an integrated and coordinated approach**. Many of the actions required in this strategy can be implemented by a number of existing groups in the catchment. There is no point setting up a new group to implement this strategy, although strategy oversight and coordination is essential. Many of the activities proposed which aim to manage nutrients will result in reductions of other pollutants "at no extra cost", for example vegetated filter strips will reduce sediment inputs to streams as well as giving other environmental benefits.
- **Best Management Practice Approach**. All contributors of nutrients in the catchment will be expected to adopt best management practices for nutrient management.
- **Concentration on phosphorus management**. The strategy will concentrate on phosphorus reduction and management as the means to reduce the risk and impact of blue green algal blooms. However, opportunities to reduce other nutrients, such as nitrogen, will also be pursued, when they are cost effective and can be associated with phosphorus management. Other water quality issues will be managed as they become evident or as knowledge develops.
- **Summer nutrient load and concentration** reductions are the first priority to reduce the risks and impacts of blue green algal blooms. At the same time, a longer term program will be implemented aimed at getting all nutrient contributors to undertake works which will reduce nutrient loads and concentrations year round.
- **Adaptive approaches**. The scientific base for managing algal blooms and nutrients is incomplete. The strategy will be adaptive and use new information as it becomes available. This may mean the strategy approach will change over time, indicating the need for flexibility.
- **Non structural measures.** Where practical, use of planning schemes, codes of practice, guidelines and best management practice (BMP) will be the preferred long term method of strategy implementation.

- **Cost effectiveness**. The implementation of nutrient management actions will only be considered where it is cost effective. Cost effectiveness may be influenced by considering a broader range of benefits than simple nutrient reduction.
- **Nutrient balance and sustainability**. In implementing nutrient management activities, resource managers will adopt nutrient balance and sustainability principles.
- **Cooperative approach**. In the first instance the preferred approach is cooperative. However, if adoption rates drop, or nutrient management is not being achieved, a range of regulatory measures will be considered.
- **Sub catchment approach**. Local communities will be asked to prepare and implement local plans for nutrient management.
- **Monitoring and Accountability**. Monitoring programs will be implemented to ensure that the desired outcomes of the strategy are actually achieved.
- **Assign Responsibility**. Responsibility to carry out specific actions will be clearly assigned.
- **Equity.** One in, all in. All sectors in the catchment will be required to achieve appropriate nutrient management targets. No one group will be singled out.
- **No nett increase**. New developments in the catchment cannot increase nutrient loads leaving the catchment. A minimum requirement is that no nett increase in nutrient loads is expected.

The Water Quality Working Group expects that similar principles will be applied in other catchments contributing nutrients to the River Murray.

4.1.3. Time frame

The strategy will be implemented over a **twenty year** time frame, beginning in 1996 and finishing in 2016. The WQWG originally considered a thirty year time frame but this was rejected in light of the urgent need to achieve water quality improvements.

4.2. Benchmark Date and Loads.

For strategy purposes the benchmarks (criteria) against which progress of strategy implementation will be measured have to be developed over a period of at least five years. Most of the nutrient loads reported in the Issues Papers were estimates only. These can only be firmed up as long term data becomes available.

The impact of the strategy will be measured against five year rolling averages.

Day 1 of strategy implementation will be July 1, 1996.

The work of some groups in reducing nutrient loads over longer time frames is acknowledged.

4.3. Managing Nutrients - the preferred strategy

4.3.1. Overview.

Coordinated implementation of the strategy over a twenty year period will reduce potential catchment phosphorus loads by 65% at an estimated cost of $147M (discounted at 8%) by:

- reducing nutrient loads from irrigation drains with farmers adopting farm reuse systems and drain diversion. Point source inputs to drains will be managed.
- minimising loads from sewage treatment plants.
- reducing sediment movement and P availability in streams by improving stream condition and installing filter strips along streams
- reducing the output of nutrients from fish farms
- ensuring all new developments in the catchment recognise water quality /nutrient issues

together with a process for coordinating strategy implementation and monitoring and evaluating progress. The strategy proposes that costs be shared between Federal and State Governments and catchment stakeholders.

Implementation of this strategy is estimated to reduce annual P loads in the Goulburn River at McCoys Bridge and in the Broken Ck at Rices Weir by 229 t and 56 t respectively. (These estimates are based on CMSS model results. They will change as our knowledge improves and the model is enhanced).

The strategy calls for a staged approach which will ultimately see improvements in nutrient management spread over the entire catchment. Improvements will be expected quickly from some sources, although improvements are expected from all sources over time. Nutrient management options which involve major capital expenditure will be delayed until the benefits of these actions can be clearly identified.

A long term commitment to strategy implementation is required from Government (Federal, State and Local), local authorities, the catchment community and individuals.

It will take two to three years to build up nutrient management works implementation to the rates required by this Strategy. Until this occurs some very useful planning exercises must be carried out which set the framework for works and the non structural component of the Strategy.

4.3.2. Implementation

The preferred strategy prepared by the WQWG will be implemented via a number of **coordinated** programs. These are:

- coordination and community involvement
- community education
- planning/non structural
- irrigation drainage

- diffuse sources
- sewage treatment plants
- urban stormwater
- intensive animal industries
- local water quality issues
- other water quality issues
- research and investigation
- monitoring, evaluation and reporting

Each is described below in detail. Implementation, and achievement of timeframes detailed, is dependent on stakeholder acceptance of this strategy and funding. There is considerable overlap between a number of programs.

The program structure reflects a cycle of
- planning
- implementation
- monitoring and evaluation
- modification of plans.

The Catchment Board has responsibility for implementing this strategy. The Board will delegate this responsibility to its River Environment and Water Quality Committee.

4.4. Targets.

The WQWG has adopted a best management approach (BMP) to achieving nutrient reduction. Resource managers will be asked to implement best management practices, which given current knowledge, are predicted to give satisfactory nutrient management benefits and reductions in the risk and impact of blue green algal blooms. Our targets will be measured in terms of BMP adoption levels.

At this stage, targets cannot be set in terms of the desired nutrient loads and concentrations in waterways which achieve an acceptable risk of blue green algal blooms, although this may occur in the future.

The reductions in phosphorus loads predicted by the CMSS model are judged by the Group to be achievable at reasonable cost, will give an satisfactory, but unquantified, reduction in risk of blue green algal blooms and will provide a substantial reduction in the nutrient loads delivered from the Goulburn Broken catchment to the River Murray.

4.5. The Programs

Each program is described in detail below. The cost of implementing each action has been estimated in two ways:
- the five year cost (sum of the cost of each activity over the next five years)
- the 20 year net present value (cost) of the activity at an 8% discount rate. (Note that this is considered a very high rate for long term assets).

Cost summaries and proposed cost sharing are presented in Section 4.6. (At this stage costs are only estimates. Programs which involve significant capital works will require detailed planning to accurately determine costs).

Primary responsibility for ensuring the action is carried out is specified. Organisations which will be able to assist (secondary responsibility) are also listed.

4.5.1. Priority Actions.

All actions set out below must be implemented over the life of this strategy. Some programs and activities have a slightly higher priority than others. These are:

- Coordination and community involvement and education. Implementation of these activities will ensure the focus of attention on nutrient management and strategy implementation. The momentum built up during strategy preparation must be maintained.
- Reduction on irrigation induced irrigation nutrient loads in drains. Activities to achieve this have the potential to quickly reduce the summer nutrient loads delivered to the River Murray and reduce nutrient concentrations in the lower Goulburn River.
- Development of non structural nutrient control instruments, such as municipal planning scheme amendments and whole farm planning, which ensure that impacts on nutrients and water quality are assessed in the planning of land use developments.
- Management of outputs from sewerage treatment plants
- Management of diffuse source nutrients in the dryland parts of the catchment.
- Research to support implementation of these activities and to ensure the strategy will achieve the desired outcomes.
- Monitoring and evaluation to ensure we have the information to assess our performance.

4.5.2. Program 1: Coordination and Community Involvement

The key to ensuring continued strategy implementation will be the ongoing participation and input of representatives of stakeholders involved and their ownership of the strategy. This program will ensure continued community and stakeholder involvement and input to the strategy development and implementation process.

Works coordination and implementation will be the responsibility of the Dryland and Irrigation Committees, relevant agencies, authorities and resource managers.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
1.1	GB Board will assign responsibility for strategy implementation to the REWQC The Board will ensure that all its activities recognise water quality considerations in implementing their programs.	High level stakeholder involvement in strategy implementation.	no cost		1/7/1996	Board	
1.2	REWQC to oversee and coordinate strategy implementation. Works implementation coordination - responsibility assigned to irrigation and dryland Board committees.	Coordinated strategy implementation. Clear responsibilities.	$325	$651	20 years	REWQC	
1.3	Day to day coordination of strategy implementation will be the responsibility	Support to REWQC and coordination of water	$375	$751	20 years	REWQC	

	of the Goulburn Broken Water Quality Coordinator, who will be employed by Goulburn Murray Water on behalf of the REWQC. The coordinator will provide executive support to the REWQC.	quality strategy activities; focus for strategy activities					
1.4	Establish a Planning Support group	Provide high level technical support, engender team approach to water quality management activities	cost met elsewhere.		by 1/7/1996	REWQC	
1.5	Implement a catchment nutrient management rate as part of a catchment environment rate	Cost sharing. Beneficiaries contributing.	Cost met elsewhere.		1996	Board	
1.6	Implement cost sharing arrangements with secondary beneficiaries.	Beneficiaries contributing.	Cost met elsewhere		1996.	Board/REWQC	
1.7	The REWQC will report annually to the community, the Catchment Board and Government on the implementation of this strategy, including: • the condition of water quality in the catchment • loads of nutrients exported from the catchment works undertaken to manage nutrients.	Accountability	$25	$50	annually	REWQC	
1.8	Review strategy regularly to ensure that	Continual adaptation of	cost		bi	REWQC	

	progress is being made in the right direction. Targets for nutrient reduction, and the assumptions made in setting these targets will be regularly tested, especially as new information becomes available.	strategy to include new knowledge	met elsewhere.		annually commencing 1/7/1998		
1.9	Ensure implementation of Goulburn Broken strategy is coordinated with implementation of similar strategies in Victoria and the Murray Darling Basin	Basin wide coordinated implementation of nutrient management strategies.	uncosted		life of strategy	Board	MDBC, VNMSIC
1.10	Monitor other water quality issues in the catchment especially biocides and acidity. Obtain technical reports on these two issues. Assess trends of water quality parameters.	Continued strategy development.	see Program 10. Trend analysis $40	$65	life of strategy	REWQC	G-MW CNR UWA MDBC EPA
1.11	Ensure provision of information about nutrient management BMP to resource managers.	Resource managers equipped with good technical information.	$30	$27	1996	REWQC	IC G-MW CNR DAEM EPA VFF UDV
1.12	Monitor relevant research and disseminate information to stakeholders	Resource managers equipped with good technical information.	cost met elsewhere			REWQC	
1.13	Formally develop roles and responsibilities	Clear understanding of	not		1/7/199	REWQC	G-MW

	of coordinator and have this confirmed by REWQC and G-MW.	roles.	costed.		6		
1.14	Become involved in state and MDBC nutrient initiatives to ensure best outcome for catchment and enable transfers of experience and knowledge, both into and out of the Goulburn Broken	Coordination, up to date knowledge.	not costed.			REWQC	VNMSIC
1.15	Overview reporting of blue green algae blooms	Accountability.	not costed.		1997	REWQC	Algal Coordinating Committee
1.16	Maintain and further develop nutrient models of the catchment.	Prediction of impacts of management impacts	$10	$8	1996	REWQC	
1.17	Apply benefit:cost analysis, currently being developed, before implementing major nutrient management works.	Cost effective nutrient reduction	not costed.			REWQC	

4.5.3. Program 2: Community Education

Community education programs aim to encourage long term change in attitude and behaviour by the community through increasing awareness and understanding. This program will ensure that the catchment community, and those affected by actions in the catchment are aware of the need for actions to manage nutrients and implement and support the actions being undertaken.

The REWQC will prepare a communication strategy, which will be part of the Board Communication strategy. This will target key audiences. The role of the Coordinator will include community education and will focus on coordination of activities.

Community education programs already underway in the catchment as part of salinity, landcare and other programs will include water quality issues in their scope. Existing resources in the catchment, including the Shepparton Science and Technology Centre, Water Authorities (Rural and Urban) and agencies, will be utilised. These activities will be coordinated via the Board Communication strategy.

The Waterwatch program in the catchment already provides community education programs to schools and landcare groups. It will continue to provide the bulk of community education activities, raising awareness of water quality issues with landcare groups and schools. Consortiums of landcare groups, such as the Goulburn Murray Landcare Network, or the Target 10 Group, can provide the necessary links across the farming community. Future source of local funds for Waterwatch needs to be determined.

The Shepparton Science and Technology Centre, a joint venture between schools, industry and further education providers in the region, will focus on the themes of food and water and is well placed to provide educational and curriculum activities in the catchment.

Baseline information is required to understand community perceptions about water quality issues, including blue green algae. The baseline information will enable assessment of progress and changes in community attitudes over time and will work to make relevant information readily available to stakeholders. Some of this information may already be available from surveys carried out by the landcare network or the Dryland Committee.

The Albury Wodonga Phoswatch campaign provides a very good model of a community campaign designed to create awareness and achieve change.

	Action	Outcome	5 Year Cost $,000	20 Year NPV Cost $,000	Time Frame	Responsibility	
						Primary	Secondary
2.1	Develop a communication strategy as part of the Catchment Board strategy.	Targeted communication from REWQC to key stakeholders.	uncosted		1996	Board	REWQC
2.2	Use the Waterwatch program as the strategy's community education tool. Future source of local funds for Waterwatch needs to be determined.	Community involvement and understanding of issues.	$250	$501	1996	REWQC	GVW and other providers
2.3	Survey current catchment community perceptions on water quality issues	Benchmark data to assess a) effectiveness of community awareness raising b) changes in community attitudes.	$30	$47	1996 and every four years thereafter.	REWQC	IC, DC
2.4	Prepare regular newsletters and media releases about strategy implementation for distribution within the catchment. Investigate other methods for distribution of information such as landcare group newsletters, the Internet and G-MWs	Awareness of strategy implementation within catchment	$25	$50	4 per year	REWQC	

	Waterline system.						
2.5	Ensure other community education programs include water quality issues in their scope and are coordinated.	coordinated, joint action	not costed.			Board	Agencies, authorities
2.6	Implementation of Phoswatch campaign	Reduced input of P to sewage treatment plants. Community awareness.	$525	$460	1996-1999	Urban water Authorities	
2.7	Develop GIS data storage tools along the lines of the watertable watch program	Data and information accessible to stakeholders.	see action 3.11			REWQC	Agencies, authorities

4.5.4. Program 3: Planning / non structural

Planning is a key tool to achieve better land use for all aspects of nutrient and water quality management. Planning approaches will be developed ensuring consistent and coordinated approaches to water quality issues in the catchment. Planning instruments include municipal planning schemes, regional and local strategies and whole farm planning. These instruments will recognise the objectives of this strategy and the need to assess and manage water quality impacts. A regional planing amendment addressing water quality will be prepared and adopted by planning authorities. Technical support will be provided to decision makers and resource managers to help achieve the aims of this program.

