

GLENELG-HOPKINS CATCHMENT NUTRIENT MANAGEMENT PLAN

- A FRAMEWORK FOR REDUCING NUTRIENT LOADS
AND THE INCREASING OCCURRENCE OF ALGAL BLOOMS IN
REGIONAL WATERS

A COMPONENT OF THE GLENELG
REGIONAL CATCHMENT STRATEGY

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TABLE OF CONTENTS

<i>Forewards</i> -----	6
<i>Abbreviations</i> -----	7
<i>Preface</i> -----	8
<i>Acknowledgements</i> -----	8
Summary-----	9
Background-----	11
National and State Policy-----	11
Setting the Scene-----	12
Glenselg-Hopkins Catchment-----	12
Geomorphology-----	12
Groundwater-----	12
Catchment Activities-----	14
Blue-Green Algae-----	15
What are they?-----	15
Toxicity-----	15
Algal Blooms-----	16
Frequency of Recorded Algal Blooms in the Region-----	17
The Contribution of Nutrients to the Growth of Algal Blooms-----	17
How do Nutrients enter our Waterways?-----	18
Overview of Process-----	19
Background Studies-----	19
Modelling Nutrient Loads-----	19
The Goal for Nutrient Reduction-----	23
Objectives of the Nutrient Management Plan-----	23
Nutrient Reduction Target-----	23
Benefits of the Actions within the Nutrient Management Plan-----	24
Benefit Cost Analysis-----	25
Selecting the Preferred Option-----	25
Identifying the Best Option-----	26
Links to Other Relevant Strategies-----	27
Who Should Pay?-----	29
Programs-----	30
1. Dryland Agriculture Program-----	32
1.1 Gully Erosion Control-----	34
1.2 Streambank Management-----	36
1.3 River Restoration Plans-----	38
1.4 Management of Intensive Animal Industries-----	39
1.5 Farm Nutrient Management-----	40
2. Forests, Parks and Public Lands Program-----	42
3. Urban Program-----	44
3.1 Stormwater Community Education Action Plan-----	45
3.2 Stormwater Management Plans-----	46
3.3 Wastewater System and Infrastructure-----	47
4. Research and Investigation Program-----	48
5. Monitoring Program-----	50
6. Plan Co-ordination Program-----	51
Implementation and Evaluation of Plan-----	52
Conclusion-----	54
<i>References</i> -----	55
<i>Appendix One</i> -----	57
<i>Appendix Two</i> -----	57
<i>Appendix Three</i> -----	58
<i>Appendix Four</i> -----	58
<i>Appendix Five</i> -----	59
<i>Appendix Six</i> -----	60
<i>Appendix Seven</i> -----	62

Tables

Table 1. Summary of Action Programs-----	10
Table 2. Point and Non-point Sources-----	18
Table 3. EPA Guidelines for Nutrient Levels-----	20
Table 4. Summary of Action Plans-----	28
Table 5. Contributors and Beneficiaries-----	29
Table 6. Summary of Action Plans for Each Program-----	30
Table 7. Gully Erosion Control Actions-----	35
Table 8. Streambank Stabilisation Actions-----	37
Table 9. River Restoration-----	38
Table 10. Management of Intensive Animal Industries Actions-----	39
Table 11. Farm Nutrient Management Actions-----	41
Table 12. Forests, Parks and Public Land Actions-----	43
Table 13. Stormwater Education Program Actions-----	45
Table 14. Stormwater Management Plan Actions-----	46
Table 15. Sewage Treatment Plant Actions-----	47
Table 16. Research and Investigation Actions-----	49
Table 17. Monitoring Program Actions-----	50
Table 18. Plan Co-ordination Actions-----	51
Table 19. Implementation and Evaluation of Plan-----	52
Table 20. Incremental Costs for Nutrient Management-----	57
Table 21. Recorded Algal Blooms-----	57
Table 22. Regional Management Units-----	58
Table 23. Benefit:Cost Ratios-----	59
Table 24. Environmental Significance-----	60
Table 25. Nutrient Reduction Rates-----	62

Maps

Map 1. Glenelg-Hopkins Region-----	13
Map 2. Recorded Algal Blooms in the Region-----	17
Map 3. Regional Management Units-----	21
Map 4. Modelled Nutrient Loads -----	22
Map 5. Gully Control Priority Areas-----	33
Map 6. Streambank Stabilisation Priority Areas-----	36

Figures

Figure 1. Estimated Economic Impact of Algal Blooms-----	9
Figure 2. Hopkins River Estuary-----	11
Figure 3. Landuses in the Glenelg-Hopkins Region-----	14
Figure 4. <i>Anabeana</i> - common blue-green algae-----	15
Figure 5. Algal Bloom at Lake Hamilton-----	16
Figure 6. Causes and Effects of Algal Blooms-----	16
Figure 7. Relative Contribution of Sources of Total Phosphorus-----	20
Figure 8. Relative Contribution of Sources of Total Nitrogen-----	20
Figure 9. Waterwatch - water testing-----	23
Figure 10. Estimated Impact of Algal Blooms for the Region-----	25
Figure 11. Basalt Plains-----	29
Figure 12. Hopkins River, Chatsworth-----	32
Figure 13. Casterton Revegetation-----	34
Figure 14. Filter Strips-----	40
Figure 15. Drain Stencilling-----	44

FOREWARDS

MINISTER'S FOREWORD

The Government is undertaking a broad range of activities to ensure the sustainability of Victoria's water resources, and to protect and improve the quality of our water supplies, particularly in regional and rural parts of the State. It is vital to maintain good water quality, not only to protect agriculture and industry, but for human consumption and for the environment.

Victoria takes great pride in its investment in sustainable natural resource management. It relies on partnerships between community and Government, at all levels, from local to federal. The community-government partnership model is essential if we are to achieve our goals in sustainable resource management and sustainable agriculture, and in achieving a healthy environment.

This partnership approach is the cornerstone of the Victorian Nutrient Management Program. The program is a practical response to concern about the number of reported blue-green algae blooms across the State and the awareness of the role that nutrients, especially phosphorus and nitrogen, play in causing these blooms. A major part of the program is the development and implementation of catchment-based nutrient management plans.

The Glenelg Hopkins Nutrient Management Plan is an excellent example of a catchment-based plan. The plan has been prepared with strong community and regional stakeholder involvement. It contains recommended nutrient management actions and agreed cost-sharing arrangements. It provides a clear framework for coordination, implementation, monitoring, reporting and accountability.

The plan acknowledges that there is 'no quick fix' to this problem and that long-term actions will be required to manage and reduce inputs of nutrients to waterbodies if the incidence of algal blooms is to be reduced. Implementation of the plan will involve all stakeholders in the catchment working in a cooperative venture.

I commend the efforts of your catchment in preparing this plan. Its implementation will clearly have a significant impact on improving the region's water quality.



Sherryl Garbutt MP

Minister for Environment and Conservation

MESSAGE FROM THE CHAIRMAN OF THE GLENELG-HOPKINS CATCHMENT MANAGEMENT AUTHORITY

It gives me great pleasure to release the Glenelg-Hopkins Nutrient Management Plan.

The plan is a compilation of the draft Glenelg, Portland Coast and Hopkins Nutrient and Water Quality Plans. This document incorporates the three plans and identifies nutrient issues across the whole Glenelg-Hopkins region.

The plan looks at taking action immediately to avoid the nutrient issues evident in more closely settled catchments. Nutrient problems are evident in the region with blooms having occurred at Lake Linlithgow, Lake Hamilton and the Hopkins River (April 2001).

While this plan concentrates on nutrient issues, it is complimentary to other environmental programs e.g. salinity and waterways management. Glenelg-Hopkins region was identified by the Federal and State Governments as a "Priority Catchment" in the recently announced National Action Plan for Salinity and Water Quality.

I would like to thank all those who have participated in the preparation of the plans. The Glenelg-Hopkins Nutrient Management Plan highlights and directs priority actions throughout the region. Community participation and acceptance of the plan is essential to achieve a reduction in nutrient loads in the catchment and take us all towards sustainability.



Michael Murphy
Chairman

ABBREVIATIONS

BMP	Best Management Practice
CALP	Catchment and Land Protection
DNRE	Department of Natural Resources and Environment
GHCMA	Glenelg Hopkins Catchment Management Authority
BGA	Blue-Green Algae
GHNMP	Glenelg-Hopkins Nutrient Management Plan
RMU	Regional Management Unit
VWQMN	Victorian Water Quality Monitoring Network
CMSS	Catchment Management Support System
STP	Sewage Treatment Plant
TN	Total Nitrogen
TP	Total Phosphorus
EPA	Environment Protection Authority, Victoria
LCC	Land Conservation Council
NPV	Net Present Value
WFP	Whole Farm Plan
IAI	Intensive Animal Industries
SEPP	State Environment Protection Policy
WoV	Waters of Victoria
SWMP	Stormwater Management Plan
WWTP	Wastewater Treatment Plant
VFF	Victorian Farmers Federation

PREFACE

The Glenelg-Hopkins Nutrient Management Plan will be used as a tool to improve water quality in the region and reduce the occurrence of algal blooms. Many of the activities will assist in not only reducing nutrients entering the waterways but improving water quality throughout the catchment. Algal blooms are not common in the Glenelg-Hopkins region on recreational waterbodies and reservoirs, but have been increasing in farm dams. Community input during the development of the plan identified water quality as an issue in the region. There was a general understanding of the economic impact of poor water quality.

Compared to other regions in the State the waterbodies of the Glenelg-Hopkins region do not have a serious nutrient problem. Therefore, the Plan focuses on avoiding further degradation of the region's water by acting now to prevent higher future costs of reparation.

ACKNOWLEDGEMENTS

The Nutrient Management Strategy for Victorian Inland Waters has provided a framework for the development of Catchment Nutrient Management Plans (CNMPs). These plans provide a mechanism for local communities to develop and implement actions to control nutrients, appropriate to their local catchment.

Three draft plans for the individual basins within the region preceded the Plan. A Draft Hopkins River Water Quality Plan was first produced by the Catchment and Land Protection Board (CALP) and was released for public comment in June 1996. The Draft Glenelg Nutrient Management Plan was released for public comment in November 1999 and there is an unreleased Draft Portland Coast Nutrient Management Plan. The GHNMP incorporates all three draft plans and identifies nutrient issues over the whole catchment.

The development of this plan has involved the contribution of many people. Cathy Wagg (DNRE) for completing the Draft Glenelg Nutrient Management Plan, Michelle Coysh (DNRE) for completing the Draft Portland Coast Nutrient Management Plan and the contributions of the Glenelg-Hopkins CALP Board for the Draft Hopkins River Water Quality Plan, prepared by WaterEcoscience.

During the development of the three draft plans and the Glenelg-Hopkins Nutrient Management Plan, there has been active participation and feedback from the Glenelg-Hopkins CMA Waterways Implementation Committee, and the Advisory Groups for each plan.

Contribution and participation was received from the following organisations:

- Glenelg-Hopkins Catchment Management Authority (GHCMA)
- Environment Protection Authority (EPA)
- Department of Natural Resources and Environment (DNRE)
- Water Authorities - South West, Glenelg and Portland Coast
- Local Government
- Victorian Farmers Federation (VFF)
- Deakin University
- Community

Appendix Four lists all participants involved in the development of the draft plans.

SUMMARY

The Glenelg-Hopkins region consists of three main drainage basins, the Glenelg Basin, the Hopkins Basin and the Portland Coast Basin. The Plan addresses nutrient management across the region.

Nutrients occur naturally in all waterbodies but it is when nutrients reach greater concentrations that problems with water quality may occur. The Nutrient Management Strategy for Victorian Inland Waters (DCNR, 1995) recognises the link between high nutrient levels in water bodies and the increasing occurrence of algal blooms. Blue green algal (BGA) blooms are potentially toxic and threaten both human use of water and aquatic biodiversity.

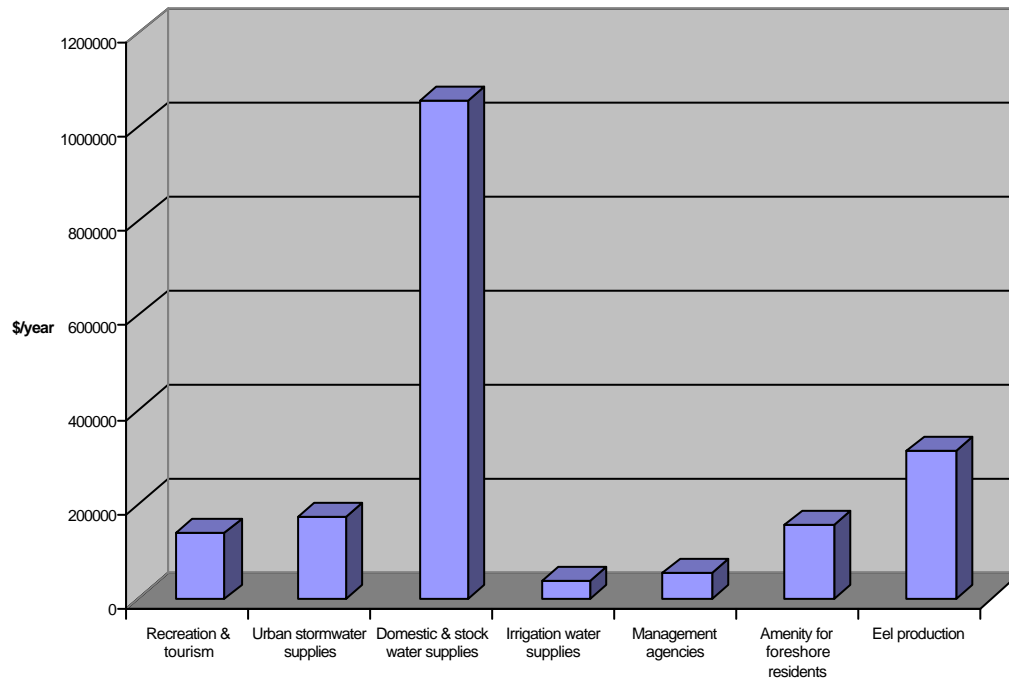


Figure 1: Estimated Economic Impact of Algal Blooms (Read *et al*, 1999)

Algal blooms can affect our capacity to enjoy and use our water and waterways. It has been estimated that algal blooms cost the Glenelg-Hopkins region approximately \$1.9 million per year (Read *et al*, 1999). This cost is not spread evenly throughout the community but is felt more by some groups and in some waterbodies or sub-catchments than others (Figure 1).

Some of the detrimental effects from algal blooms have been costed, for example recreation and domestic and stock water supplies. However, impacts on environmental and public health, the image of the region as a tourist destination and as a producer of 'clean food' have not been costed.

A range of activities designed to reduce nutrient loads (the amount of nutrients exported from different sources) to waterways have been investigated to determine the benefit to cost ratio. The limitation of relying on this ratio alone is that the Glenelg-Hopkins region currently has low value for current water use. There is not yet large scale irrigation or other water use industries in the region and there is the possibility that this will continue to be the case in the future. Thus, non-costed impacts of increased nutrient loads must be carefully considered.

The Glenelg-Hopkins region does not have a serious algal bloom problem, but the activities outlined in Table 1 will prevent an increase in nutrient levels assisting the avoidance of major expense if a serious nutrient problem arises in the future.