Land capability mapping is a useful planning tool. Land capability studies, covering parts of the catchment, will be expanded to provide full catchment coverage. In some cases soil information can be interpreted to provide land capability information. Municipal planning schemes will utilise land capability information.

The whole farm planning process in place in irrigation areas will take into account farm nutrient planing issues. Government assistance is conditional on the preparation of a whole farm plan. Irrigation development in dryland areas has considerable potential to increase nutrient loads unless BMPs are implemented. These issues can be resolved via a whole farm planning process or by planning referral and assessment.

Farm business plans will include improvement of water quality as a fundamental basis for land and water management. This will be achieved via the Farmsmart program.

Local catchment plans to address nutrient issues or algal hot spots will be developed. Special Area Plans, under the Catchment and Land Protection Act will be appropriate in circumstances where additional legislative support is required.

A tradeable pollution rights (or local offsets) scheme will be developed and, if feasible, piloted in the catchment.

Use of rates, or rating concessions based on a nutrient audit process will be developed and piloted by G-MW and municipalities.

Information about catchment land use, characteristics, etc, will be collected, collated and stored in an easily accessible format.

	Action	Outcome	5 Year Cost $,000	20 Year NPV Cost $,000	Time Frame	Responsibility	
						Primary	Secondary
3.1	Local government to apply the principles set out in this strategy in their planning schemes and municipal strategies.	Adoption of nutrient management BMP.	not costed		life of strateg y	Municipali ties	DP&E, water authorities, referral authorities.
3.2	Amend municipal planning schemes to provide a consistent process for assessment of nutrient impacts of development in the catchment by developing a regional planning amendment for water quality issues.	Developments take water quality management considerations into account.	$130	$117	by 2001	Municipali ties	MASNV and its dryland equivalent
3.3	Provide technical support to decision makers and resource managers.	Adoption, implementation and long term management of BMP.	$560	$518	1996-2001	agencies	municipaliti es
3.4	Development proponents will assess the impact of their proposal on nutrient concentration and loads.	Ensure that developments apply BMP to proposals; no net increase in the impact of nutrients leaving the catchment	uncoste d		life of strateg y	Municipali ties	DP&E EPA G-MW CNR DAEM
3.5	Develop consistent land capability	Information for	$200	$165	by	CNR/DAE	Municipaliti

	mapping for the entire catchment; provide training to relevant stakeholders in the application of this mapping.	assessment of development applications; adoption of BMP.			1998	M	es
3.6	Irrigation whole farm planing to take into account nutrient management issues. Government funding to be dependent on preparation of a WFP	Adoption of nutrient management BMP.	uncosted		by 1996	Irrigation committee.	Farmsmart Target 10 Environmental Group, VFF UDV Industry advisers and consultants
3.7	Landholders will prepare property management plans that implement this strategy on a local basis.	Farm business plans include improvement of water quality as a fundamental objective. Adoption of nutrient management BMP	uncosted		by 1997	Dryland Committee	Farmsmart, VFF, Agencies
3.8	Develop local, or sub catchment, plans to address water quality issues in priority areas. These are (not ranked): • catchment to Lake Nillahcootie • catchment to Lake Eildon • mid Broken River (Nillahcootie to Caseys Weir) • Broken Ck • catchment to Lake Mokoan	Targeted implementation of nutrient management works. Solutions developed in concert with local stakeholders.	$20 per plan $180 total	$166	all by 2001	REWQC, with agencies and communities of concern.	

	• lower Goulburn River (downstream of Goulburn Weir) • local catchment to Goulburn Weir Pool • lower Broken River (below Caseys Weir) • catchment to Greens Lake/Lake Cooper • other, more local, areas contributing nutrients directly to waterways. • blue green algae hot spots. Provide technical and extension support for implementation of these plans.						
3.9	Implement special area plans under C&LP Act as required.	A possible method of achieving nutrient management.	not costed			Board	REWQC, CNR
3.10	Develop and, if feasible, pilot a pollution trading scheme to permit cost effective nutrient management	Cost effective nutrient management.	$70 initial invest $70 pilot Total $140	$125	1998	REWQC	agencies
3.11	Catchment characteristics mapped and stored in a format readily accessible by all agencies and community groups in the catchment.	Community education;	$50	$40	1998	REWQC	agencies
3.12	Investigate use of rating, or rating concessions, to achieve nutrient management.	Increased rate of nutrient management.	$60	$50	1998	REWQC	Municipalities, water authorities.

4.5.5. Program 4: Irrigation Drainage

The major issue this program addresses is the management, and reduction of flows resulting from excessive irrigation water runoff from farms. BMP will be adopted by all irrigated agriculture sectors, including dairy, horticulture, cropping and grazing. Irrigation drainage nutrient outputs will be reduced by 50% of the benchmark load. Reductions will be initially targeted at the summer irrigation season and the WQWG expects these reductions will be achieved within 10 years. Once summer irrigation induced loads are managed the focus will shift to loads induced by summer rainfall events, then winter events. Nutrient management improvements will have to cope with existing loads as well as the increase resulting from implementation of the surface drainage program of the Salinity Program. Some sectors, for example, irrigated perennial pasture, will be better placed to achieve nutrient management within this time frame, and consequently will be a priority.

Whole farm plans are the mechanism for dealing with farm nutrient issues. All farms will prepare and implement a whole farm plan. In 1994/95 160 WFP were prepared. Our target is to increase the rate of preparation and implementation of WFPs by 25% (40 per year). Farm reuse systems, in some form, have been installed on 60 - 70 % of farms in the region, and about 200 have been constructed each year for the past 6 years. Our target is to increase implementation by 20% per year until 80% (5360)of farms have functioning reuse systems. We will ensure that all installed systems are used optimally.

Currently 553 drain diverters are licensed to divert approximately 68 000 ML of water from drains. Based on 1991/92 figures a further 64 000 ML needs to be diverted to reduce nutrient loads by 50%. However, the actual amount needing to be diverted will be dependent on the success of farm activities, such as reuse and other BMP, in reducing the amount of water available in drains. The final target will be an mixture of reuse systems, drainage diversion and other BMP.

The cost of installing reuse and drainage diversion systems should not be an impediment to their adoption. Extension programs to encourage implementation and their on going management are required. Measures to ensure maximum development, adoption and use of reuse and drain diversion, for example supply of electric power to pumps, or rate rebates, are required.

A methodology, and policy, for allocating extra drainage diversion licences is being prepared by G-MW for the Deakin and Bamawn areas, and should be available by mid 1996. The methodology will be quickly applied to all catchments to allow issue of extra diversion licences. This requires work by landholders and G-MW to provide suitable institutional arrangements to permit increased drain diversion. Issues to be considered include reliability and security of water supply, impacts on existing diverters, optimising diversions and water quality. In some cases

it may be feasible to divert drainage water back into the channel supply system. The volume of irrigation water outfalling from G-MW channels to drains will be reduced as system management techniques are improved.

Strategically located storages for diverted drainage water are required to reduce the impact of short duration drain high flows in summer. An incentive will be provided to construct storages.

Once reuse and diversion schemes are constructed, considerable effort needs to be made to ensure that they are used to their maximum capacity. It is proposed that incentives will be provided to install electric power and automatic switch gear to pumps to achieve this. There appears to be a considerable understating of drainage water reuse. All diversion licences will be metered. The practicalities of metering require investigation. Cost sharing for meters will be in line with that applying in the salinity program. Administration costs associated with meter reading, recording and maintenance will be recovered via the cost of drainage water.

Reuse systems must be managed to ensure the water remains free of blue green algae and useable for irrigation purposes. Research is required to define management parameters.

Technical and practical issues associated with strategic water harvesting near the downstream end of drains will be resolved. The potential for wetlands to treat drainage water will be investigated and trialed.

Point sources discharging to drains, such as industry, urban stormwater and sullage and sewage treatment plants will be identified and registered, and a program developed to minimise discharges. Monitoring and reporting of discharges from these sources is required.

No farm will directly discharge dairy shed effluent to drains. The issue of the definition of effluent from dairy sheds will be resolved. BMP for discharges from feed pads, calf sheds and other intensive dairy operations will be developed.

Priority catchments are Deakin Main Drain, Murray Valley Drain 6, Broken Ck (Drains S11, S12, MV 13, MV 18). In addition to normal monitoring, the Waterwatch program will be used to identify those catchments with higher than expected nutrient exports. Action plans to address these catchments will be developed.

Drains outfalling to rivers and streams will be treated as point sources. G-MW will be responsible for these point sources for monitoring and accountability purposes. Responsibility for Community Surface Drains outfalling to G-MW drains will also be G-MW's responsibility. Responsibility for Community Surface Drains discharging directly to streams will be resolved. Responsibility for outfalls to drains is that of the individual land manager. G-MW is currently discussing drain management arrangements with EPA.

The farm program of the SIRLWSMP is compatible with this strategy. Potential conflicts will be resolved by careful coordination between the REWQC and Irrigation Committees.

Other water quality concerns associated with irrigation drains, especially biocides, heavy metals and pathogens, will be investigated and action programs developed to address issues.

The current whole farm planning process will explicitly consider nutrient issues. Irrigation BMP will be developed and made easily accessible to the farming community. Adoption of these BMPs will be encouraged by implementation of a targeted extension program. Research and investigations to provide the technical certainty of these BMP will continue to be implemented.

A proposal to upgrade weirs on Broken Ck has potential to minimise nutrient loads by 30 to 40%, by enabling improved water management in the creek. This proposal will be implemented as part of the Broken Creek Strategy.

River management works, carried out in the irrigation area, have been included in the diffuse program (Program 5)

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
4.1	Achieve new drainage diverters to reduce annual drain flows by 64 000 ML, especially in Deakin Drain, Broken Ck and	Approximately 50% reduction in drain nutrient loads (32 t TP	Capital $8.7M O&M	Capital $6.9 M O&M	by 2006	G-MW	

	MV Drain 6. Offer an incentive to construct storages for diverted water.	reduction, assuming TP conc is 0.5 mg/L)	$3.4M	$6.9M			
4.2	Investigate practicalities of metering. Then meter all diversion licences.	Accountability of individual diverters. Management information will become available.	Capital $550 O&M $110 $20	Capital $738 O&M $653 $19	2001	G-MW	
4.3	All irrigation farms with an approved whole farm plan. Increase rate of WFP adoption and implementation by 25% (40/yr)	Better farm water and nutrient management. Less water leaving farms.	$750	$1.5M		DAEM/IC	
4.4	80% (5360) of irrigation farms with functioning reuse systems. Increase rate of adoption by 40 per year.	Less water and nutrients leaving farms. Potential nutrient loads reduced considerably.	Capital $12M O&M $1M	Capital $16.4 M O&M $6.3M	by 2006	DAEM	
4.4 A	All reuse systems will be used effectively by encouraging installation of electric power		Capital $22.5 M O&M $225	Capital $30.1 O&M $2.8M			
4.5	All dairy effluent systems managed in accord with best management practice. No farm directly discharging dairy effluent to drains. Implement an extension program to achieve this.	8.4 t TP reduction.	Cap $500 O&M $130	Cap $446 O&M $718	1998	DAEM/EPA	
4.6	Point source discharges to drains identified and registered, especially industrial, urban	14.8 t TP reduction.	$120	$107	a) by 1997	EPA	G-MW industry

	stormwater and sullage sources and action plans developed to minimise discharges.				b) by 2001		municipalities
4.7	Investigate opportunities for the use of natural and constructed wetlands to process drain water, especially near drain outfalls.	Potential for treating nutrients associated with large flows.	$60	$53	by 1999	REWQC	G-MW, CNR
4.8	resolve institutional arrangements about responsibilities for drain management	Responsibility for managing source can then be assigned.	not costed		1997	REWQC	G-MW, EPA
4.9	adoption of nutrient management BMPs by all sectors of the farming community	General nutrient reductions; improved farm management	$500	$1000	life of strategy	Target 10 Environment Group, NVFGA	landholders DAEM EPA landcare groups VFF UDV municipalities
4.10	investigate water quality issues associated with drains, especially biocides, heavy metals and pathogens.	Issues of concern addresses; targeted action	see Program 10			G-MW	EPA, DAEM
4.11	Ensure current WFP processes recognise nutrient issues.	Adoption of BMP.	not costed.			IC	DAEM, Target 10, G-MW
4.12	Use Waterwatch to identify hotspot catchments. Agencies and landholders will develop action plans to address issues in these catchments.	Targeted action.	Costed elsewhere			REWQC	Waterwatch, Landcare, Agencies, authorities

4.13	Develop BMP for feed pads, calf sheds and other intensive dairy operations.	Adoption of BMP	$40	$36	1997	DAEM	UDV, Target 10
4.14	Finalise methodology for allocating new diversion licences. Implement this over the irrigation region.	Adoption of drainage diversion BMP	$100	$89	1997	G-MW	
4.15	Implement an extension program to encourage adoption of BMP by irrigators.	Adoption of BMP	see 4.9		2016	DAEM/G-MW/IC	
4.16	Define requirements for reuse systems to remain blue green alae free.	Continued implementation of BMP	$225	$193	1998	DAEM	
4.17	Continue development and implementation of the Broken Ck Weir replacement program	Reduction on nutrient loads by approx 50% from Broken Ck (~20 t)	$450	$358	1998	G-MW	IC
4.18	Investigate opportunities to divert drainage water back into the channel supply system.	Reduction in drain flows and nutrient loads.	$100	$87	1998	G-MW	

4.5.6. Program 5: Diffuse Sources

This program will implement nutrient management activities in the dryland part of the catchment. In these areas the bulk of nutrient loads are from diffuse sources, although there are also a large number of relatively small point sources scattered across the catchment. This program will also target these small point sources.

Best nutrient management practices for diffuse nutrient sources will be adopted over the entire catchment. Nutrient management BMPs will also meet the requirements of other land management programs in the catchment, eg river management, salinity, etc. We need to accelerate implementation of BMP and focus on areas that provide multiple benefits, or synergies. However, some catchments will be targeted as priorities for nutrient management activities, based on the assessed risk of nearby water bodies to blue green algal blooms. The principle focus will be on reduction of direct sediment inputs to waterways and stabilisation of sediment and nutrient sources in waterways.

Sediment sources such as eroded gullies, roads, construction sites will be treated, especially those which discharge directly to waterways..
A priority ranking of generic works or BMPs to reduce P loads is:

- control of point sources of nutrients directly discharging to streams
- erosion control:
    - stabilise bed and banks of streams and provide buffer strips along streams to assist revegetation
    - control of diffuse sources of nutrients discharging directly to streams by providing filter strips and undertaking erosion control works
- control of point sources indirectly discharging
- control of diffuse sources indirectly discharging

In the Goulburn Broken priority areas will be:

- Areas above storages which could act as sediment/nutrient traps thus providing sources of internal loading of P. In particular, water supply catchments, especially those listed as special areas under Schedule 5 of the Catchment and Land Protection Act 1995. These include Eildon (Upper Goulburn), Nillahcootie, Kilmore, Ryans Ck, Honeysuckle Ck, Sunday Ck (Broadford Kilmore), Seven Creeks and Mountain Hut Ck (Euroa), Mollison Ck (Pyalong), Nine Mile Ck (Longwood).
- Mokoan (implement the Mokoan Restoration Strategy)

- weir pools on Broken River
- weir pools on Broken Ck and tributaries
- Goulburn Weir backwaters

(note the overlap with sites listed in program 3, action 3.6).