Many nutrient reduction activities are integrated with other environment protection works and are, therefore, complimentary to good catchment practices. Activities that have this attribute have been included in the Action Plans.

A summary of proposed Action Plans is provided in Table 1.

Table 1: Summary of Action Programs

	Program		Action Plans	Costed benefit:cost ratio to reducing BGA blooms	Non-costed economic benefit of nutrient reduction	Non-costed social benefit of nutrient reduction	Non-costed environmental benefit of nutrient reduction	Equivalent annual cost over 30 yrs (\$ p.a.)	Outcomes
1	Dryland Agriculture	1.1	Gully Erosion Control	0.25	Protection of private land	Protection of native vegetation	Protection of wildlife reserves	1,556,000	Decrease in nutrient and sediment runoff
		1.2	Streambank Stabilisation	0.14	Protection of private land	Protection of remnants	Increase in native vegetation	1,908,000	Increased stream stability and improved water quality
		1.3	River Restoration	NC	Improved water quality	Community empowerment	Protection of riverine environs	240,000	Co-ordinated approach to river management
		1.4	Management of Intensive Animal Industries	0.04	Effective effluent reuse	Community empowerment	Improved water quality	1,105,000	Increased adoption of BMPs on farms – reduction in nutrient runoff
		1.5	Farm Nutrient Management	0.36	Efficient fertiliser application	Increased awareness of nutrient management	Improved water quality	67,000	Improved effluent management – reduction of pollutant export from dairy sheds
2	Forest	2.1	Forest and Public Land Activities	0.55	Improved roading	Awareness of private forestry practices	Protection of remnant vegetation	85,000	100% compliance with Code of Forest Practice
3	Urban	3.1	Stormwater Education Program	1.18	Reduced littering	Prevention of litter in stormwater	Improved water quality	53,000	Nutrient export reduced in priority urban areas
		3.2	Stormwater Management	NC	Improved litter management	Prevention of litter in stormwater	Improved water quality	200,000	Stormwater management plans produced and implemented in priority towns
		3.3	Wastewater System and Infrastructure	0.04	Increased recreation	Improved human health	Improved water quality	1,440,000	Decrease in nutrient exports from treatment plants
4	Research & Investigation	4.1	Coordinated Research and Investigation Program	NC	More efficient fertiliser application	Increased understanding of nutrient export	Improved nutrient management	To be costed	Increased understanding of nutrient contributors in the catchment
5	Monitoring	5.1	Monitoring and Evaluation of Action Plans	NC	Improved water quality	Awareness of water quality	Improved water quality	40,000	Identify where the gaps are in monitoring and develop a benchmark for water quality in the region
6	Coordination	6.1	Coordination and Implementation of Plan	NC	Reduction in BGA blooms	Awareness of nutrients to the contribution of BGA blooms	Improved water quality	55,000	Ensure implementation of the GHNMP

BACKGROUND

In March 1995 the State Government of Victoria released the Nutrient Management Strategy for Victorian Inland Waters (DCNR 1995). This strategy recognised the link between high nutrient levels in water bodies and the increasing occurrence of algal blooms. Blue green algal (BGA) blooms are potentially toxic and threaten both human use of water and aquatic biodiversity. The strategy recommended a planning process to assess regional issues and encourage local communities to develop and implement Catchment Nutrient Management Plans (CNMP) specific to local nutrient problems. The Glenelg-Hopkins Nutrient Management Plan (GHNMP) aims to provide a strategic framework for nutrient management projects. Nutrient management works have been prioritised to ensure that they provide maximum net environmental, economic and social benefits.



Figure 2: Hopkins River Estuary - all catchment activities affect estuarine water quality

NATIONAL AND STATE POLICIES

National Water Quality Management Strategy

The National Water Quality Strategy, developed by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ), *aims to achieve the sustainable use of the nation's water resources by protecting and enhancing their quality, while maintaining economic and social development*'. The strategy has produced policies and guidelines covering a diverse range of water quality issues.

National Action Plan (NAP) for Salinity and Water Quality

In November 2000 the Federal Government announced the National Action Plan for Salinity and Water Quality. The Glenelg-Hopkins Catchment has been included in the National Action Plan as a priority region. This plan together with other complimentary plans the GHCMA has prepared will underpin the Regional Catchment Strategy. The Glenelg-Hopkins Regional Catchment Strategy will be the key document for determining priority activities in the region.

State Environment Protection Policy - Waters of Victoria (SEPP - WoV)

The SEPP's goal is to *'attain and maintain levels of water quality that are sufficient to protect the beneficial uses of the surface waters of the policy area'*. Water quality targets relate to marine, estuarine and freshwater areas together with the beneficial use to which the waters are used. The policy is currently under review.

Nutrient Management Strategy for Victorian Inland Waters

Developed by the Victorian Blue-Green Algae Project Team in 1995, the objective of the Strategy is *'to provide a policy and planning framework to assist local communities and the State Government to manage nutrient levels in waterbodies to minimise the potential for the development of algal blooms, particularly blue-green algae'*. This framework includes guidelines for the development of Catchment Nutrient Management Plans such as this plan for the Glenelg-Hopkins region.

Glenelg Regional Catchment Strategy

A high priority of the Glenelg Regional Catchment Strategy was the development of a nutrient management strategy for the region. The priority stated *'to develop and implement a regional surface and subsurface Water Quality Management (Nutrients) Strategy'*.

NEED FOR A NUTRIENT MANAGEMENT PLAN

This plan will look at actions that will reduce excess nutrients entering waterways. All actions will not only contribute to protecting water quality in the catchment from excess nutrients it will also assist in protecting and improving other waterway health issues in the region such as salinity. Salinity is a major problem in some areas of the catchment. The Glenelg-Hopkins Nutrient Management Plan is an essential part of implementing the National Action Plan for Salinity and Water Quality in the Glenelg-Hopkins region.

SETTING THE SCENE

GLENELG-HOPKINS CATCHMENT

Regional catchments managed by the Glenelg-Hopkins CMA stretch from Ballarat in the east to the South Australian Border in the west and from the Southern Coast of Victoria to the city of Ararat in the north. The Glenelg-Hopkins region consists of three main drainage basins:

- Glenelg
- Hopkins
- Portland Coast

The average annual discharge for the catchments is 1,397,000 ML, which corresponds to 6.27% of the state's total annual discharge. Annually rainfall ranges between 900mm in the south near Heywood to 500mm near Lake Bolac (RCS, 1997). The region experiences higher rainfall between April and November.

All three basins are south of the Great Dividing Range in South West Victoria. The entire region covers approximately 2.6 million hectares with in excess of 20,000 km of streams (RCS, 1997). The region includes the cities of Hamilton, Ballarat (in part), Warrnambool, Ararat, Casterton, Coleraine, Port Fairy, Beaufort and Portland (Map 1).

The Glenelg basin waterways are dominated by the Glenelg River which begins in the north east corner of the drainage basin flowing west where it is stored by the Moora Moora Reservoir and the Rocklands Reservoir. The river then flows south towards Nelson where it enters the Southern Ocean. The main tributaries of the Glenelg River are the Wannon, Chetwynd, Stokes and Crawford rivers.

The Hopkins basin waterways are the Hopkins and Merri rivers. The Hopkins River begins north east of Ararat and flows in a southerly direction towards Warrnambool, where it enters the Southern Ocean. The two main tributaries of the Hopkins River are Mount Emu Creek and the Fiery Creek/Salt Creek system. Minor tributaries of the Hopkins River are the Mustons and Brucknell Creeks. The Merri River, an independent waterway, is located in the Hopkins drainage basin to the west of the Hopkins River. This waterway is approximately 50 km in length and enters the Southern Ocean at Warrnambool.

The Portland drainage basin consists of numerous independent waterways which enter the Southern Ocean. The waterways which all extend inland approximately 50 km, include the Moyne, Surrey, Fitzroy, Shaw and Eumeralla rivers plus Darlots Creek.

GEOMORPHOLOGY

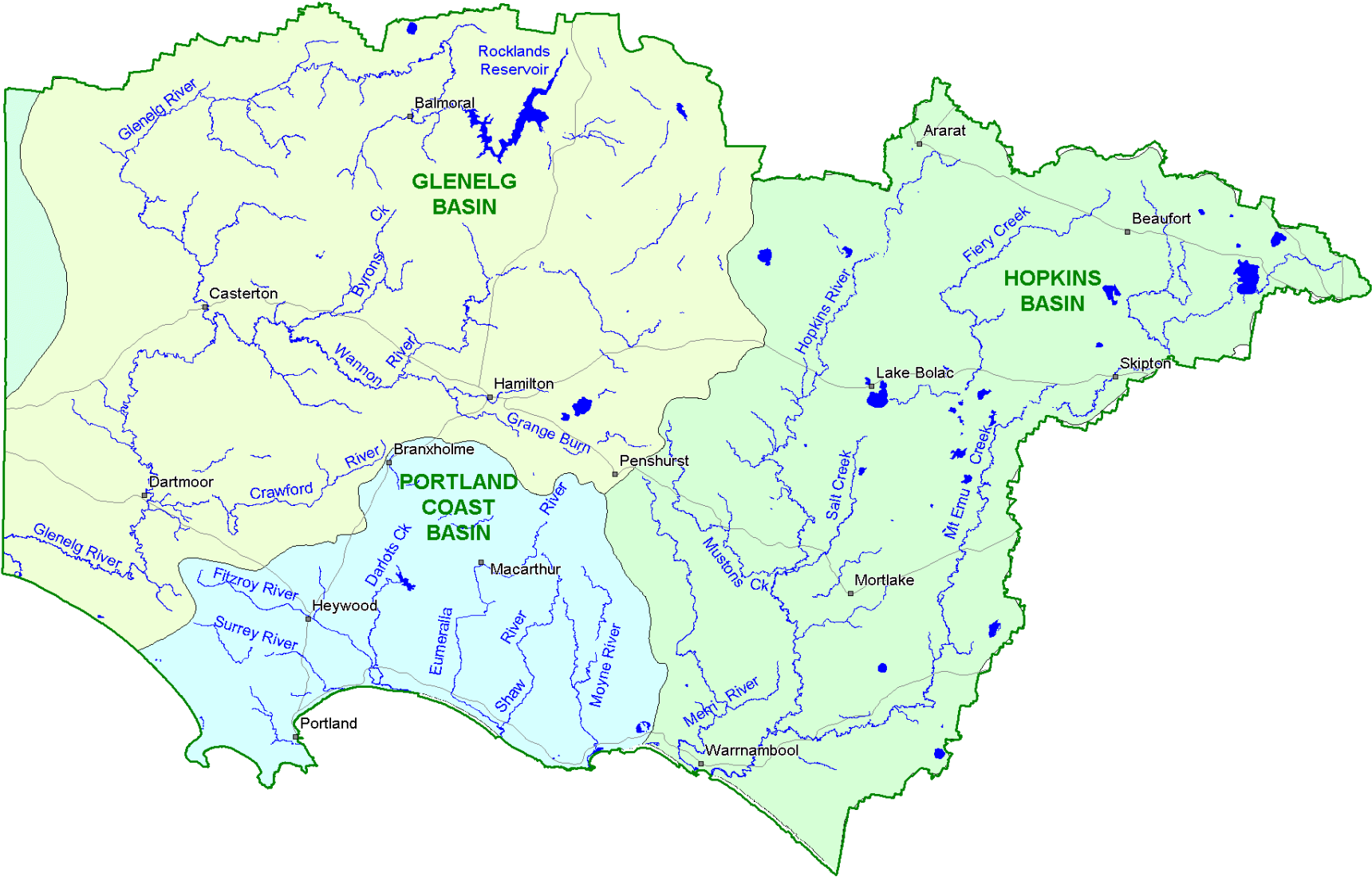
An extensive volcanic plain covers much of the southern and eastern part of the region. The north of the region is dominated by the older rocks of the Grampians, the Dundas Tablelands, the Central Highlands and sedimentary rises which are the western extremity of the Great Dividing Range. Soil types in the region consist primarily of red, yellow, brown and grey duplex soils, grey cracking clays and lateritic/stony profiles. These different soil types are distributed in a complex manner throughout the Glenelg, Hopkins, and Portland Coast region. Areas of high soil fertility, generally in the south of the region, have more intensive farming practices which can play a larger part in nutrient export in the region (RCS, 1997).

GROUNDWATER

Substantial reserves of groundwater of varying salinities are present throughout the region. Three groundwater basins underlie the Glenelg-Hopkins Region; the Otway, Murray and Highland basins with the Otway being the most significant of these. Issues of quality and quantity of groundwater are important, as the health of the catchment has been adversely affected by changes to both.

During periods of low flow salt and nutrients can enter the rivers from groundwater. The most common nutrient in groundwater is nitrogen in the form of nitrate ion. Phosphate is not normally present in appreciable concentrations.

Map 1: Glenelg-Hopkins Region



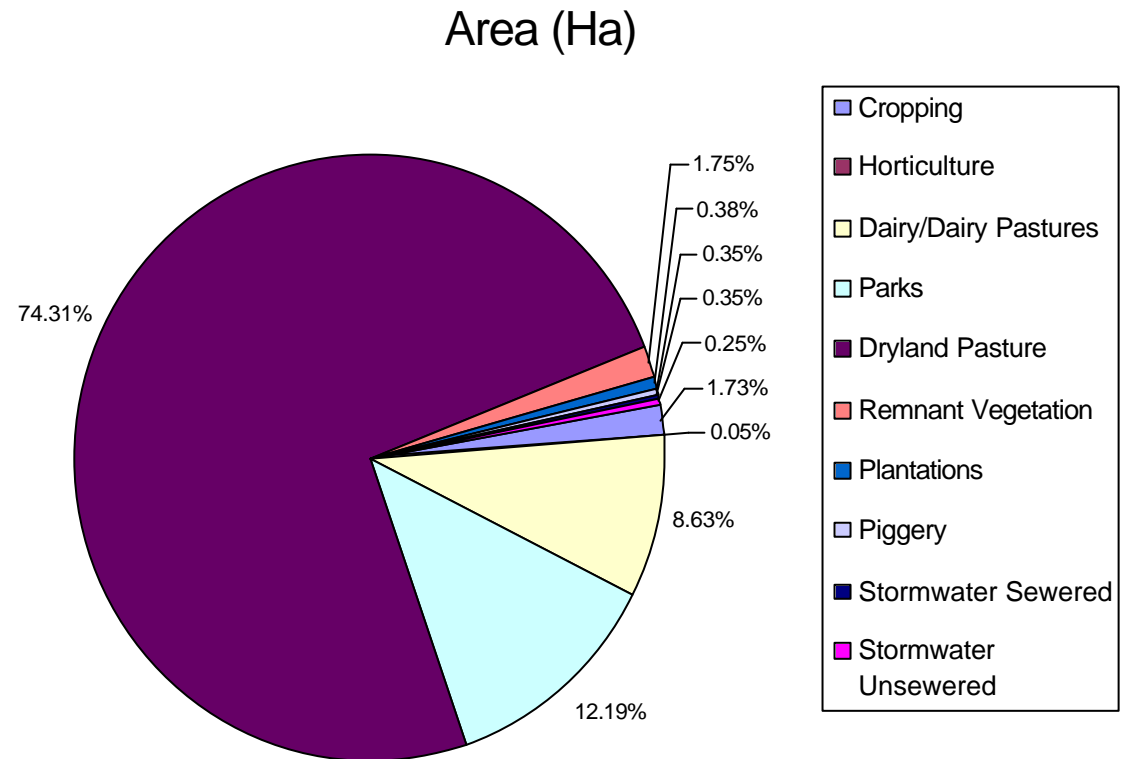
CATCHMENT ACTIVITIES

Recent trends in land use over the last five years show an increase in timber use, mainly through the conversion of grazing land to Blue Gum production and a smaller area of land converting from grazing to dairy production. This expansion has been, in the main, at the perimeter of the established dairy areas in the South of the region. In the centre of the catchment both cropping and grazing are supported, with the North being predominantly cropping, reflecting annual rainfall (Figure 3).