Distributed point sources will be surveyed and an action program developed to manage these sources.

Irrigated areas within the dryland present similar problems to those within the true irrigation areas. The actions required in Section 4, especially the need for WFP and reuse systems will also apply to dryland irrigated areas.

A program of river management works to stabilise sediment sources from stream bed and bank erosion will be developed and implemented over the entire catchment. The level of development of river management works programs varies across the catchment. Some areas are very well planned, while other areas, which have never been served by river management authorities, have no planning at all.

Land managers will continue to apply the Code of Forest Practice and local prescriptions to their forestry operations. All land managers will apply the principles set out in relevant codes and Guidelines to minimise sediment production and movement.

Land managers will report on their adoption and implementation of BMPs, including relevant Codes or Guidelines.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
5.1	Install approx 550 km of filter strips along rivers and streams by increasing the rate of implementation of river management	Nutrient inputs to streams reduced by approximately 3.6 t.	Capital $5.5M O&M	Capital $11M O&M	2016	CNR/ WWMA/farm forestry	landcare landholders

	works by 25% and the rate of farm works by 25%	Condition of riparian zone improved.	$360K	$2.6M		program.	
5.2	Develop and implement a program of river management works so that the rate of implementation is increased in priority areas by 25%	Nutrient inputs from instream sediment reduced by 25 t TP. Condition of riparian zone improved.	Capital $2.5M O&M $165K	Capital $5.1M O&M $1.2M	2016	Waterway Management Authorities	landcare groups landholders
5.3	Review point source discharges in the catchment and implement management activities.	Nutrient inputs to streams reduced by an unknown factor.	$110	$98	1996-1998	EPA	land managers
5.4	Develop and implement sub catchment nutrient management plans for the high priority catchments listed above in 3.8	Solutions to local issues developed locally. Management actions developed, and implemented on a priority basis	Development costed in 3.8, Implementation not costed.		1999	REWQC	Agencies, landcare groups
5.5	encourage adoption of BMPs by all land managers by the provision of technical and extension services (2 people).	Adoption and on going management of BMP.	$500	$1000	2016	DAEM CNR Dryland committee	landholders landcare groups VFF municipalities
5.6	Ensure irrigation BMP are adopted by irrigators	Potential nutrient increases avoided.	not costed		1997	REWQC	DAEM, G-MW, municipalities.

5.7	Ensure WFP processes recognise water quality issues.	Adoption of BMP.	Not costed		1996	REWQC	Farmsmart, DC, agencies
5.8	Investigate use of special area plans		Not costed.		1997	Board	CNR
5.9	investigate methods of prioritising areas using turbidity data.	Targeting of works to high priority catchments.	$60	$53	1998	REWQC	
5.10	Use Waterwatch to identify hotspot catchments. Agencies and landholders will develop action plans to address issues in these catchments.	Targeting of works to high priority catchments.	Costed elsewhere.		1999	REWQC	Waterwatch, agencies, authorities, landcare.
5.11	Investigate catchment condition as a means of prioritising areas	Possible means of targeting action.	$50	$45	1997	REWQC	
5.12	Land managers will adopt principles to minimise sediment production and movement.	Adoption of BMP to minimise nutrient production.	Not costed.			DC	agencies
5.13	Public land managers will continue to apply the Code of Forest Practice to their operations.	Continued adoption of BMP.	Not costed.		1996	Land managers.	
5.14	Land managers will report on their adoption and implementation of BMP, including relevant Codes or Guidelines.	Accountability.	Not costed.		annual	Land managers.	REWQC
5.15	Develop and implement Mokoan restoration strategy.	Treatment of a BGA hot spot.	$650	$533	1996	G-MW	

4.5.7. Program 6: Sewage Treatment Plants

Nutrient discharges to waterways from sewage treatment plants will be minimised. Where this is not feasible, or cost effective, other measures, which give an equivalent result will be investigated. While end of pipe solutions may be initially implemented, waste minimisation and nutrient reduction at source, offer long term sustainable improvements.

Initially, a five year program of achieving zero summer (November - April, inclusive) discharge, or its equivalent, is to be adopted, especially for Benalla, Mooroopna, Seymour and Shepparton. This will give nutrient concentration reduction in streams over the crucial summer, high blue green algal risk, period. A 20 year target of full wastewater reuse on land, or tertiary treatment to remove phosphorus, to give the equivalent result is to be adopted in line with Government and EPA requirements. (In reality full reuse to land , or equivalent, will mean 90 - 95% load reduction as some discharges will be necessary in very wet periods). This target requires very large investment to achieve the predicted improvements in nutrient loads. A 20 year time frame is required to ensure we are confident this level of investment is justified and in the light of a sensible investment approach. In the longer term water authorities are committed to substantially reducing loads over and above the 5 year program.

Actions from the Government's effluent standards report will be implemented. The urban water authorities have prepared waste management strategies to meet the requirements of the Effluent Standards Report. This has identified a significant backlog of works and difficulties with sustainable effluent disposal at some locations.

All authorities are working towards nutrient reduction. Ovens Water will continue to work towards full reuse to land at Benalla and Yarrawonga. GVW are continuing to work towards full reuse to land at all STPs except Shepparton and Mooroopna, where investigations to determine the most suitable, and sustainable, outcome are underway.

A tradeable pollution scheme will be developed and piloted to test cost effective nutrient reduction on a catchment scale.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV**	**Time Frame**	**Responsibility**

				Cost $,000		**Primary**	**Secondary**
6.1	All STPs with the equivalent of zero summer discharge. Priorities - Shepparton, Mooroopna, Seymour, Benalla.	Reduction in nutrient loads by 4.5 t	Capital $9M	Cap $8.3M O&M $2.6M	5 years	Urban Water Authorities.	EPA CNR
6.2	Full wastewater reuse on land or equivalent.	Reduction in nutrient loads by 44 t from 1993-4 figures.	Capital $5.6M O&M $220	Capital $15.1 M O&M $2.3M	20 years	Urban Water Authorities	EPA, CNR
6.3	Implementation of waste minimisation schemes by industry	Reduced input of nutrients to STP, reducing the need for discharges.	not costed.			Industry	Urban Water Authorities, EPA
6.4	Continue to develop waste management plans in line with Government requirements. Implement these plans to meet SEPP and strategy requirements.	Reduced input of nutrients to STP reducing the need for discharges.	not costed			Urban water authorities	CNR EPA REWQC
6.5	Further develop recommendations of Water for Industry and Wastewater for Industry reports for possible implementation.	Reduced input of nutrients to STP reducing the need for discharges.	not costed.			industry.	Urban Water Authorities

4.5.8. Program 7: Urban Stormwater

Urban stormwater will be the responsibility of municipalities. Municipalities will prepare stormwater management plans for urban and semi urban areas, which will review existing management practices and investigate nutrient management options. At some towns, eg Tatura, natural wetlands appear to provide stormwater treatment. There is a need to investigate opportunities for similar arrangements at other towns and to implement appropriate management regimes as part of stormwater management plans.

Urban stormwater BMPs will be incorporated in new developments with the cost of implementation being met by development proponents. Sullage issues are dealt with under program 9. Apart from nutrients, urban stormwater may also discharge toxicants, heavy metals and pathogens to waterways. The local impact of these discharges must be assessed prior to carrying out management activities.

A statewide project, developing urban stormwater management principles, is nearing completion.

In general, retrofitting of stormwater treatment options to existing drains is not considered feasible because of cost and poor cost efficiency of nutrient removal. However this cost may be off set by amenity improvements or by improved management of sullage and septic tank effluent.

Urban lakes, such as Kialla Lake at Kialla or Craigmuir Lake at Mooroopna, have high potential for blue green algal blooms. Municipalities will consider this when reviewing development applications and management arrangements.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
7.1	Responsibility for urban stormwater assigned to municipalities.	Accountability.					
7.2	All new subdivisions will incorporate stormwater best management practice.	Adoption of BMP.	uncosted			Municipalities	developers EPA, CNR,

	This will be achieved via planning requirements.						G-MW, DPE
7.3	Review stormwater treatment practices and prepare stormwater management plans at all towns in the catchment. Seek opportunities to improve current stormwater treatment practices at reasonable cost Put in place appropriate management regimes especially for wetlands.	Targeted adoption of BMP.	$650	$519		Municipalities	EPA, CNR, G-MW, DPE
7.4	Assess local impacts of urban stormwater contaminants (eg toxicants, heavy metals) on receiving waters.	Increased knowledge and awareness; targeted action..	$300	$238	1999	Municipalities	EPA, CNR, G-MW

4.5.9. Program 8: Intensive animal industries.

This program covers two major industries - fish farming and piggeries. Best management practices will be developed and adopted by intensive animal industry managers. Other industry types may become more important over time

Feedlot guidelines have recently been published by DAEM. Many of the principles in this can be applied to other intensive animal industries.

Piggeries - The current Piggeries Code of Practice does not require consideration of nutrient balance for effluent management. The aim is to adopt and implement nutrient balance approach for effluent management. For new developments this will require revision of the Piggeries Code of Practice. It is uneconomic to expect existing piggeries to implement nutrient balance effluent disposal, but as new or existing units are upgraded, this should become mandatory.

Fish farms - will be encouraged to continue to develop BMP for feed formulation, feed management, pond sediment and waste management. All fish farms in the upper Goulburn area between Eildon and Seymour will implement these BMP as they become available.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
8.1	Piggeries-review Code of Piggeries Practice to incorporate nutrient balance requirements for long term sustainability. Ensure municipalities are aware of these when assessing development applications	Long term sustainability of industry.	$50	$46	1997	DAEM	Municipalities
8.2	Piggeries - Upgrade existing requirements for effluent treatment as changes are	Long term sustainability of industry. Nutrient	not costed		by 2016	Industry.	Municipalities,

	proposed to ensure long term sustainability.	loads reduced by 1 t (based on current estimates).					DAEM
8.3	Fish Farms - research, adopt and implement BMP for improved feed formulations, feed management techniques, pond sediment and waste management. All farms will adopt these BMP.	Industry expansion may be possible. Nutrient loads maintained at current levels or improved.	$200	$166		Industry	EPA

4.5.10. Program 9: Local Water Quality Issues

Local water quality issues are defined as water quality problems occurring at a local level within the catchment. While these may be insignificant at a regional level they may restrict the beneficial uses of water. For example the AEAM model showed that septic tanks were not a key nutrient load source on a catchment scale, but septic tanks and management of sullage water were identified as a key local issue, especially from a health viewpoint. A number of areas have been identified where septic tanks are causing local water quality problems. These areas include Kinglake, Toolangi, King Parrot Ck, Kilmore East, Wandong, Benalla (groundwater), Merrigum and Tungamah. Alternatives to septic tanks are available and will be encouraged. Municipalities will determine the need for improved sanitation and assist urban water authorities to develop management options.

Impacts on groundwater will be investigated, especially where groundwater is used for potable water supply.

Water quality in the upper reaches of the Broken Ck was raised as an issue. We know that water quality in the lower section of the Creek is degraded. Investigations by Broken River Management Board indicate that water quality in Lake Benalla is degraded. These investigation will continue and solutions developed over the next two years. Recreational use of public land, without sanitation facilities has been raised as a concern. Investigation, development and implementation of strategies on a catchment basis to improve water quality is required (Refer also Programs 3 and 5).

Other local water quality issues will be investigated and solutions developed, in collaboration with relevant stakeholders.
Local issues will be dealt with by the appropriate authority or agency. Action will be monitored by the REWQC. Cost sharing arrangements will be developed on a case by case basis using the principles outlined in Section 5.

Emergency management procedures for critical issues (eg blue green algal blooms, toxic chemical spills, sewage spills, etc) affecting water quality will be monitored or developed.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost**	**Time Frame**	**Responsibility**

				$,000		**Primary**	**Secondary**
9.1	Investigate local water quality concerns associated with septic tanks at Kinglake, Toolangi, Flowerdale, Wandong, Merrigum, Tungamah ($30K each), and others as they arise.	Issues addressed and action plans developed.	$180 each	$145	1996-98	Municipalities	EPA, urban water authorities.
9.2	Investigate other local water quality concerns.($30K each * 4)	Issues addressed and action plans developed.	$120 each	$99			
9.3	Implement actions to overcome local water quality concerns.	Concerns addressed.	uncosted		1997 onwards		
9.4	Investigate impacts of local water quality issues on groundwater.	Knowledge of impacts.	uncosted.				
9.5	Finalise Lake Benalla water quality investigation.	Knowledge leading to implementation of an action plan.	$20K	$18		BRMA	Delatite Shire.
9.6	Ensure development of emergency management procedures for critical issues.	Risk minimisation.	Cost met elsewhere		by 1998	REWQC	agencies.

4.5.11. Program 10: Other Water Quality Issues

The REWQC will monitor water quality issues in the catchment and take appropriate action to develop action plans or strategies to overcome these issues. The two key issues are surface water acidity, in the dryland areas, and biocides, especially in irrigation drainage water. Water borne pathogens may be an issue, along with toxicants and heavy metals from urban stormwater. Groundwater contamination issues may arise in the future.

The costs of addressing these issues, and the associated cost sharing, will be developed on a case by case basis.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
10.1	Encourage coordinated investigation into other water quality issues, especially acidity in dryland area.	Increased knowledge leading to action plans.	$30	$28	acidity by 1997	REWQC	Dryland committee, G-MW
10.2	Encourage coordinated investigation into other water quality issues, especially biocides in irrigation areas.	Increased knowledge leading to action plans.	$270	$232	biocides by 1999	REWQC	Irrigation committee, G-MW, DAEM
10.3	Investigate occurrence of pathogens in waterbodies and toxicants and heavy metals from urban stormwater.	Increased knowledge leading to action plans.	$300	$221	by 2001	REWQC	
10.4	Implement actions from these investigations	Enhanced water quality.	not costed.		1997 onward	REWQC	appropriate authorities

					s.		

4.5.12. Program 11: Research and Investigation.

REWQC will coordinate nutrient management research activities in the catchment. Implementation of this program will increase the confidence and certainty in strategy direction as well as providing land managers with nutrient management best management practices for adoption.

REWQC will maintain a register of all relevant activities being undertaken in the catchment and will ensure the results of all research and investigation activities undertaken in the catchment are widely circulated, not just within the Goulburn Broken, but to other relevant groups in other areas.

A comprehensive research and investigation program is outlined in Section 9. This is developed from information gaps and research needs identified during the preparation of issues papers. The key requirements include knowledge of nutrient sources (irrigation and dryland), criteria for setting nutrient targets, the relative importance of summer vs winter nutrient loads and development of cost effective and sustainable BMP.

REWQC will work closely with research organisations to develop and implement research programs in the catchment. The National Eutrophication Management Program (NEMP) was established in mid 1995 by LWRRDC and MDBC to provide the scientific underpinning necessary for effective management of algal blooms. The program aims to concentrate research in four focus catchments considered representative of Australian catchments where water bodies experience eutrophication problems.