The trends recorded above are demonstrated in the following statistics. In the last decade sheep numbers have declined from 10 to 8 million, while dairy cow numbers have increased from 307 to 424 thousand. The area cropped has increased from 62,000 to 205,000 ha and Blue Gums now cover 40,000 ha from a base of zero in 1991 (Socioeconomic Impact of Changing Land Use in South West Victoria, 2000).

Recreation and tourism is a significant industry in the region, with waterbodies being a major attraction to those visitors. Healthy rivers and waterways contribute, markedly, to the tourism industry and closure of water amenities is estimated to impact on the region's communities to the value of \$140,000 p.a. (Read *et al*, 1999).

Figure 3: Landuse in the Glenelg Hopkins Region
 Source: Read *et al*, 1999



BLUE-GREEN ALGAE

WHAT ARE THEY?

Blue-green algae (Cyanobacteria) are primitive bacteria that are autotrophic (*auto* = self, *trophic* = nourishment) despite the absence of internal organelles, a discrete nucleus and histone proteins. Their autotrophism is achieved via photosynthesis but unlike most photosynthetic organisms blue-green algae (BGA) distribute their photosynthetic material throughout their cells as opposed to binding to chloroplasts. Blue-green algae are unable to move and they reproduce asexually and therefore capable of dividing and doubling in number every 2-3 days.

One interesting feature of some species of blue-green algae is their ability to use vegetative cells to collapse their internal pockets of gas. This enables them to regulate their buoyancy and move vertically through a body of water maximising light near the surface and nutrients near the water bed (Smith, 1999).

Some blue-green algae have the ability to “fix” atmospheric nitrogen using heterocysts located within blue-green algae cells and to absorb and store phosphorus. These features give blue-green algae a competitive advantage over other algae when these nutrients are in short supply. In unfavourable conditions blue-green algae can survive for long periods of time on the water bed and “wait” until conditions improve.



Figure 4: Anabaena - a common blue green algae of regional waterways. Source: Smith, 1999.

TOXICITY

Only a small number of the many blue-green algae have been found to be toxic, these include *Anabaena* (present in lakes and slow moving rivers), *Microcystis* and *Cylindrospermopsis* (generally in lakes and dams), and *Nodularia* (in brackish waters).

The four main types of toxins produced by blue-green algae are (DNRE, 1998):

Hepatotoxins - produced by species of *Microcystis*, *Nodularia*, and *Anabaena* and can cause liver damage and gastrointestinal symptoms

Neurotoxins - produced by species of *Anabaena* and have been observed to cause muscle tremor, staggering, paralysis and respiratory arrest in animals. The neurotoxins produced by *Anabaena circinalis* in south east Australia have recently been shown to be the same compounds as those produced by dinoflagellates in the marine environment and responsible for paralytic shellfish poisoning (PSP)

Cytotoxins - produced by species of *Cylindrospermopsis* and can cause kidney damage. *Cylindrospermopsis* is more prevalent in tropical waters

Endotoxins - contact irritants produced by most species of blue-green algae and can cause skin rashes, eye irritation, allergic reactions and gastroenteritis.

A multitude of toxic compounds that fall into any one of the above categories may be produced by blue-green algae. Some are very toxic. For example Microcystin LR (produced by *Microcystis*) has a relative toxicity 1000 times greater than cyanide (DNRE, 1998).

The toxins are released into the water following the death of blue-green algal cells and can remain potent for a period of several weeks after the algae have disappeared.

ALGAL BLOOMS

Blue-green algae are important contributors in most natural aquatic ecosystems but under favourable conditions can experience growth “explosions” known as “blooms”.

The key factors that encourage blooms are:

- seasonal conditions – blooms occur more frequently in summer and autumn especially in calm conditions,
- water temperature – warmer water temperatures promote blooms,
- nutrients – higher concentrations of available phosphorus, particularly, and nitrogen promote blooms,
- light availability – moderate turbidity (cloudiness) favours blue-green algae over other algae,
- flow conditions – low flows and still conditions promote blooms,
- ecological conditions – unbalanced ecosystems are more likely to favour blue-green algae growth.

Of the factors above, management of nutrient levels offers the greatest potential for the long-term control of blue-green algal blooms in the region. Algal blooms have a considerable impact on communities in our region (Figures 5 & 6). They affect human and animal health, water supply, tourism, industry, water-based recreation, ecological values and commercial fisheries (Read *et al*, 1999).

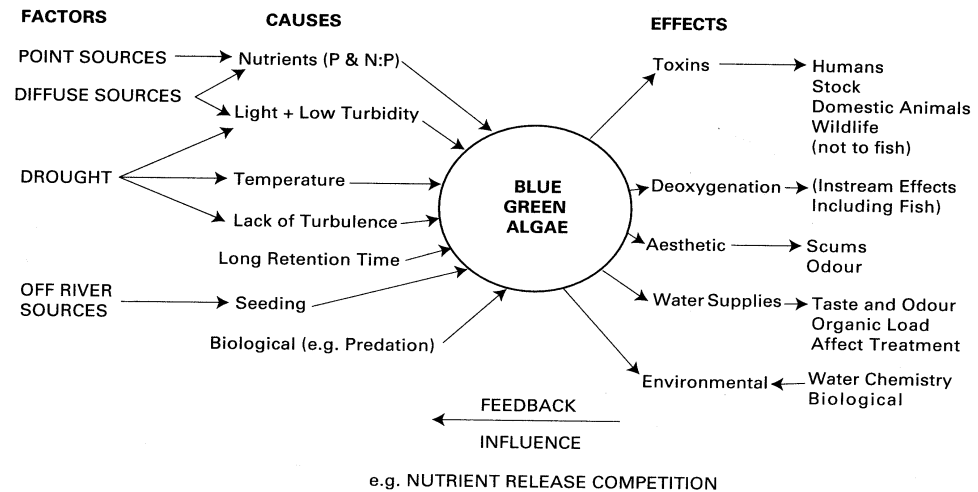


Figure 5: Major causes and effects of blue-green algal blooms.
Source: Smith 1999