The Goulburn Broken catchment has been selected as a focus NEMP catchment. Other focus catchments are Wilson Inlet (WA), Namoi R (NSW), Fitzroy R (Qld).

Some activities, or proposals will be ideal student thesis projects. The strategy will support students undertaking research in the catchment and will build close links with tertiary institutions which may be in a position to carry out research and investigation projects.

A number of projects being undertaken at ISIA Tatura address BMP development.

Costing of this program is based on the experience of the Goulburn Broken Salinity Program where level of funding for research is currently around 10% of the total program cost. In the longer term this is expected to drop to 5 - 7%. Industry organisations will continue to contribute to relevant research projects.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000 $**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
	Incorporate research results into strategic policy direction and development	Improved confidence in strategic direction.				REWQC	
	Develop and implement a coordinated research and investigation program.	Knowledge gaps addressed. BMP developed. Risk minimisation.				REWQC	Research organisations.
	Develop National Eutrophication Management Program research program in conjunction with LWRRDC/MDBC and research organisations.	Key knowledge gaps addressed.				LWRRDC/ MDBC	REWQC

4.5.13. Program 12: Monitoring and Evaluation and Reporting.

We must monitor our strategy implementation performance. We need to know what's happening and if we are achieving results; we need to report to stakeholders and to those who are paying for strategy implementation.

Changes that occur as a result of strategy implementation (eg adoption of BMPs) are indicators. Measuring these indicators is monitoring. The "so what does this mean" tests are evaluation. Benchmarks will be established against which performance will be assessed.

The key indicators to be monitored as part of this strategy are surface water quality parameters and adoption of best management practices. Water quality data will be coupled with flow data to derive nutrient load estimates.

Extensive water quality monitoring, carried out under the Victorian Water Quality Monitoring Network, the Major Storages Operational Monitoring, the MDBC monitoring program, the irrigation salinity program and the EPA, is carried out in the catchment and will continue. The VWQMN monitoring should be expanded to included measures of algal growth (chlorophyll a and phaeophytin).(approx cost $50 per sample). The MSOM already monitors chlorophyll. This monitoring will also give information on the total contribution of nutrients from the Goulburn Broken catchment to the Murray River.

This type of monitoring underestimates nutrient loads associated with large flow events. Two Aqualab units have been deployed within the catchment to provide information about the changes in nutrient loads over short time frames. Studies examining the use of daily turbidity data collected by water treatment plants as a cost effective method of more accurately monitoring nutrient loads and water quality will continue. This technique may also be applied via the Waterwatch program to provide cheap, and easily obtained, local indicators of the need for remedial works and their success.

Point source contributors, such as urban stormwater, STPs and irrigation drains will monitor their contributions as part of a compliance monitoring program and will report their results to the REWQC. Results of all monitoring will be published annually by REWQC, with major interpretation of results every three years. Stakeholders will be encouraged to be involved in monitoring via programs such as Waterwatch.

Complementary programs carried out by waterway managers will be reported on. On public land, land managers (CNR, VPC, ARC) will report on nutrient management activities.

Measures of adoption of best management practices will be reported by land managers. The indicators to be measured will be defined, keeping in mind cost effectiveness of data collection.

Detailed analysis of monitoring must wait at least five years after strategy implementation beginning to allow time for trends in implementation and effectiveness to be seen.

Reporting to Government and the community will be via the REWQC component of the Catchment Board Annual Report. REWQC will coordinate these monitoring programs in the catchment and encourage the development of information and interpretation systems which allow easy access and understanding of the information gathered. REWQC will ensure monitoring information is widely, and easily available.

There is a need to monitor not only quality of water, but also the impacts of that water quality eg ecological impacts. An index of stream condition is being developed and will provide a useful framework. This provides a summary of hydrology, physical form, riparian zone, water quality and aquatic life. The Broken River is being used as a pilot. Biomonitoring may provide a useful indicator of the impacts of nutrient discharges.

	Action	**Outcome**	**5 Year Cost $,000**	**20 Year NPV Cost $,000 $**	**Time Frame**	**Responsibility**	
						Primary	**Secondary**
12.1	Continue VWQMN, MSOM, EPA salinity and MDBC monitoring. This will be coordinated in the catchment by the REWQC.	Accountability; indication of results from strategy implementation.	$940	$1.8M		CNR, G-MW, EPA, MDBC	
12.2	Monitoring will be supplemented to include measures of algal growth.	Vital indicator of outcome of strategy.	$35	$70		G-MW	

12.3	Point source monitoring	Accountability.	not costed			EPA	licenced dischargers.
12.4	Monitor adoption of BMP, especially • WFP implementation • Reuse systems • drain diversion • filter strips installed.	Accountability.	$100	$200		REWQC	IC, DC, resource managers.
12.5	Publish monitoring results annually	Accountability.	costed elsewhere.			REWQC	
12.6	Use Aqualabs to improve knowledge of nutrient fluxes, especially over short timeframes.	Increased knowledge.	$75	$60		REWQC	G-MW
12.7	Continue to investigate the use of daily turbidity data collected by water treatment plant operators	Development of easily collected water quality monitoring parameter.	$45	$41		REWQC	
12.8	Waterwatch monitoring by community.	Community education.	costed elsewhere			Waterwatch	
12.9	Develop index of stream condition indicators.	Long term monitoring of performance.	costed elsewhere			CNR	
12.10	Investigate use of biomonitoring to assess stream health and impacts of nutrient discharges.	Long term monitoring of performance.	$150	$129		REWQC	CNR, water authorities

4.6. Summary - Cost of Implementing the Preferred Strategy.

Table 10 summarises the costs and proposed cost sharing arrangements. Detailed information about costs and proposed cost share can be found in the Background Paper on costs and cost sharing. Cost sharing is also further discussed in Section 8. The cost of strategy implementation does not show all the uncosted contributions for some actions, for example, industry implementing waste minimisation schemes or G-MW implementing channel management systems which reduce the volume of water in irrigation drains. Costs associated with implementing sub catchment plans are also not included. These costs, and associated cost sharing, can only be determined when these plans are prepared or detailed investigation A number of programs show no nutrient reduction. These programs provide the support to works orientated programs, and without them strategy implementation will not occur.

Table 10: Summary of Costs and Cost Share.

Program		P reduction t/yr	5 year cost $,000	Capital $,000 (discounted over 20 years @ 8%)				O&M, $,000 (discounted over 20 years @ 8%)			
				Total	Fed Govt	State Govt	Stakeholder	Fed Govt	State Govt	Stakeholders	Total
1	Coordination and community involvement	-	805	1552	601	601	351	0	0	0	0
2	Community education	-	830	397	397	264	0	0	0	0	0
3	Planing/non structural	-	1320	1180	435	435	311	0	0	0	0

4	Irrigation drainage	70-100	52282	56890	7332	7332	42990	0	0	17419	17419
5	diffuse	28.6	9944	17858	6108	6108	5624	0	0	3830	3830
6	Sewage	50	14793	23529	3922	3922	15686	0	0	4901	4901
7	Urban stormwater	-	950	758	262	262	233	0	0	0	0
8	IAI	1	250	212	65	65	83				0
9	Local issues	-	320	263	88	88	88	0	0	0	0
10	other WQ issues	-	600	481	240	240	0	0	0	0	0
11	Research and Investigation	-	8344	14354	4785	4785	4785	0	0	0	0
12	Monitoring evaluation and reporting	-	1345	2383	725	1026	632	0	0	0	0
Total			90617	120517	24958	25260	71064			26149	26149
%					21	21	59			100	100
Grand Total Cap+O&M				147431	24958	25266	97213				
Tot %					16.9	17.1	69				

Federal Government (FG) = Basin community and Australia (downstream communities)
State Government (SG)= Victorian Government
Stakeholders (SH) = catchment community, including individuals, farmers, industry, regional water authorities and municipalities.

Costs and cost sharing have also been calculated with 4% and 6% discount rates. These figures are shown in Table 2A.

Table 10A: -

	Discounted Cost over 20 years.		
	4%	**6%**	**8%**
Capital	157	137	121
O&M	40	32	26
Total*	198	170	147
Cost share (%)			
FG	16.7	16.8	16.9
SG	16.9	17.0	17.1
SH	66.4	66.2	65.9

* Note rounding errors.

5. Who Pays?

5.1. Cost benefit

5.1.1. Costs

Costs of implementing the preferred strategy are set out in Table ~~2~~10.

5.1.2. Benefits.

The benefit of implementing this strategy is best thought of in terms of avoiding damage from blue green algal blooms. This damage could be loss of recreation and tourism, costs to water authorities of providing alternative water supplies or the loss of export markets due to loss of consumer confidence that the product produced in the Goulburn Valley is "Clean and Green". A hypothetical example of the costs to the Goulburn Valley of a blue green algal bloom, is as follows.

"Annual production from the food sector in the Goulburn Valley is about $1.5 billion. Over the next 30 years, that would have a present value of over $17 billion at an 8% discount rate. Let's say for the purpose of a hypothetical example, that if there was a calamity due to water quality problems in the next decade, and the resulting damage to the reputation of the Goulburn Valley as a processor of clean foods led to a drop in the demand for food products from the Goulburn Valley such that production were reduced by 20% for the next five years. This would be equivalent to a reduction in the present value of production over the next 30 years of about $1 billion. Taking that further if there was a 1 in 100 chance of such a calamity due to a major blue green algal bloom in the next decade, the expected value of such a loss in production would be about $10 million."

Unfortunately it is not yet possible to meaningfully estimate the number of algal blooms prevented by implementing this strategy, nor is it possible to meaningfully estimate the cost of damage avoided. A method of estimating some of these benefits is being developed. We will apply this to waterbodies in the catchment before implementing major works.

Apart from economic benefits, strategy implementation will have substantial non dollar benefits, the costing of which is impossible. These include environment and social benefits.

5.2. Cost sharing Principles.

5.2.1. Government Cost Sharing Principles.

The State Government is finalising nutrient management cost sharing guidelines. The guidelines are underpinned by the principle that no one has the right to cause damage to waterways, but that everyone has a duty of care to ensure their activities have a minimal impact. Given individual responsibilities and the range of benefits resulting

from nutrient management, the following principles form the basis of the Government's cost share policy for nutrient management:

- the prime responsibility for paying the cost of a nutrient management activity is the person of body responsible for the related nutrient contribution.
- beneficiaries of nutrient management are encouraged to contribute
- Government contributes to facilitate the up-take of nutrient management on a scale necessary so that its environmental, economic and social objectives are met.

Government will not share in the cost of nutrient management activities which are not cost effective and which depend on a continuing subsidy. Government will only contribute to address existing nutrient issues. It will not share in the cost of addressing nutrient discharge from new development put in place after the adoption of the Government's Nutrient Management Strategy in March 1995.

5.2.2. Goulburn Broken Cost Sharing Principles

The WQWG developed the following cost sharing principles:

Costs should be split between Government (federal and state), the regional catchment community and stakeholders (who have to fund and carry out works):

- to reflect the extent to which they contribute to the nutrient problem (polluter pays) and the extent to which they benefit from nutrient management (beneficiary pays).
- to share the consequences and costs of past actions
- to attribute the costs and consequences of future activities to the cause
- to take into account fairness and equity principles
- in an economically efficient way encouraging practices which are known to reduce nutrient inputs and discouraging practices which are known to contribute to the nutrient problem
- in a manner which encourages integration and coordination with other programs
- in a flexible and adaptive environment
- in a transparent and accountable environment.

5.3. Contributors and Beneficiaries.

Contributors are those whose action result in nutrients reaching streams and waterways.

Primary beneficiaries are those who directly benefit from works undertaken to manage nutrients and the consequent improved water quality. Primary beneficiaries include downstream communities, who benefit from improved water quality and reduced risk of algal blooms, and communities who benefit from their produce being processed in the Goulburn Broken catchment.

Secondary beneficiaries include those who indirectly benefit from improved water quality. For example the state of Victoria, and the Commonwealth both indirectly benefit from strong industries exporting products which are seen by overseas consumers as "Clean and Green." These beneficiaries gain from implementation of the works program proposed in this strategy.

Secondary beneficiaries will not be asked to contribute to the O&M costs of this strategy.

Contributors and polluters will pay by their direct contribution towards the cost of carrying out works to manage nutrients as well as the associated costs on going O&M and compliance monitoring.

Primary beneficiaries will contribute to the cost of strategy implementation by undertaking, and paying for, nutrient management activities.

The Goulburn Broken catchment community will contribute indirectly in a number of ways. The community will contribute, via their rates, to the nutrient management activities of regional authorities such as urban and rural water authorities, municipalities and waterway managers. They may also contribute via a proposed catchment environment levy, or rate, applied by the Goulburn Broken Catchment and Land Protection Board.

Contributions from downstream primary beneficiaries will be made via Federal and State contributions.

The state and federal secondary beneficiaries will be asked to pay via contributions to State and Federal programs which provide for nutrient management. For example, the MDBC Natural Resource Management Strategy provides for MDBC contributions matched by State contributions.

5.4. Proposed Cost Sharing

The proposed cost sharing arrangements are set out in Table 10~~2~~. Federal and State Governments are each asked to contribute approximately 17% each to the cost of strategy implementation. The catchment community and catchment stakeholders are asked to contribute 66% of the overall cost of strategy implementation, which includes capital and operations and maintenance costs.

In general terms, Governments are asked to contribute to extension, coordination and research activities and to contribute a smaller share of works activities, especially where there is a need to encourage works adoption. Government is asked to contribute a greater share towards works which have an environmental benefit, for example, river management works and filter strip construction along streams.

Catchment stakeholders will contribute towards works activities and will provide the full cost of on going operations and maintenance of these works. These stakeholders include farmers, industry, water authorities and municipalities. In many cases there will also be substantial contributions which cannot be costed at this stage. These costs, and the associated cost sharing, will be determined on a case by case basis using the principles outlined above.

PART C Background Information.

6. PART C - Background Information

6.1. Nutrients in the Goulburn Broken - Overview.

6.2. Key Concepts

There are two key concepts to understand.

1 Nutrient Load = Volume of water * Nutrient concentration.
Load can be measured in kilograms or tonnes
Volume of water can be measured in flow terms eg megalitres per day
Concentration can be measured in terms of weight per volume of water. It is commonly expressed in terms of mg/L.

For example:

- if the concentration of runoff from an area is 0.06 milligram of phosphorus per litre (mg/L) this is the same as 0.06 kilogram of phosphorus per megalitre of runoff and
- the area produces run off of 0.5 megalitres (ML) per year then
- the total phosphorus load exported from the area is 0.5 ML x 0.06 = 0.03 kg of phosphorus.

Nutrient management can be achieved by modified by altering the volume of water or the concentration of nutrients in water.

2 Catchment Nutrient Loads = Area of land use * a nutrient generation rate attributed to that land use

Catchment nutrient loads can be modified by altering the land use nutrient generation rates.

6.3. Overview - nutrient sources in the catchment.

From the AEAM process, and the detailed issues papers, it is clear the major sources of nutrients in the catchment are:

- dryland area in times of high flow
- irrigation drains in times of both high and low flow
- sewage effluent flows.