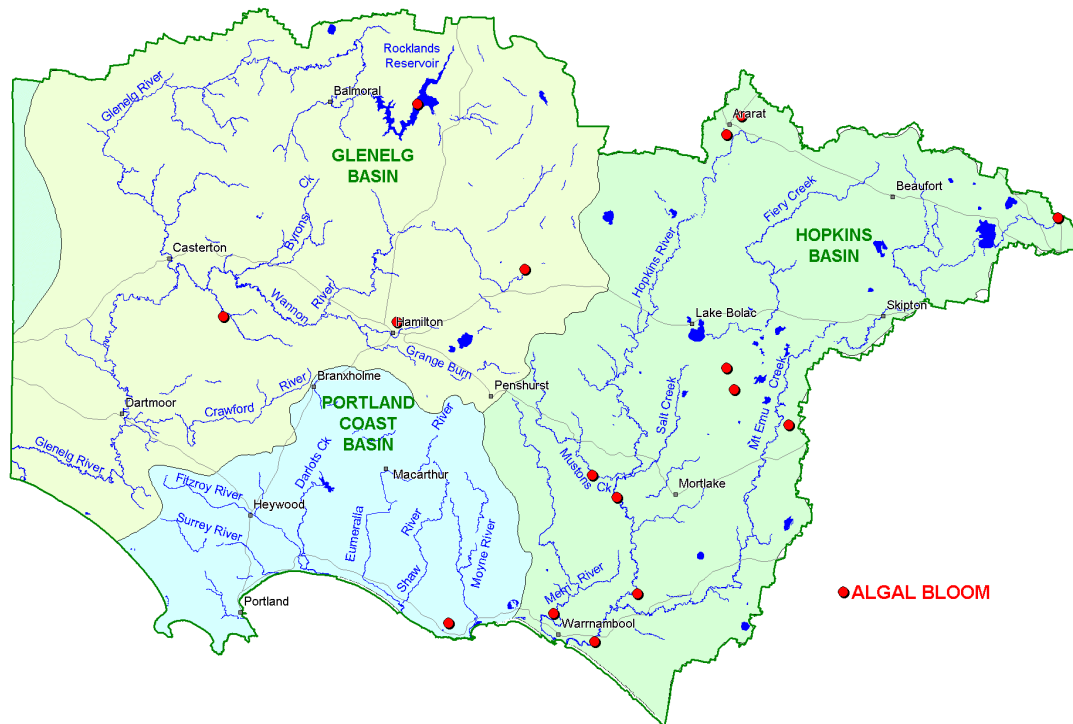


Figure 6: A regular feature at Lake Hamilton - visible algal blooms (1996).

FREQUENCY OF RECORDED ALGAL BLOOMS IN THE REGION

From 1928 to 2000, algal blooms have been recorded at 20 sites in the Glenelg-Hopkins region. Some sites have experienced more than one bloom over the years. All sites are shown on Map 2, with the full list of waterbodies listed in Appendix 2.

Map 2: Recorded Algal Blooms in the Glenelg-Hopkins Catchment



THE CONTRIBUTION OF NUTRIENTS TO THE GROWTH OF ALGAL BLOOMS

The concentration of nutrients in water indicates the availability of essential elements to fuel algal growth. The higher the availability of nutrients, the higher the likelihood of algal growth. Nutrients entering water bodies are either used by plants and algae for growth, are retained in the water, or are trapped in the sediments.

Blooms are commonly associated with eutrophic (rich in nutrients) shallow lakes, either natural or artificial. Eutrophication leads to increased algal and/or macrophyte production and a reduction in biodiversity owing to the algae depleting the waters' oxygen supply. Eutrophication can occur naturally but is greatly enhanced by human-induced changes.

High concentrations of nutrients present in the region's streams have seen them classified as poor to degraded during periods of high flow (Wagg, 1997). During periods of high flow, increased streambank material, containing nutrients, is swept into the waterway. As the flow decreases sediment is deposited creating a store of nutrients available for release during periods of low flow.

In Australia the low gradient of many rivers, as well as their prolonged periods of low flow, cause these rivers to act as a series of elongated pools with limited connectivity (i.e. like shallow lakes) (Wagg, 1997). Under such conditions the turbidity (cloudiness) of the water is reduced as the finer suspended sediment is deposited. The resulting greater light penetration favours plant and algal growth.

HOW DO NUTRIENTS ENTER OUR WATERWAYS?

Nutrients occur naturally in waterbodies providing organisms with vital “food” for growth. The concentration of nutrients determines the suitability of the environment for each organism. Phosphorus, for example, is commonly absorbed to the surface of clay particles and can settle to the river bottom with them. Inorganic dissolved forms (e.g. nitrate, phosphate) are readily utilised by algae. Guidelines for nutrient concentrations, chemical and biological, exist to support specific environmental values, which differ across the State as local climate, geology, flora and fauna all impact upon the natural condition of a water-body (DNRE, 1996).

There are three potential sources of nutrients:

Diffuse or non-point sources - diffuse sources enter the waterway along its length, are difficult to pinpoint and are therefore difficult to monitor and manage. Examples of these sources include nutrients from gully erosion and agricultural runoff.

Point sources - nutrients enter waterways from a known activity or process such as a sewage treatment plant (STP), dairy shed effluent or other industry. These nutrients are generally traceable to the source and are easier to monitor.

Internal loadings - these nutrients are generated from within the waterbody, e.g. from streambank and bed erosion, or from nutrients bound to sediments in a waterbody. Certain environmental conditions enhance nutrient release from sediment including increases in pH and temperature. Internal loads can cause problems for many years, even if external diffuse and point sources are controlled (DNRE, 1996). There is very little information regarding internal loading in the Glenelg-Hopkins region.

Nutrient export rates vary between different land types due to variation in rainfall, erodibility, fertility, and the inputs and outputs of the industries using the land. Rates also vary over time according to other less predictable factors such as climate change.

Table 2 describes the estimated nutrient export rates, in dissolved and particulate form, from ‘point’ and ‘diffuse’ sources for different land uses within the Glenelg-Hopkins region.

Table 2: Estimated annual nutrient loads for point and diffuse sources in the Region.

Source: Rea *et al*, 1999.

Diffuse Sources of Nutrients	Total Phosphorus	Total Nitrogen
<i>Landuse</i>	tonne/ha/yr	tonne/ha/yr
<i>Cropping</i>	25	159
<i>Horticulture</i>	1.8	2.8
<i>Irrigated Pasture</i>	20	165
<i>Crown Land/Parks – on public land</i>	13	147
<i>Dryland Grazing</i>	169	3,190
<i>Remnant Vegetation – not on public land</i>	0.6	15
<i>Plantations</i>	0.8	28
Point Sources of Nutrients		
<i>Source</i>	tonne/yr	tonne/yr
<i>Coleraine STP</i>	0.3	0.8
<i>Hamilton STP</i>	2.4	4.1
<i>Casterton STP</i>	1.4	2.0
<i>Ararat STP</i>	3.8	10
<i>Beaufort STP</i>	7.0	1.9
<i>Ballarat STP</i>	1.9	48.3
<i>Terang STP</i>	0.8	1.3
<i>Dairy</i>	18	141
<i>Stormwater sewered</i>	9.0	87
<i>Stormwater unsewered</i>	47	102
<i>Piggery</i>	0.4	2.8

OVERVIEW OF PROCESS

Development of this plan has involved consultation with a wide range of key stakeholders. The core groups involved in the development of the plan are listed in Appendix 4. The Glenelg-Hopkins Waterways Implementation Committee provided advice and direction for the economic assessment of the costs of algal blooms and the benefits of preventing them.

BACKGROUND STUDIES

During the development of the plan, important technical investigations were carried out and, to a varying degree, have shaped the plan:

Identifying Nutrient Hotspots in the selected sub-catchments in the Glenelg, Hopkins and Portland Coast Basins (Vinall et al, 1999).

Previous studies had observed high nutrient concentrations in the main rivers of the Glenelg-Hopkins region. The study was designed to investigate nutrient and sediment loads in the main rivers and tributaries of the region. This study assisted in identifying high priority areas and nutrient contribution from different land uses.

Benefits and Costs for Reducing Frequency of Algal Blooms in the Glenelg-Hopkins CMA (Read et al, 1999).

The study involved a rapid appraisal of the estimates of the costs and benefits of nutrient reduction for the Glenelg-Hopkins region. Read *et al* (1999) calculated benefit to cost ratios for activities in each nutrient management activity. This takes into account the costs of the nutrient reduction activities as well as the potential economic benefits that can occur based on these activities.

Development of a Catchment Management Support System (CMSS) model for the Glenelg-Hopkins CMA region (Wagg, 1999).