Nutrient loads from point sources such as septic tanks, urban runoff and fish farms did not appear to have a high significance when considered from a regional perspective, but can be potentially important at a local level. Table 11 and Graph 3 show the relative importance of sources. Fish farms may be significant sources of nitrogen.

Sections ~~X~~6.3 to 6~~X~~.9~~8~~ summarise the issues papers and include information about relevant work already underway in the catchment. Section 6.10~~X.9~~ overviews the costs and cost effectiveness of nutrient management options.

Seasonality of nutrient input is important. Direct inputs of nutrients to waterways at times when algae can make direct use of them (ie warmer, summer months) is considered to be more important, all other things being equal, than nutrient inputs which occur at other times, or via indirect means (ie sediment) when the nutrient is made available via chemical transformations as conditions allow. In some situations, for example storages, nutrient inputs at any time of the year are important.

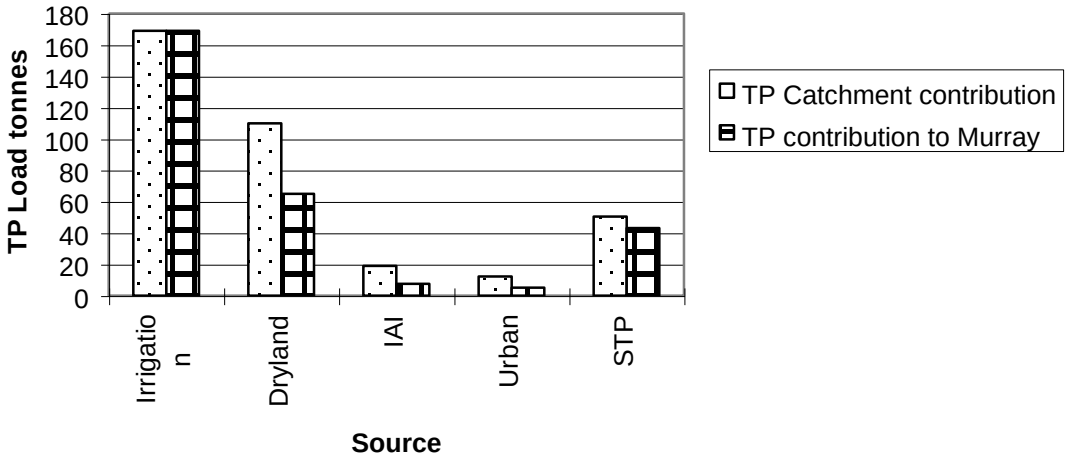
Because nutrients are diverted within the catchment, along with water, or trapped in reservoirs, not all reach the River Murray. The estimated proportion reaching the River Murray is shown in Table 11 and Graph 3.

Table 11: Estimated catchment nutrient contribution of various sources and their estimated contribution to the River Murray (typical year).

Source	Total catchment contribution				Estimated contribution to the Murray			
	TP tonnes	% of total	TN tonnes	% of total	TP tonnes	% of total	TN tonnes	% of total
Irrigation (1993/94)	169	47	619	22	169	58	619	32
Dryland (estimated)	110	30	1866	65	65	22	1100	56
Intensive Animal Industries (IAI) (estimated)	19	5	115	4	7.5	3	45	2
Urban (modelled)	12.3	3	70	2	5.2	2	29.6	1.5
Sewage Treatment Plants (STP) (1993/94/95)	50.5	14	184.5	6	43.2	18	158	8
TOTAL	**360.8**		**2854.5**		**289.9**		**1951.6**	

Source: Issues Papers and Background Paper.

Graph 3 - Goulburn Broken TP Sources and Contributions to the River Murray - "Typical" Year



6.4. Urban Stormwater (Issues Paper No 1)

6.4.1. Contribution

Nutrient loads from urban stormwater generated from towns in the catchment were modelled. Estimated catchment load of nutrients is as follows (Table 12~~19~~):

Table 12~~19~~: Estimated Urban Stormwater Nutrient Loads.

	Dry Year kg		Typical Year kg		Wet Year kg	
	TN	TP	TN	TP	TN	TP
Total Goulburn catchment	47000	10000	54000	10300	68000	11500
Total Broken catchment	14000	1600	16000	2000	22000	2400
Catchment total	61000	11600	70000	12300	90000	13900

Loads for all nutrients are higher in wet years than in dry years. In all years, the greatest loads of nutrients occur during the wetter winter months. Nitrogen generation rates are related to the area of urban development, whereas the phosphorus generation rate is influenced by the presence of reticulated sewage in a town.

6.4.2. Sources

Sources of nitrogen and phosphorus in urban stormwater include nutrients naturally occurring in rainfall; disturbance of soil from construction sites; accumulation of atmospheric deposits; application of fertilisers to gardens; ovals and golf courses, tennis courts and bowling greens; sullage and septic tank effluent; vehicle and machinery washing; and vegetation. They are carried from the source by stormwater, in solution, attached to soil particles or as organic matter.

6.4.3. Management options.

There are a range of options for improving the quality of urban stormwater which can be broadly subdivided into structural and non-structural options. Available options under each grouping are discussed in the following table. The list is not intended to be comprehensive, and a large range of minor variants are available. Some options are not suitable specifically for the removal of nutrients, although they may be effective for other contaminants.

An investigation of the impacts of urban stormwater on water quality in the Broken River at Lake Benalla is underway. A salinity funded project, D118, provides useful information on the stormwater treatment effect of a natural wetland at Tatura.

Table 13~~20~~: Stormwater Management Options

Non Structural Measures	
Regulatory Controls	.
Regulatory Discharge Control	The Environment Protection Authority has power under the *Environment Protection Act* to control and licence discharges to watercourses. This has traditionally been applied primarily to point sources of contaminants, such as wastewater treatment plants and industrial waste treatment facilities
Land Use Controls	Zoning and planning controls can be used to limit industrial and commercial development.
Source Controls	
Street Sweeping	Street sweeping has some potential to reduce sediment related pollutant loads. It can remove up to 50% of the total solids and heavy metals in urban stormwater with cleaning once or twice daily (Australian Water Resources Council, 1981). Cleaning once a week has been found to be ineffective (Novotny and Olem, 1994). Street sweeping may be an important way of controlling P inputs from decaying vegetation such as leaves and twigs. Loads from these sources can be significant after windstorms and in autumn.
Construction Control	Sediment from construction sites can be a major source of pollutant loads. A wide range of techniques is available to control construction sediment at the source including: • sediment basins; • use of hay bales to trap eroded sediment; and level spreaders and catch drains in the vicinity of recently constructed slopes.
Reduction in Fertiliser Application	Fertilisers, applied as part of horticultural activity in residential areas can be a major source of nutrients.
Animal Waste Control	Many authorities in overseas countries have implemented controls over animal wastes by enforcing owner collection of pet faeces where these are deposited in public areas.
Septic Tank Maintenance	Overflows from poorly maintained septic tanks can be a major source of nutrient loads in urban runoff from unsewered areas. Prevention can only be achieved by effective maintenance programs.
Public Education	Many public authorities, most notably Melbourne Water, have implemented highly successful public education campaigns aimed at reducing the discharge of solid wastes such as litter to streams and waterways. This principle could readily be extended to other contaminants.
Structural Measures	
Detention Based Measures	Detention is primarily aimed at sedimentation, and is far less effective at removing dissolved pollutants.

Wetlands	Wetlands, both artificial and natural, have been shown to be relatively effective in reducing nutrients being discharged to streams. ACT Guidelines recommend that wetlands be designed to reduce phosphorus loads by 70%. Correlation of observed data indicates that this can generally be achieved by providing a storage volume sufficient to provide a mean hydraulic residence time of around 30 days.
Flood Retarding Basins	Flood retarding basins are commonly used to reduce peak flows from storm events in urban areas. Because flood retarding basins are designed to be normally empty, their only pollutant reduction mechanism is sedimentation during the relatively infrequent storm events when the capacity of the low flow pipeline is exceeded. They will have almost no impact on dissolved pollutant loads. Retrofitting of retarding basins to provide a permanent water body or wetland, and therefore the dual functions of peak flow and pollutant reduction, is possible in some instances.
Vegetative Based Measures	
Grassed Swales	Grassed swales comprise an open channel lined with vegetation, and achieve pollutant reduction by both filtration and infiltration.
Filter Strips	The removal mechanisms for filter strips are similar to those for grassed swales. The major difference is that the flow is perpendicular to the strip, and some form of upstream control is therefore required to ensure an even flow distribution.
Infiltration Based Measures	Infiltration basins retain runoff to allow infiltration to the underlying soil. They should not be used in instances where these can reach surface waters via groundwater, or where the quality of the underlying groundwater is itself an important consideration. In the Goulburn-Broken catchment, many urban centres are located where the water table is likely to be high. Where this occurs, infiltration is inappropriate.
Gross Pollutant Traps	Gross Pollutant Traps (GPTs) are now in common use in many parts of Australia, and are devices designed to remove sediment and litter from urban runoff.

6.4.4. **Current Practice in the Goulburn Broken Catchment.**

Stormwater quality management practices are not commonly carried out in the catchment. According to the responses from municipalities only Alexandra and Benalla undertake any type of stormwater quality control. Alexandra vacuums up leaves in autumn and Benalla cleans the gutters in the Central Business District daily and vacuums leaves in autumn. Some treatment of stormwater occurs at Tatura in the eastern arm of the Mosquito Depression.

In general terms the WQWG does not believe it is feasible on cost grounds alone to justify the widespread retro fitting of structural control measures. However they are essential for new developments and the use of non structural measures will be an important component of the strategy.

6.5. Local Water Quality issues (Issues Paper No 1).

6.5.1. Issues identified

A number of local water quality issues were identified during the sources of strategy preparation. Local water quality issues are defined as water quality problems occurring at a local level within the catchment. While these may be insignificant at a regional level they may restrict the beneficial uses of water. For example the AEAM model showed that septic tanks were not a key nutrient load source on a catchment scale, but septic tanks and management of sullage water were identified as a key local issue, especially from a health viewpoint.

State and local authorities were requested to identify local water quality problems. The responses identified the following issues

- blue green algal blooms
- weed growth
- effluent
- undefined pollution
- turbidity
- bacteria
- dissolved oxygen
- salinity.

The response to the survey was disappointing and it is more than likely that many more local water quality issues await to be identified. Indeed responses to issues papers identified local problems occurring at Merrigum, Kinglake and other locations. More recently the Shire of Moira pointed out problems at Tungamah. Concern has also been expressed about the impacts of non formal recreation on water quality. This type of recreation occurs along the River Murray and at other public land sites in the catchment. Highway resting places, adjacent to streams, eg Midland Hwy at Caseys Weir, which provide for overnight stops, are also of concern.

A large proportion of the possible causes to these water quality problems are urban based. Septic tanks, sullage, urban stormwater and sewage discharges are all indicated in responses.

6.5.2. Management options

The source of local water quality problems varies between locations. It may be a specific waste discharge, the affect of landuse upstream, or effluent from septic tanks. ~~Hence, i~~Investigations to solve local water quality issues need~~s~~ to be undertaken at a local level, and assessed on a case by case basis. Documented~~Local~~ local investigations will also aid in the compilation of a central data base. Table 14~~21~~ lists some water quality problems and their generic solutions.

Table 14~~21~~: Water Quality Problems and Potential Solutions

Issue	Potential Solution
High health risk associated with sullage and septic tank effluent.	Sewer unsewered towns. In semi-sewered towns, sewer facilities such as caravan parks.
Unspecified chemical pollution	Monitor discharges and stormwater from industry. Install a treatment facility where required.
High bacterial count	Solution depends on source. Treat by avoiding or treating discharges.
Algae/Weed growth	Conduct local investigation to locate nutrient source. May be agricultural practices, urban stormwater or treated effluent.
Turbidity	Conduct upstream investigation to locate source of turbidity. May be from upstream land use or urban development.

6.6. Dryland Diffuse Sources(Issues Papers 2 and 2A)

The dryland portion of the catchment covers approximately 1 830 000 ha., or 75% of the catchment. Approximately 33% is forested, 60% is used for agriculture (cropping and grazing) with small areas used for intensive agriculture (irrigation and horticulture), softwood plantations and urban areas.

6.6.1. Contribution

Nutrient contributions from the dryland vary enormously depending on climatic conditions (Table 15). ~~–~~In a normal year the bulk of nutrient loads are contributed during the months of August, September and October which correspond with high flow periods. Dry years contribute small amounts while wet years contribute large amounts.

Table 15~~4~~ Estimated dryland nutrient loads for dry, typical and wet years.

	TP tonnes	**TN tonnes**
Dry year	18	~~990~~92

Typical/Average year	143~~110~~	2294~~1866~~
Wet year	340~~121~~	4794~~2283~~

~~These figures can only be considered preliminary estimates until better data becomes available. The wet year figure, in particular, seems low. (Source IP2A).~~

6.6.2. Sources

Analysis of the key land types supplying nutrients in the dryland indicate that pasture (that is the cleared agricultural areas) contribute the bulk of the loads (approx 64%), followed by forested areas (25%). This is not surprising given the area of these land types.

Analysis of catchment nutrient generation rates (Table 1~~6~~5) shows that no particular catchment stands out as having a high nutrient generation rate. Check this against revised table.

Table 1~~6~~5: Summary of Revised Catchment Nutrient Generation Rates.
Insert from spreadsheet – include SS

~~Sino~~	~~Sub-catchment~~	~~Length of data record (years) used to calculate loads~~	~~Catchment area (ha)~~	~~Average Generated Loads kg/ha/yr~~		~~Average Nutrient Load (tonnes/yr)~~	
				~~TP~~	~~TN~~	~~TP~~	~~TN~~
~~405214~~	~~Delatite R~~	~~4~~	~~36800~~	~~0.17~~	~~2.3~~	~~6.4~~	~~84~~
~~405237~~	~~Seven Ck at Euroa~~	~~2~~	~~33200~~	~~0.13~~	~~2.63~~	~~4.3~~	~~87~~
~~404207~~	~~Hollands Ck~~	~~4~~	~~45100~~	~~0.11~~	~~1.77~~	~~4.9~~	~~80~~
~~405209~~	~~Acheron R~~	~~4~~	~~61875~~	~~0.11~~	~~2.08~~	~~7.0~~	~~128~~
~~404206~~	~~Broken R @ Moorngag~~	~~4~~	~~49700~~	~~0.11~~	~~2.15~~	~~5.3~~	~~107~~
~~405205~~	~~Murrindindi R~~	~~4~~	~~10800~~	~~0.10~~	~~2.41~~	~~1.1~~	~~26~~
~~405234~~	~~Seven Ck @ Polly McQuinns~~		~~15300~~	~~0.09~~	~~2.81~~	~~1.4~~	~~43~~
~~405264~~	~~Big R~~	~~4~~	~~33300~~	~~0.09~~	~~1.57~~	~~2.8~~	~~52~~
~~405231~~	~~King Parrot Ck~~	~~4~~	~~18100~~	~~0.04~~	~~1.28~~	~~0.7~~	~~23~~
~~405251~~	~~Brankeet Ck~~	~~1~~	~~12100~~	~~0.03~~	~~0.46~~	~~0.4~~	~~5.6~~
~~405219~~	~~Goulburn R (upstream Jamieson)~~	~~1~~	~~69400~~	~~0.03~~	~~0.25~~	~~1.8~~	~~17.6~~
~~405212~~	~~Sunday Ck~~	~~1~~	~~33700~~	~~0.01~~	~~0.11~~	~~0.2~~	~~3.6~~
~~405246~~	~~Castle Ck~~	~~1~~	~~16400~~	~~0.01~~	~~0.11~~	~~0.2~~	~~1.7~~
~~405240~~	~~Sugarloaf Ck~~	~~1~~	~~60900~~	~~0.00*~~	~~0.05~~	~~0.1~~	~~3.2~~
	~~TOTAL~~		~~496675~~			~~36.6~~	~~661.7~~

~~NB data for Big River from station 405264, rather than 405227 as used in IP2. * rounded.~~

Agricultural use of fertilisers is contributing only a very small percentage of diffuse nutrients. Broad scale modification of fertiliser management is therefore unlikely to have any significant benefit in reducing overall catchment nutrient loads, although it may be important locally.

Nutrient runoff from irrigated pasture in the dryland part of the catchment also appears to be a significant nutrient source. It is also likely a large number of small point sources contribute to the overall load.

Regardless of the land uses contributing nutrients the key phosphorus source is via P associated with sediment. Nitrogen appears to be mostly generated from atmospheric sources. An issue of concern is phosphorus associated with sediment stored in reservoirs or in sediments already in train in streams. It is concluded:

- reworking of alluvial material from within streams during storm events may be a significant source of P
- P associated with this reworked sediment can provide internal loadings of P at critical periods of the year.
- BMPs, of any type, will be less effective in times of high flow.
- we can't say with any certainty that instream sources are more important than catchment sources in terms of sediment or P delivered
- however, given that bed and bank sources of sediment can immediately supply P directly to waterbodies it seems not unreasonable that these sources should be treated as a priority.

6.6.3. Management options.

Based on the above, the WQWG has developed a priority ranking of works or BMPs to reduce P loads in the dryland area. These priorities are:

- control of point sources of nutrients directly discharging to streams
- stabilisation of bed and banks of streams and provision of filter strips along streams
- areas above storages which could act as sediment/nutrient traps thus providing sources of internal loading:
    - Water supply storages (especially those listed as Special Areas under the Catchment and Land Protection Act)
    - Mokoan
    - Weir Pools on Broken River
    - Weir Pools on Broken Ck and tributaries
    - Goulburn Weir backwaters
- control of diffuse sources of nutrients discharging directly to streams by providing filter strips
- control of point sources indirectly discharging to streams
- control of diffuse sources indirectly discharging to streams.

BMP to achieve this include managing sediment sources, dispersed point sources, installation of filter strips to trap sediment, stabilisation of in stream (bed and bank) sediment sources and the implementation of best management practices to achieve these. Implementation of various Codes of Practice, for example Code of Forest Practice, Guidelines for Minimising soil Erosion and Sedimentation from Construction Sites, Septic Tank Code of Practice is necessary. Other management options considered in the issues papers include buffer strips in forest operations (part of the Code of Forest Practice) and relocation of roads (only viable in limited applications).

Goulburn Murray Water is investigating development of a restoration strategy for Lake Mokoan. This involves a range of measures, both within and external to the lake, attempting to restore the lake from its algal dominated status. This builds on successful trials in the Duck Pond at Lake Mokoan.

Waterway management authorities are in the process of being established over the entire catchment. Their activities will be an important part of strategy implementation. Landcare groups, working in association with agencies are implementing erosion control activities and frequently work with waterway management authorities to address riparian issues.

6.7. Intensive Animal Industries (Issues Paper No 3)

6.7.1. Contribution

The issues paper estimated animal numbers in the catchment as follows:

Table 17: Intensive Animal Industries in the Goulburn Broken catchment.

Industry	Estimated animal numbers	Estimated Production Value	Estimated % of Victorian Production
Pigs	138 000	$40M	27
Poultry	400 000	$5M	3
Cattle Feedlots	0	0	0
Trout/Salmon	1 000 t pa	$8M	80

The estimated nutrient loads from these are:

Table 18: Estimated Nutrient Loads - Intensive Animal Industries.

Industry	Nutrient Load (tonnes p.a.)					
	Dry Year		Average Year		Wet Year	
	TN	TP	TN	TP	TN	TP
Piggeries	1	0	5-50	1	12-80	4
Poultry	negligible	negligible	negligible	negligible	negligible	negligible
Feedlots*	0	0	0	0	0	0
Fish Farms	87	18	87	18	87	18
TOTAL	88	18	92-137	19	99-167	22
* No feedlots were identified in the catchment						

Fish farms have a seasonal spread of production. Farms in Goulburn tributaries have the greatest production in spring and autumn. Farms on the main stem of the Goulburn have a different production peak due to cold water releases from Eildon. Peak production from these farms is in summer.

Although piggeries are required to discharge to land, it is estimated there is runoff from overloaded effluent disposal areas.

6.7.2. Sources

From Table 18 the major contributor in this category are fish farms. These are located in the upper parts of the catchment, in the Alexandra and Yea districts. Nutrients from this source are derived from excess feed being applied to fish ponds and from fish excreta. The load from piggeries, while minor now, is expected to increase over time as effluent disposal areas degrade.

6.7.3. Management options

For fish farms two main nutrient management options were identified. Both involve improved feed management. The first involves development of low phosphorus feeds. The second involves low phosphorus feeds plus improved feed conversion ratios.

Work is currently underway at Snobs Ck in conjunction with Ridley Corporation (Barastoc) examining feed alternatives.

For piggeries and other intensive animal operations the development, or revision, and implementation of Codes of Practice which recognise the need for sustainable effluent disposal is seen as the most important management option. This will overcome concerns with current Codes.

6.8. Sewage Treatment Plants (STP) (Issues Paper No 4)

26 STPs have been identified in the catchment. From time to time up to 17 discharge effluent to waterways. Five plants frequently discharge effluent, while others may discharge in wet years. There are also a number of industrial plants which may discharge to waterways.

6.8.1. Contribution

Total phosphorous and total nitrogen loads discharged to streams in the catchment from STPs were calculated from effluent quality monitoring data, and effluent flow information. These data are of varying availability, and for some plants, single grab samples were required for analysis to provide an indication of effluent quality. Accordingly, the load estimates are based on limited data, and will require verification by improved monitoring. STPs are identified as contributing an estimated annual load of 50.5 t TP and 185 t TN to streams in the catchment. (Based on 1993/94/95 figures).

Of the STPs investigated, Shepparton STP contributes approximately 41 % of the total effluent flows, 44% of the total phosphorus and 51% of the total nitrogen discharged to stream from STPs. Across the catchment, the higher discharge volumes occur in the months from April to October, when wetter, colder conditions preclude land discharge. Winter discharge has less impact than summer discharge because nutrients are not directly available for algal growth. Overall, the loads estimated to be discharged to streams in the catchment are as follows (Table 1~~9~~6):

Table 1~~9~~6: Seasonal Distribution of Nutrient Loads from STP

	TP Tonnes	TN Tonnes
May-October	43	159
November-April	8	26
Total	51	185

Goulburn Valley Water estimates that the annual load discharged from their Shepparton plant has decreased by more than 50% over the past five years.

6.8.2. Management options

This study examined in detail five options for nutrient removal from STP effluent:

- Total effluent re-use to land. This included consideration of the water balance at the STP, and the long term sustainability of irrigation.
- Summer reuse. Although this option does not completely remove nutrient from streams in the catchment, it does allow significant reductions during the warmer summer months when there is a greater risk of algae blooms.
- Phosphorus reduction by chemical precipitation and clarification. This option requires tertiary treatment of effluent after an existing lagoon or trickling filter system, and could be used as a pretreatment to reduce the load of phosphorus for land disposal. This option can achieve phosphorus levels of 1-3 mg/L. (Iron salts may also be used to achieve low P levels).
- Biological reduction of phosphorus and nitrogen. This option~~s~~ uses an activated sludge process modified for nutrient reduction followed by dosing with aluminium salts and filtration to further reduce phosphorus levels. This treatment could achieve phosphorus levels of approximately 0.2 mg/L and total nitrogen below 10 mg/L.
- Chemical treatment, dissolved air flotation and filtration. This process could achieve levels of phosphorus of 0.2 mg/L, and a total nitrogen concentration of 5-15 mg/L.

The WQWG has added a further option - that of nutrient reduction at source or *nutrient minimisation*. Some communities have successfully reduced influent phosphorus concentrations by conducting waste minimisation campaigns. For example, the phosphorus levels in sewage influent to the Albury STP have been reduced by around 20% by encouraging the use of low or no phosphorus detergents and undertaking education and marketing campaigns. Such programs make a useful reduction in the total amount of phosphorus released to the environment and involve the entire community in nutrient management activities. These campaigns, especially those involving industrial effluent sources, need to be carefully designed in full consultation with water authorities to ensure the operating efficiencies of STPs are not compromised.

The Wastewater for Industry report features waste minimisation programs as a major method to reduce discharges.

The unique qualities of some of the treated, especially those with a high proportion of waste from food processing, may preclude the total irrigation option as being sustainable at some STPs in the catchment. In the upper catchment, terrain and climate make the total irrigation option impractical.

Development of the most suitable option to manage nutrients at each STP in the catchment must involve detailed site specific investigation. However the WQWG is of the view that waste minimisation program offer significant improvements.

6.8.3. Northern Victorian Wastewater Management Strategic Plan.

The Northern Victorian Regional Water Authorities Wastewater Management Strategic Plan is a response to the Effluent Standards Report prepared by Government.~~(Sec 10.10.1).~~ This strategy provides the framework for the five urban water authorities in northern Victoria to fund and implement the activities required to:

- fully understand the implications of the discharge of wastewater to land where that land is subject to rising water table, salinity, sodicity and other environmental problems
- ascertain the volume and content of wastewater discharges
- minimise the volume and content of wastewater discharges
- promote a coordinated whole of catchment approach to the problem of wastewater management; and
- utilise the knowledge gained from the NVRWA's research initiatives to assist regulatory agencies to develop consistent and sustainable environmental requirements for the region.

6.8.4. Industry Requirements

6.8.4.1. Wastewater for Industry.

This study, carried out under the auspices of the Sustainable Regional Development Committee, aims to develop a strategy for treatment and disposal of wastewater from industry, particularly the food processing industry, throughout the study area.

6.8.4.2. Water for Industry.

This study, also carried out under the auspices of the Sustainable Regional Development Committee, developed and evaluated a range of strategies to provide an improved water supply to the food processing industries and rural centres within the SIR. A number of industries are vulnerable to supply disruptions through contaminations of supply with blue green algae or spills of toxic materials.

6.9. Irrigation Drainage (Issues Paper No 5)

The Goulburn Broken catchment irrigation area covers approximately 500 000 ha of which about 455 000 ha is farmed. Only about 284 000 ha is currently irrigated. In 1991/92 there were an estimated 6 700 farms classified as mixed (3 400, 51%), dairy (2760, 41%) and horticulture (580, 9%). Most irrigation is carried out using the border check system. (For this study the irrigation area is assumed to be all of what was the Shepparton, Rodney, Tongala, Murray Valley Irrigation districts, 48% of the area of the Rochester Irrigation District and all the irrigated land under private diversions.)

The Shepparton Irrigation Region (SIR) covers all the land in what is now the Murray Valley, Shepparton, Central Goulburn and Rochester irrigation areas and includes all the irrigated land in the Goulburn Broken catchment plus areas to the west which drain to the Campaspe and the Murray to the west of the Campaspe.

In 1989, high water tables existed over 188 000 ha (36%) of the SIR, and are projected to increase to 274 000 (55%) if no action is taken. A program of upgrading drainage (surface and sub surface) is proposed to effectively control groundwater levels and salinity.

Surface drainage will be provided to 268 000 ha in the SIR, in addition to the 183 000 ha already serviced. Sub surface drainage will be extended to cover 180 000 ha.

An estimated 60 - 70% of farms have some form of reuse. Some 30% of the area (1300 farms) has been covered by a whole farm plan since 1987. An estimated 5% of the area was covered prior to 1987.

About 550 diverters are licensed to take 68 000 ML of water from drains. In the 1991/92 irrigation season drains discharged 128 000 ML of water, 45 tonnes of P and 171 tonnes of N to streams.

6.9.1. Contribution.

Irrigation drainage from the 200 000 ha irrigated portion within the Goulburn Broken catchment is estimated to have contributed 169 t of TP and 618 t of TN to waterways in 1993/94 (47% of the total). This excludes the irrigation drainage contribution from the dryland (counted in the dryland section). Given that this was a wetter than normal year, the load contributed from this source may be overestimated. Analysis of flows in the Deakin Drain from 1982/83 onwards indicate that flows in the drain in 1992/93 and 1993/94 were up to 50% higher than in the four previous years.

An important feature of loads from irrigation drainage is the high proportion contributed in the summer months.

Implementation of the surface drainage program of the salinity program over the next 20 years is predicted to increase the nutrient contribution from this source to 203 t for phosphorus and to 802 t for nitrogen.

6.9.2. Sources

The potential nutrient load from catchments in irrigation areas has been determined by estimating areas of land use and applying nutrient runoff rates to that land use. Potential nutrient loads are considerably higher than loads measured at gauging stations because of uncertainties in calculations and the non conservative nature of nutrients. Actual loads and generation rates for some drain catchment are shown below in Table 20.

The bulk of nutrients in irrigation drains in summer is excess irrigation runoff from farms. Other sources include summer and winter rainfall events, runoff from dryland areas in the catchment, urban stormwater, effluent from sewage treatment plants, industrial discharges, dairy shed waste and groundwater pumps.

The dominant land use in irrigation areas is irrigated perennial pasture (135 000 ha), followed by irrigated annual pasture (100 000 ha). The annual potential nutrient generation rate for perennial pasture is 8.66 kg/ha TP and 13.9 kg/ha for TN, while for annual pasture the generation rates are 1.37 kg/ha and 3.4 kg/ha respectively. The dominant land use nutrient source therefore is irrigated perennial pasture.

Table 2012: Average Annual Nutrient loads from some Irrigation Drain Catchments. (Load figures are averages over the period 1990-1994).

Drain	Area (ha)	TP Load kg	TN Load kg	TP kg/ha	TN kg/ha
Deakin	56114	45006	160661	0.802	2.863
Rodney	26780	9705	79222	0.513	2.958
Murray Valley Drain 6	18343	25586	67884	1.395	3.701

From June to October the nutrient load from irrigation drainage is only a small percentage of the loads in the Murray and Goulburn Rivers (although these loads may be of significance downstream). However, from November to May irrigation drainage has a significant impact on loads in these streams.

6.9.3. Management options

There are many ways in which nutrient export in irrigation drainage might be reduced, ranging from activities on the farm to large scale catchment approaches. A number of these options are listed, and briefly described, in Table 2113 (in no particular order). This is by no means an exhaustive list.