The CMSS model estimated nutrient contributions for different sources in the Glenelg-Hopkins region.

and for this reason it was necessary to understand nutrient loads in the catchment.

The *concentration* of nutrients in water indicates the availability of nutrients to fuel algal growth. The higher the availability, the higher the likelihood of algal growth. An examination of nutrient *loads* determines the amount of phosphorus and nitrogen that are exported from different point and diffuse sources in the catchment. These may accumulate in receiving waters such as lakes, estuaries and ocean. The main rivers in this catchment are typified by sequences of deep pools. This is ideal for the deposition of sediments (and associated nutrients)

MODELLING NUTRIENT LOADS

In order to model nutrient loads in the catchment it was important to define more carefully where in the landscape the nutrients are generated and exported from. For example, an eroding gully has potential to contribute more nutrients than a well grassed paddock with no exposed soil.

The estimated source of nutrients from both cleared and forested catchments was obtained through consultation with DNRE, CMA, Deakin University and members of the community. Landuse areas are presented in Figure 3 (page 14) for comparison.

A Catchment Management Support System (CMSS) model has been used to model nutrient loads from the catchment, based on landuse and geography. For the purposes of the model, the catchment was divided into sub-catchments largely based on the position of VWQMN gauging stations. Within each sub-catchment areas of similar geographical type were grouped into Regional Management Units (RMU) displayed on Map 3. Then within each RMU the landuse was identified using DNRE's Corporate Geospatial Library layer for landuse at a scale of 1:100,000. Point sources were also added using local knowledge or Australian Bureau of Statistics 1995/96 data.

Each landuse has been assigned a nutrient export rate. The model provides an overall load of phosphorus and nitrogen for each sub-catchment and final load exiting the system at the river mouth. In addition, the program can assign a nutrient export rate for each hectare of each sub-catchment or an overall rate for each landuse. The sub-catchments are linked to simulate the actual affect of the stream network. The longer water takes to travel through a sub-catchment, the more nutrients can be deposited and assimilated by natural stream processes. Figures 7&8 show the relative contribution of nutrients from 'point' and 'diffuse' sources.

Table 3: EPA Guidelines for Nutrient Levels

Maximum base flow nutrient concentrations to prevent deterioration of aquatic ecosystem health in the Glenelg-Hopkins region are given by the following Preliminary Guidelines maxima (mg/L). This document is currently being reviewed.

Source: EPA, 1995

Area	Total Phosphorus (TP) (mg/L)	Total Nitrogen (TN) (mg/L)
South West River Region	0.035	1.0
*Foothills River Region	0.030	0.2

*The Glenelg-Hopkins region is predominantly categorised as South West River Region with a small Foothills (Grampians) component.

There is limited water quality and biological data for South West Victoria. The data generally shows that many of the streams in the southwest are clear, slightly saline, and moderately low in phosphorus but high in nitrogen. The macrophyte communities are very diverse and abundant, compared to other rivers and streams in the State (EPA, 1995). Table 3 shows the interim guideline maxima for the region. The guidelines are based on base flow information, thus the need for assessment of the current water quality in the region.

Information from the Victorian Water Quality Monitoring Network (VWQMN) shows that at the Hopkins Falls gauging station Total Nitrogen (TN) ranges from 0.5 to 3.5 mg/L and Total Phosphorus (TP) from 0.02 to 0.25 mg/L. From the guidelines depicted in Table 3, neither phosphorus or nitrogen values are within the guideline values.

The Wannon River at Dunkeld also shows a large range with TN ranging from 0.5 to 4.0 mg/L and TP ranging from 0.02 to 0.40 mg/L. The two sites have recorded the greatest readings and range in nutrients monitored over a period of 25 years.

An analysis of six years of monthly nutrient data in the catchment shows that approximately 322 tonnes of total phosphorus and 4076 tonnes of total nitrogen are exported in the catchment each year (Wagg, 1997).

Figure 7: Relative Contribution of Sources of Total Phosphorus (TP) in the Glenelg-Hopkins Region.

Source: Read *et al*, 1999.

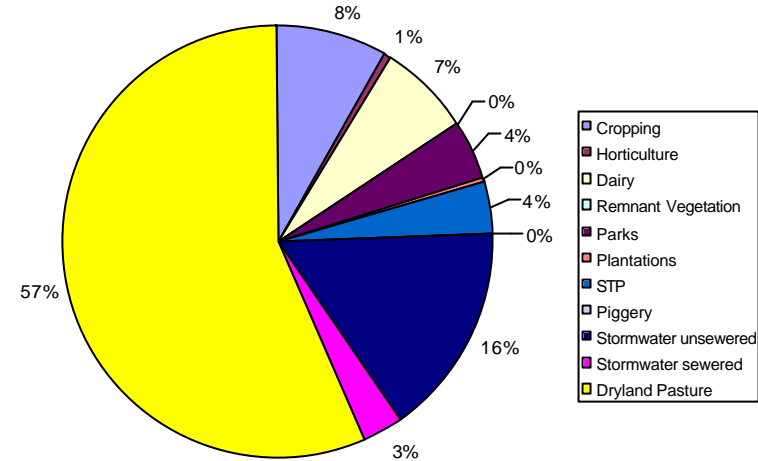
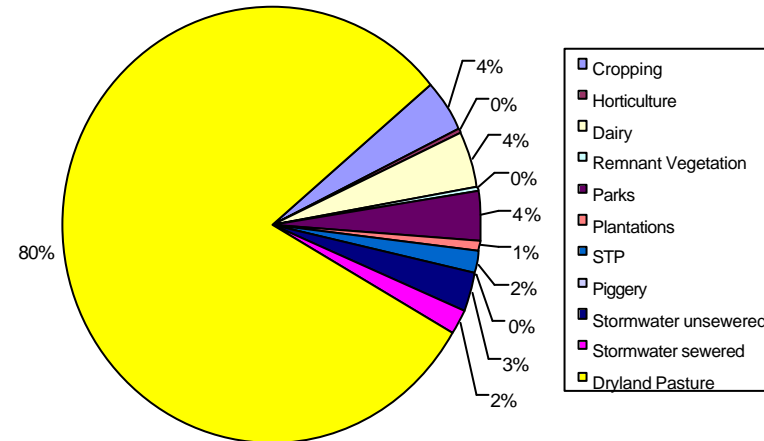


Figure 8: Relative Contribution of Sources of Total Nitrogen (TN) in the Glenelg-Hopkins Region.