Table 2113: Generalised Available Nutrient Management Options

OPTION	DESCRIPTION
Change Irrigation Methods	Change current irrigation techniques from predominantly flood irrigation to another more directed method. The aim is to reduce flow, and hence nutrient load, leaving the farm and entering the drain. Improve irrigation scheduling with on farm storages to better

	match crop water requirements and hence reduce runoff, and therefore nutrient loads.
Constructed Wetlands and Vegetated Drains	Install wetlands (either on farm or adjacent to irrigation drains) and vegetated drains to serve as nutrient sinks.
Containment of Dairy Shed waste on farms	Utilise storages for dairy shed wastewater for a source of nutrients to be used on the farm.
Dilution/Flushing Flows	Flush rivers with good quality water to increase flow and reduce nutrient concentrations and hence reduce the potential for algal growth. Flushes would be based on monitoring of critical indicators and risk assessment of an algal bloom.
Drain Design	On a site specific basis, utilise drain design features to reduce concentration of nutrients or increase diversion for re-use - eg drain dimensions to allow easier diversion for re-use, a series of swales along a drain to act as nutrient sinks, drain dimensions to increase retention time (hence related to level of service offered by drain).
Drain Diversion	Install storage dams on farms to divert drainage water for irrigation. Increase drain diversion without dams.
Drain Maintenance	Protect and manage existing drains to stop livestock access and prevent erosion. Hence reduce nutrient load carried in sediment to drains.
Economic Policies	Change water supply and pricing policies to conserve and re-use water and nutrients.
Fertiliser application Techniques	Look at the timing, type and method of application to maximise crop uptake of fertilisers, reducing concentration and load leaving the farm.
Installation of Riparian or Buffer Strips	Place vegetation as a barrier between tail water and farm drains, reducing the concentration and load in the tail water.
Irrigated Woodlots	Use irrigation drainage to irrigate commercial tree plots, reducing flow and nutrient load in the drainage system.
Minimise Tail Water	Install fully automated irrigation systems, laser grade and improve pasture to ensure full utilisation of irrigation water. Hence reduce load leaving the farm.
Reduce Channel outfalls	Reduce channel outfalls to increase effectiveness of drain diversion. Reduction in nutrient load associated with reduced outfalls likely to be minor.
Re-use Systems	Installation of farm re-use systems to collect and re-use irrigation tailwater, thus minimising the nutrient enriched water discharged to irrigation drains.
Sediment Management	Remove sediment from drains, re-use dams, and apply to farms as a source of nutrients. Remove sediment stockpiles from drain banks.
Storage of Drainage Water, Changed Discharge Timing	Install large storage facilities to hold irrigation drainage to protect receiving waters during times of low flow - discharge at times of high flow. Hence reduce concentration in receiving waters at critical times.
Sub-surface drainage	Install sub-surface drainage to encourage greater recharge, and

	hence less runoff. Hence reduce flow and load entering drain (disposal of sub-surface drainage water, possibly at a lower concentration of TP and higher concentrations of TN and salinity, is required - eg evaporation, to drain) .
Tile Drainage and re-use	Install tile drainage to reduce groundwater flow to drain and re-use for irrigation. Hence reduce concentration in drains (particularly for TN).
Transfer Drainage Water back to supply system	Transfer irrigation drainage to local irrigation supply systems, and possibly to other catchments or irrigation regions. Hence reduce flow, and therefore load in the drainage system.

The key management options considered by the WQWG are drainage diversion and reuse systems together with a range of complementary institutional arrangements to encourage adoption and implementation of farm and drainage catchment scale management options. A key output will be reduced nutrient load by more efficient irrigation water use. Assignment of accountability for irrigation drainage is expected to lead to a focussed approach to the issue of drain water and nutrient management. Other important options include improved irrigation management, dairy effluent management, fertiliser application techniques. At some stage all these options and more can be used to manage nutrients.

A number of projects are underway investigating drainage diversion practices, methods of increasing diversion, developing and extending dairy effluent management practices and fertiliser best management practices. A proposal to improve management of the water flows in Broken Ck, by the reconstruction of old weirs has been developed. This has the potential to reduce nutrient loads from Broken Ck by at least 25%.

All new drains are constructed with features to minimise nutrient contributions. These features include flow limiters, water held on farms by restriction on the size of outlets, cutoff loop wetlands, in line retardation basins and farm reuse systems.

6.10. Costs, and Cost Effectiveness, of Nutrient Management

The issues papers identified a range of nutrient management options and costed these options in terms of a) capital and operations and maintenance and b) dollars per kilogram of nutrient removed per annum. This enables identification of the most cost effective nutrient management options. Costs, and estimates of nutrient reduction efficiency are approximate only and will be refined over time. This exercise did not identify benefits associated with the implementation of these options, nor did it identify other associated land management (eg linkages with salinity and landcare programs) or environmental benefits. Graph 4 gives an indication of the relative cost effectiveness of phosphorus management options considered in the issues papers. Similar information is available for nitrogen.

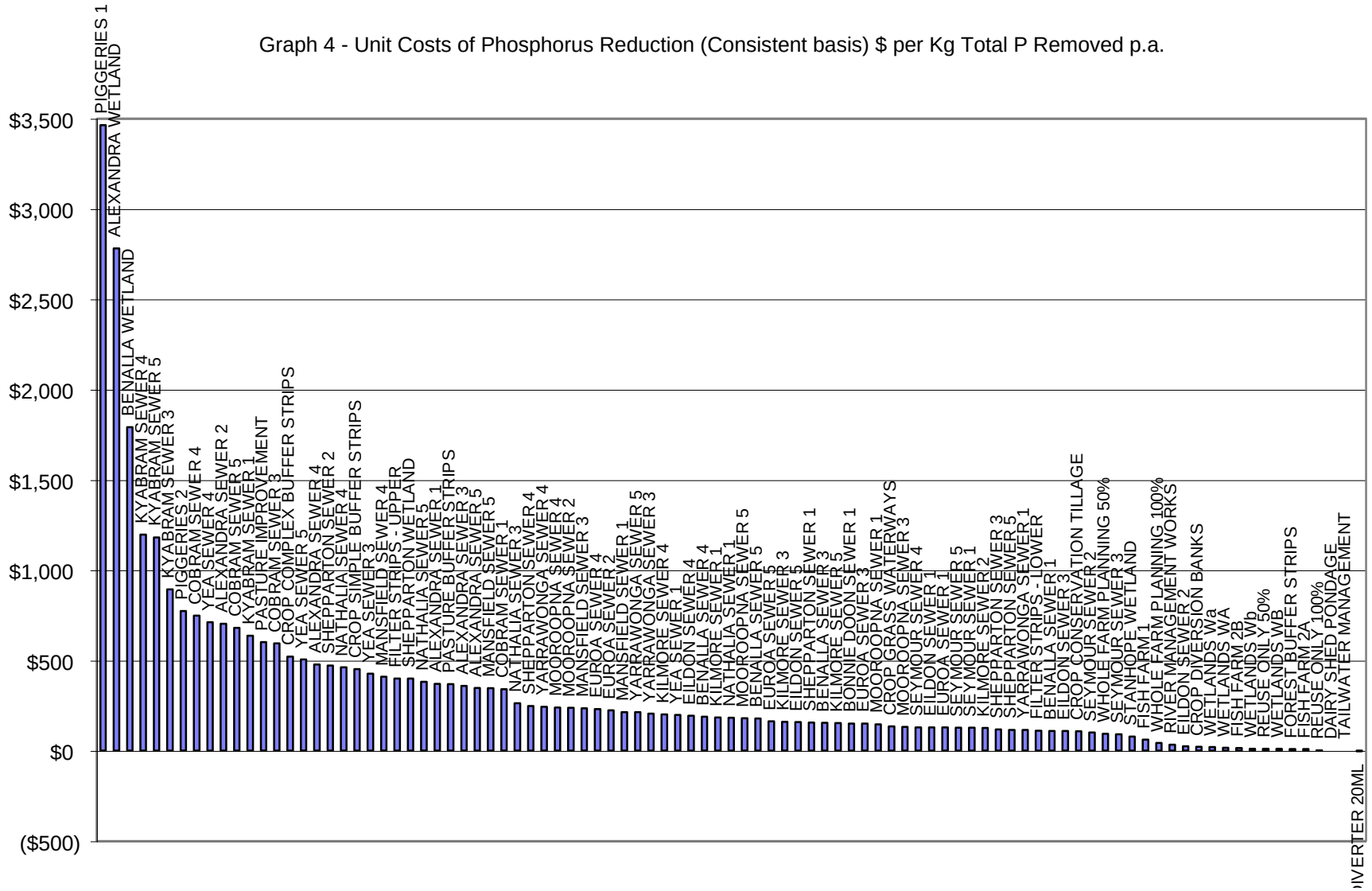
It can be seen that options to remove phosphorus from irrigation drains, in particular, are at the "cheap" end of the scale.

Further economic studies are underway to determine methods of estimating the benefits of nutrient reduction works.

The WQWG is firmly of the view that a sensible investment approach is required when considering nutrient management options. The cost, cost effectiveness and the amount of nutrient removed must all be assessed in selecting appropriate management options.

The listing of an option means that is simply considered as an option for managing nutrients. It does not necessarily mean that it will be a "recommended" nutrient management option for the Goulburn Broken.

Graph 4 - Unit Costs of Phosphorus Reduction (Consistent basis) $ per Kg Total P Removed p.a.



7. Approaches to Target Setting

7.1. Approaches to target setting

There are three alternative approaches to setting targets for nutrient reduction works. These are:

Nutrient concentration targets. These could be set on some relationship between the concentration of nutrients (especially phosphorus) and algal growth. At present these relationships are only crude and are confounded by other factors such as flow and turbidity.

Nutrient loads. This type of target can be set to reflect a desirable catchment net nutrient export and potential downstream impacts. This also requires an assessment of potential for algal growth in relation to nutrient levels

Best management practice (BMP). This approach uses the rate of adoption of best management practices as the target. Certain BMP reduce nutrient levels by a predicted amount. A target for the level of adoption of the BMP can be adopted which gives a predicted desired nutrient management or reduction. Monitoring the rate of implementation and adoption of these best management practices will be a useful performance measure. Traditional measures, such as monitoring stream nutrient concentrations and loads, will be required to check that the predicted reductions actually occur.

What are Best Management Practices?

Best management principles are principles of good resource management. For example, an irrigation area best management principle may be to minimise the volume of water and nutrient leaving the farm.

Best management practices are the practices by which best management principles are achieved. The example above would be achieved by implemented the best management practices of irrigation whole farm planning, constructing reuse systems, etc.

BMPs are practical guidelines for sustainable land management. They aim to achieve good natural resources management, while maintaining or improving productivity. Land managers will use BMPs to contribute to on-farm, local, regional, state and national goals for natural resource management.

BMPs should not be seen as restrictions being imposed on land managers, but as important management tools. Adoption of BMPs will benefit land managers by reducing land degradation and improving economic returns.

In broad terms best management practices (BMPs) can be equated to the nutrient management options identified in the issue papers. The adoption (and

implementation) of best management practices (BMP) will have an impact on nutrient loads and concentrations in waterways in the catchment.

MDBC Position on targets.
The Murray Darling Basin Commission is not in a position to provide a specific nutrient load discharge target for the Goulburn Broken catchment. However a nett reduction of the nutrient load from the Goulburn Broken catchment is expected.

7.2. WQWG Approach to Targets - a "Best Management Practice Approach".

The WQWG has adopted a best management approach to achieving nutrient reduction targets. The WQWG will aim to achieve the MDBC request for a substantial reduction in the nutrient load from the catchment.

A BMP approach has a number of advantages including being relatively easy to understand, easy to sell to managers, etc.

The anticipated level of adoption of BMP can be estimated, or set to a desired level, and the level of adoption by land and water managers can be used to broadly assess progress of implementation of the water quality strategy. Of course, other indicators, such loads and concentrations will also be monitored.

The BMP approach is cooperative, but in the longer term it may be necessary to have them implemented via a regulatory framework if required adoption levels are not achieved.

Key Best Management Practices to be adopted and implemented have been discussed in Section 6. In summary, these include:

Irrigation Drainage
- development of irrigation farms according to a whole farm plan
- farm reuse
- minimising water runoff
- drainage diversion
- dairy effluent management

Dryland diffuse sources
- Land use in accord with land capability principles
- control of stream bed and bank erosion
- construction of filter strips along waterways
- adoption of Code of Forest Practice
- preparation of local catchment plans for nutrient management
- maintenance of roads and tracks to minimise sediment movement

Sewage Treatment Plants
- summer disposal of effluent to land or effluent nutrient reduction.
- adoption of water, nutrient and salt balance approaches

- waste minimisation at source, including low P detergent campaigns

Urban Stormwater
- waste minimisation at source
- wetlands
- gross pollutant traps
- sediment control on construction sites
- land capability approach
- septic tank maintenance
- development application assessment for water quality impacts

Local water Quality issues
- case by case assessment

8. Nutrient Management Scenarios

A number of different nutrient management scenarios, focussing on phosphorus management, have been evaluated by the Water Quality Working Group. A base case, do nothing scenario, has been prepared against which the effectiveness of management scenarios can be compared. A thirty year time frame is used to evaluate scenarios. (Note this is different to the time frame adopted for strategy implementation.). Scenario evaluation does not include program development, management and coordination costs over the life of the scenario.

Scenarios, and their impact on phosphorus, have been evaluated using the Catchment Management Support System (CMSS) model. Costs presented in Table 23 cannot be directly compared with the costs presented in Table 10.

8.1. The Do nothing/without strategy Scenario

The "without strategy" provides the baseline against which other options and measures are evaluated. (It is actually about what would happen if current management levels are maintained). Estimated P loads in the catchment in the "Without Strategy" situation are shown in Table 22.

Pre Existing trends

Factors which can impact, or affect, water quality in the catchment over the next 30 years, include:

- irrigation land use and drainage management
- irrigation salinity plan implementation
- management of areas of dryland farming
- dryland salinity plan implementation
- urban development
- urban stormwater management
- sewage disposal management
- septic tanks and sullage
- types, numbers and waste management practices of intensive animal industries
- waste management practices of industry
- river flow management, including environmental flows in the Goulburn River
- recreational use of public lands
- landcare activities in the catchment
- activities of river management authorities
- forest (hardwood and softwood) areas logged
- population growth, industrial changes including development in "non" irrigation areas.

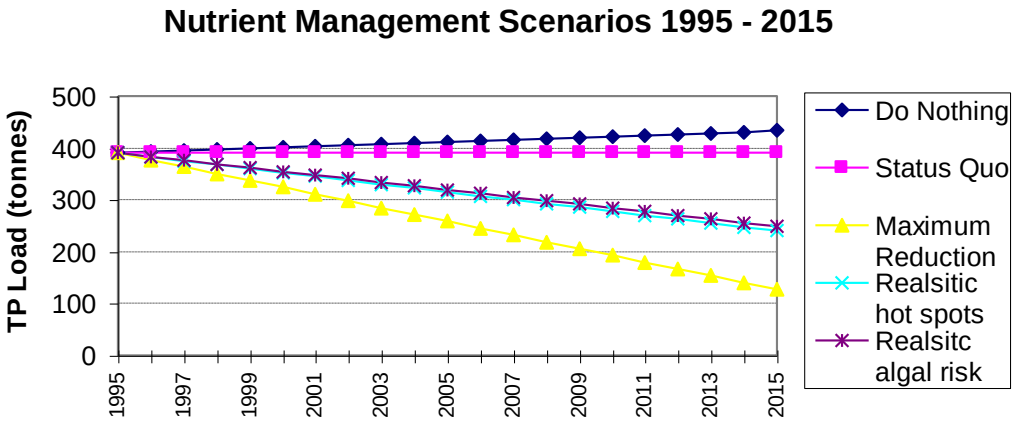
Each of these, and others may have some impact on water quality. In summary

Table 22: The "Without Strategy Scenario" - Phosphorus Loads.

TP Source	1995 load tonnes	2025 load tonnes	change tonnes
irrigation	169	203	+34
dryland	110	126.5	+16.5
urban stormwater	12.3	14.1	+1.8
STP	50	50	0
IAI	19	31	+12
Total	360.3	424.6	+64.5

Irrigation loads will increase in line with the increased area drained under the surface drainage program of the SIRLWSMP. Other inputs, eg industries are assumed to remain stable. In the dryland the major increase is attributable to an increase in irrigated areas, as existing water allocations are taken up along the Goulburn and Broken Rivers and the Broken Creek. The load from stormwater is anticipated to increase in line with population growth, while the load from STP is expected to remain constant. Increases in production from fish farms in the upper part of the Goulburn catchment are expected to increase loads. Loads from piggeries will increase as effluent disposal areas degrade.

Graph 5



8.2. Scenario 2 - Maintain the Status Quo

This scenario keeps phosphorus load and concentration steady over the next 30 years. To achieve this a net reduction in P loads of 64 tonnes is required over the 30 year time frame. This would be achieved by

- reuse systems and whole farm planning for additional irrigated perennial pasture in dryland areas
- drain diversion to cater for the increase in drainage in irrigation areas
- implementing low P feed option and improved feed conversion ratios at fish farms
- achieving nutrient balances on piggery effluent disposal areas
- ensuring all new urban developments implement urban stormwater best management practices.

Cost of this option is estimated to be $10.7M (capital) and $0.12 M O&M (Costs are not discounted).

8.3. Scenario 3 - Maximum reduction of Nutrients

This involves reducing P loads to their original or natural state, thereby giving maximum nutrient reduction. This involves adopting as many nutrient management options as possible while ignoring the associated costs. This option would be achieved by:

- adopting buffer strips in all possible dryland situations (forest and agriculture)
- implementing all possible river management works
- having all irrigation farms minimise water leaving the farm
- excess irrigation flows diverted from drains
- all STP, except Mt Buller, fully disposing effluent to land. Mt Buller treating effluent with BNR and DAF processes.
- fish farms implementing low P feeds and improving feed conversion ratios
- piggeries achieving nutrient balances on effluent disposal sites
- urban stormwater being treated before discharge to streams
- overall reduction from individual point sources.

The cost of this scenario is estimated to be $708M capital and $22M/yr O&M to achieve a reduction of P loads of approximately 90%.

8.4. Scenario 4 - Realistic reduction targeting Hotspots

This scenario aims to reduce P exports from "hotspots" to achieve substantial reduction in loads exported from the catchment and improvements in P concentrations at McCoys Bridge (along with improvements upstream). This scenario targets large nutrient sources in the lower part of the catchment. It aims to reduce nutrient concentrations over the critical summer months when the risk of BGA blooms is high.

Implementation of this scenario involves targeting nutrients from irrigation areas. Two ways of achieving this are by installing reuse systems on farms (scenario 4A) or diverting water from drains (scenario 4B).

Scenario 4A reduces potential loads by 55% (52% reduction at McCoys Bridge), at a cost of $217M. Scenario 4B reduces potential loads by 31% (46% reduction at McCoys Bridge), at a cost of $78M.

In reality a mixture of these scenarios will be implemented in irrigation areas. Farmers are already moving to install reuse systems on farms to increase water use efficiencies, improve farm management efficiencies and for other reasons which have nothing to do with nutrient management.

8.5. Scenario 5 - Realistic reduction targeting algal risk and hotspots.

This is similar to Scenario 4B, except that areas with a BGA high risk/impact are also targeted for nutrient reductions. Management options include drain diversion, summer disposal to land at 7 STPs, improvements at fish farms, and gross pollutant traps for Shepparton and Seymour.

This scenario reduces potential loads by 48% at a cost of $93M.

8.6. Scenario evaluation.

In summary:

Table 23: Scenario Evaluation - Summary.

	Scenario	Potential catchment P Load Change	Estimated P load change tonnes Goulburn at McCoys Bridge (against present estimated load of 291 t)	Estimated P load change tonnes Broken Ck at Rices Weir (against present estimated load of 67 t)	Capital Cost $
1	Do nothing	+ 4%	+51.4	0.30	0
2	Status Quo	~ 0	-9	-0.3	~ $10.7M
3	Maximum Reduction	- 90%	-263.4	-64.9	~$708M
4	Realistic - hot spots	- ~55%	-150.6	-45.7	$78-217M
5	Realistic - targeting algal risk	~48%	-141.9	-39	$93M
	Preferred	- ~ 65%	-229	-56	not comparable

Table 24: Assessing Scenarios Against WQWG Objectives.

WQWG Objective	Scenario				
	1 do nothing	2 Status quo	3 maximum reduction	4 realistic hot spots	5 targeting algal risk
minimise BGA blooms	may get worse	may get worse	will improve over time	should improve	should improve
minimise/optimise water treatment costs	No improvement	slight improvement	maximum improvement	minimal impact in GB catchment	minimal impact in GB catchment
minimise nutrient contributions to the Murray	No improvement	No improvement	Maximum improvement	substantial reduction	substantial reduction
foster regional development (by	regional development hindered	Status quo, although may be hindered by	Improvement, but cost of achieving this may	improvement	improvement

ensuring quality water to industry, agriculture and the community) and		more BGA blooms	drive industry elsewhere		
enhance the riverine environment	No improvement, probably worse	No improvement	great improvement	some improvement, but only in lower part of catchment	some improvement, but only in lower part of catchment.

WQWG rejects Scenarios 1 and 2 because they simply do not achieve the improvements we need. Scenario 3, while giving great improvements, is not achievable because of the cost. Scenarios 4 (especially 4B), and 5 are realistic, but do not spread management activities across the entire catchment or the range of contributors, especially in dryland areas.

Using the scenarios outlined above the WQWG has developed a preferred option which is explained in more detail in Part B.

9. Research and investigation/ information gaps

A range of information gaps and research needs were identified during the preparation of issues papers. These gaps and needs are summarised below. The WQWG will work with organisations involved with nutrient management and algal research to identify further information gaps.

Research will be coordinated via the WQPSG and the REWQC. An annual "register" of relevant research projects underway in the catchment will be maintained.

Information generated through the research and development of any of the various strategies and studies both current and future, will be broadly circulated to enhance co-ordination of future research and educate the target audience, namely the farming community.

The lack of data on land use and nutrient loads was evident when preparing this strategy. A catchment based information system is required to provide this data. Better information on nutrient fluxes, especially in the dryland is required. This information is critical to further refining the approach developed in this strategy.

9.1. Economics.

- Undertake economic studies to further investigate the relative cost effectiveness of nutrient control options, especially as many of the options reported in the issues papers relied on scanty information.

- Undertake full economic analysis of options at a regional scale, incorporating other beneficiaries and costs (eg. salinity, cost of algal blooms, value of water saved)

9.2. Irrigation

- There are a number of significant knowledge gaps in our understanding of how nutrients behave in the irrigation drainage system in the study area. These include:

    - Nutrient cycling on farms. For example, research has or is in the process of quantifying nutrient levels in tailwater runoff from individual irrigation bays for a range of different land uses. At this stage however, no research has been undertaken on the fate of nutrients in the farm drainage system before the tailwater leaves the farm.
    - The benefits of BMP on farms. Based on the balance of probability many BMP are worth doing at any rate. However, without quantification it is often difficult to rank different options and educate farmers about their merits.
    - Farmer's attitudes to the different BMP.
    - Nutrient cycling in the drainage system. Nutrient levels in the drainage system show a decrease in concentration downstream along the drainage system. At present, it is not clear whether nutrient levels are falling because of dilution effects and/or nutrients are being removed from the drainage water. If nutrients are being lost it is not clear how much is being taken up,

what the relationships might be and the longer term fate or these nutrients ie. remobilisation or permanently removed from the system.

- An accurate description of landuse for the irrigation areas in the SIR that is easily manipulated to suit the purpose and boundaries of the study. Land use information for the area is also unreliable and further development of GIS or a similar system would improve invaluable for studies utilising land use information
- Pathogens, pesticides and heavy metal levels in streams and irrigation drainage.
- Quantification of impacts on ecological processes.
- The methodology for setting N and/or P targets for nutrient exports to the Murray River.
- The impacts of nutrients on re-use dams and drains and the nutrient and algal management options for these systems.
- The cost sharing, funding and institutional arrangements for nutrient reduction options.
- The short and long term ability of engineered systems and biological options eg. swales, wetlands and weedy drains for nutrient stripping.
- The interrelationships of the chemical dynamics eg. nutrients, heavy metals etc.

- Additional monitoring sites need to be established to measure the impact of extending the drainage system and effectiveness monitoring of future nutrient strategies. Site specific monitoring along drainage, especially from the end of the farm and along the first several hundred metres of drain.
- Investigate legislative, regulatory and innovative and unorthodox approaches within preferred packages of options.
- Research into quantifying the effects of Management Practices on farms on the nutrient concentration and volume of run-off requires investigation. Economic and social ramifications of BMP also require study.
- Investigate the effects of sedimentation in the drains and the impact of sediment mobilisation in high flow situations.
- Investigate the potential of en-route, or end of drain, wetlands as potential treatment options for reducing nutrient concentration in drainage water including ability of wetland plants to take up nutrients.
- Impacts on agricultural of the use of irrigation water contaminated with blue green algae, and ways of ensuring farm water systems, especially reuse systems, remain free of blue green algae.

9.3. Sewage

- All municipal STPs in the catchment area should closely monitor nutrients in their effluent on a monthly basis and record total monthly flows, including influent, effluent to receiving waters and effluent to irrigation flows. This would provide a firmer analytic foundation for future investigation. The conclusions of the sewage issues paper, for example, are limited by the lack of reliable and long term nutrient and effluent flow data.

- The priority for removal of total phosphorus as compared with total nitrogen should be evaluated. If blue-green algae is the prime concern, removal of TP to low values will be required. Removal of TN would have a lower priority and may not be favoured. A coordinated approach is required for all sewage effluent discharged into the larger Murray River system
- Investigate long term sustainability issues associated with land disposal of effluent.
- Clearly identify environmental concerns with disposal of effluent to waterways.
- The Northern Victorian Regional Water Authorities Wastewater Strategic Plan calls for a program of carefully targeted economic and technical research to enable determination of the cost effectiveness and sustainability of existing wastewater disposal guidelines and regulations.

9.4. Dryland

During the completion of this study a lack of vital data was identified. Specific data gaps identified are:

- Investigate land use impacts on nutrient generation rates. Research to address methods of determining the relative nutrient generation importance of subcatchments and to determine the importance of instream sediment sources is warranted.
- Insufficient gauging data for a broader range of catchment and land use areas. In particular more gauging data needs to be gathered for sub-catchments on the alluvial plains and in actively forested sub-catchment. Gauging data needs to include monitoring of phosphorus and nitrogen levels.
- A lack of long term stream flow data which covers high flow periods when it is suspected that the major erosion events occur.
- A lack of high frequency nutrient monitoring data, (most data being only weekly or monthly).
- The influence of proposed best management practices, in particular the nutrient reductions from use of buffer strips. The effectiveness of the BMPs needs to be evaluated for a wide range of scenarios of landuse, land classes, rainfall events, and overland flow conditions.
- A lack of data regarding the pre-existing waterway conditions in relation to sediment loads and stored nutrients.
- An understanding of the in-stream nutrient dynamics, in particular, the large storages acting as major nutrient sinks and possible low level sources is not well understood.
- These programs should involve:
    - the establishment of gauging stations in targeted sub-catchments on the alluvial plains and other forested areas.
    - the establishment of a field monitoring program to ascertain the site-specific sources of nutrients from the upper-mid catchment. Particular areas requiring attention are forestry roads, forestry roadside recreational reserves and logging areas, dryland dairy farms, and intensive agriculture and horticultural areas.
    - the trialing of best management practices in a pilot sub-catchment area. Extensive monitoring will be required to ascertain the direct benefits in terms of nutrient reductions.

- stream and sediment sampling during a variety of flow conditions to ascertain current nutrient characteristics of the major waterways.

- The completion of CSIRO studies similar to those completed for the Murrumbidgee, and Snowy River catchments are recommended in order to characterise the source of sediments in the streams. Firmer quantitative relationships between in-stream sediment loads and nutrient loads need to be determined.
- Continue to support activities of the Murray Sediment Working Group investigating turbidity/suspended sediment/phosphorus relationships and sediment sources using daily turbidity collected by water treatment plant operators and radionuclide tracing.
- Investigate in some detail the environmental condition of catchment streams to enable better estimates of the length of stream requiring treatment with filter strips.

9.5. Intensive Animals

Poultry farms and piggeries

- Investigate beneficial uses of wastes from poultry farms and piggeries.
- Significant research needs to be conducted in the areas of storage, spreading and utilisation of solid wastes fro maximum benefits. Research is essential to develop protocols for sustainable nutrient loadings on different soils.
- Monitoring and measuring the movement of nutrients through the soil profile is an area of significant importance and needs to be investigated.
- There needs to greater awareness by farmers of the potential value of what they consider as "waste". Mechanisms need to be applied to encourage farmers to more efficiently utilise waste and cut down on imported fertilisers on their farms. Farmers need to be made aware of the effects which their management practices can have on the environment.
- Effects of leachate from dead animals is an area in need of research.

Fish farms

- trial of alternative feed practices
- fate of fish pond sediments
- effectiveness of settling ponds and wetland filtration systems.

9.6. Urban stormwater

- Investigate opportunities for use of wetlands to process urban stormwater.
- Investigate local impacts of urban stormwater on water quality (nutrients, toxicants, heavy metals), especially in the lower Goulburn.

9.7. Blue Green Algae

- Investigate relationships between nutrient loads and BGA blooms.
- Investigate triggers which lead to BGA bloom formation.
- Investigate potential impacts of BGA blooms on actions to be implemented as part of this strategy (eg bloom formation in reuse systems).
- Investigate agricultural impacts of BGA blooms, and living with blooms.

9.8. Statewide priorities

The Victorian government supports a coordinated national research and investigation effort. A number of national priority research areas have been identified and endorsed by ARMCANZ. These include:

- prediction and quantification of nutrient sources in identified problem catchments
- processes for determining nutrient reduction objectives
- improving management practices to minimise nutrient inputs to waterways
- flow characteristics to reduce algal blooms
- monitoring toxin levels in waterbodies and understanding their effect on human health
- short term control of algal blooms
- water treatment to achieve appropriate water quality.

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