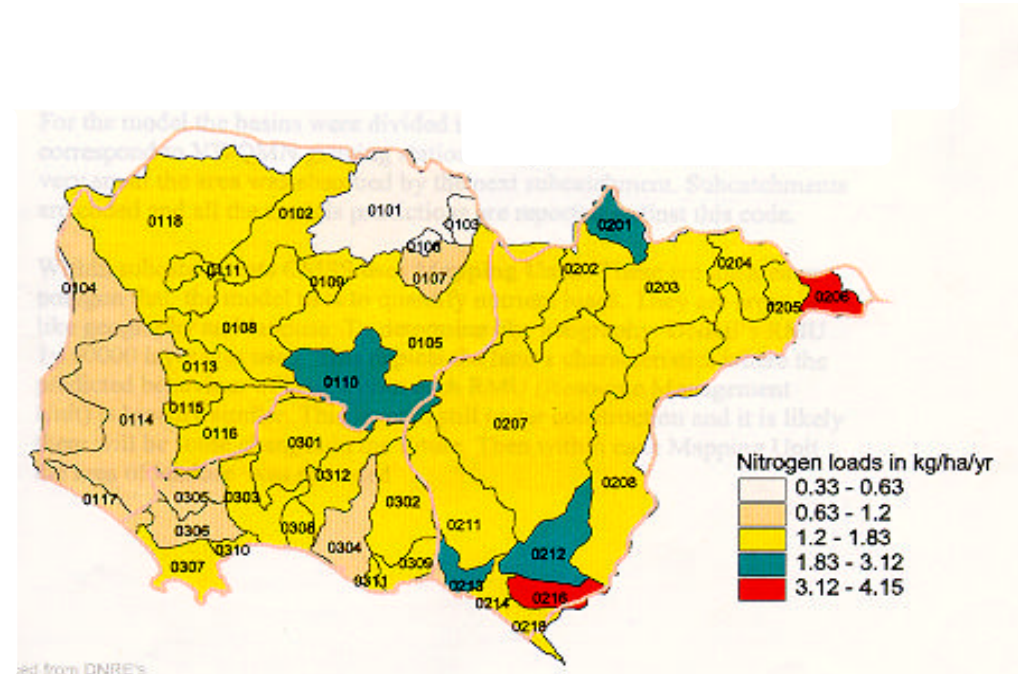
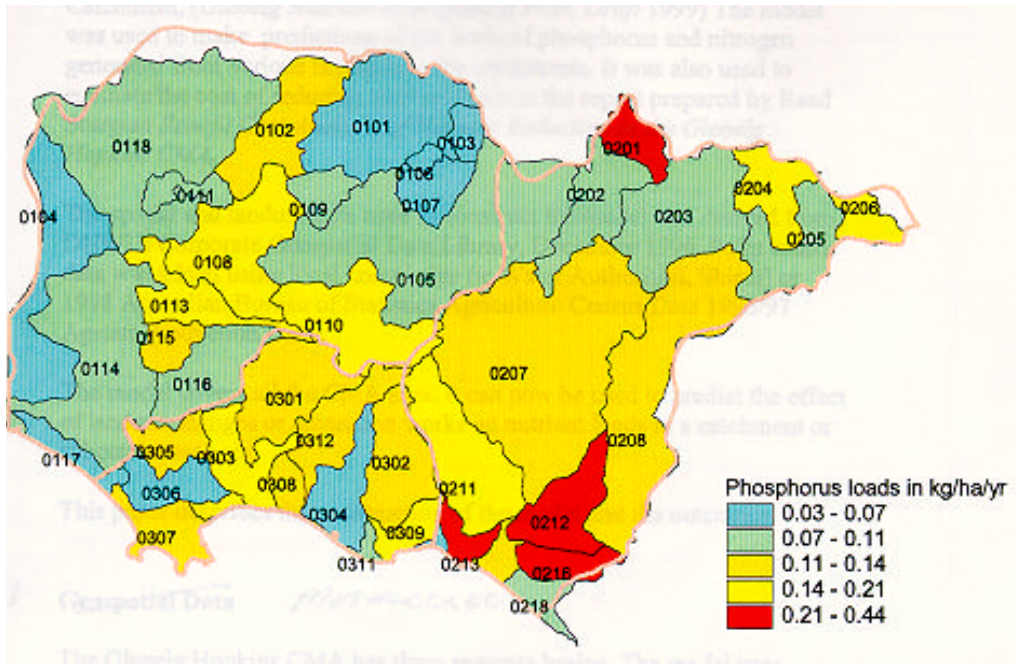
Source: Read *et al*, 1999.



The RMUs depict the land characteristics where the predicted behaviour of land within each region is broadly similar. Map 4 shows the modelled nutrient loads in the catchment, with regards to land use and geography. Each land use is given a different nutrient export rate.

Understanding export rates from RMUs helped to identify sources of nutrients within the catchment and where to target specific activities to reduce the input of nutrients to waterways.

Map 4: Modelled Nutrient Loads.



THE GOAL FOR NUTRIENT REDUCTION

The goal of the Glenelg-Hopkins Nutrient Management Plan is to target action areas which will reduce nutrient input to waterways and improve river health, and so prevent the escalation of blue green algal bloom occurrence in the catchment.

OBJECTIVES OF THE NUTRIENT MANAGEMENT PLAN

Objectives of this plan are:

1. To reduce the risk of blue-green algal blooms within the Glenelg-Hopkins catchment
2. To reduce nutrient concentrations in the waterways of the Glenelg-Hopkins catchment
3. To maintain and improve the quality of surface and ground waters in the Glenelg-Hopkins catchment
4. To reduce sediment loads in the waterways of the Glenelg-Hopkins catchment
5. To maintain and improve riverine environments throughout the Glenelg-Hopkins catchment
6. To develop a greater understanding of the movement of nutrients in the catchment
7. To develop a greater understanding of the availability of nutrients to algal growth
8. To foster regional development by ensuring supplies of high quality water for industries and communities.

NUTRIENT REDUCTION TARGET

The Glenelg-Hopkins Nutrient Management Plan, through implementation of the priority activities of the whole plan, will aim to reduce the nutrient level in the local waterways by 54.5% Total Phosphorus (TP). Appendix 7, page 62, outlines assumptions for the nutrient reduction target.



Figure 9: Water quality testing (2000).

BENEFITS OF THE ACTIONS WITHIN THE NUTRIENT MANAGEMENT PLAN

The benefits of a Nutrient Management Plan are to co-ordinate and facilitate activities that reduce nutrient loads to waterways. The major objective of the Nutrient Management Plan is to reduce nutrient loads in the region's waterbodies and deliver a wide range of benefits. It is important to understand that the cost of rehabilitation in damaged areas will always be significantly higher than appropriate preventative measures implemented and managed now. 'Works on Waterways' licensing is now a function of the CMA, thus water quality protection needs to be included as a licensing condition for all works undertaken on or near waterways.

Biodiversity

An important objective of the Nutrient Management Plan is to minimise adverse impacts on flora and fauna in streams and wetlands. Toxic algal blooms lead to reduced biodiversity in waterbodies and waterways, both for aquatic species and water fowl, however there is little information available to quantify those impacts in the Glenelg-Hopkins region.

Appendix 6 provides a summary of the environmental values in the catchment and the potential risk of deterioration of these values associated with increasing nutrient levels.

Rivers

All rivers provide important natural values that vary between waterways. Many studies have shown that the community ascribes very high economic and social values to the natural values of its rivers (LCC, 1990; Read Sturgess and Associates, 1990; Read Sturgess and Associates, 1997).

The values of the river fall into two categories, "use" and "non use". "Use values" include those of commercial fishing for the Short Finned Eel while "non use" include providing sites for the natural migration of non commercially fished species such as the rare Glenelg Prickly Back Crayfish and the Ewans Pygmy Perch.

Parts of the Glenelg River have been declared Heritage River status to reflect the river's significance to the State with respect to natural values, such as:

- State faunal significance;
- State botanical significance;
- National canoeing significance;
- State geological/geomorphological significance;
- High value scenic landscapes;
- High value angling ;
- Diverse native fish fauna.

Wetlands

A wetland involves a mix of use and non-use values that are difficult to separate, for example "use values" include bird watching, picnicing, eel harvesting, duck shooting and the wetland as a photographic subject. Wetlands provide many important "non-use values" including those associated with:

- habitat for native plants and animals;
- refuges for rare and threatened species;
- assimilation and recycling of nutrients;
- traps for nutrient-rich sediments;
- flood control basins;
- hydrological stability between surface water and ground water in catchments;
- landscape values;
- drought refuge.

Benefits to the Regional Image

Any incidence of algal blooms at popular tourism sites, farms or at food processing companies, would have a negative effect on the image of the region as a tourist destination or as a producer of "clean food". The additional expenditure to improve and protect water quality could be insignificant compared to the lost value of tourism to the region, or the lost value of food products within the region.

Experience has shown that tourists and export food markets are unforgiving. A water quality catastrophe in only one short period can lead to a sustained withdrawal of support from tourists and markets beyond the region (Read *et al.*, 1999).

BENEFIT COST ANALYSIS

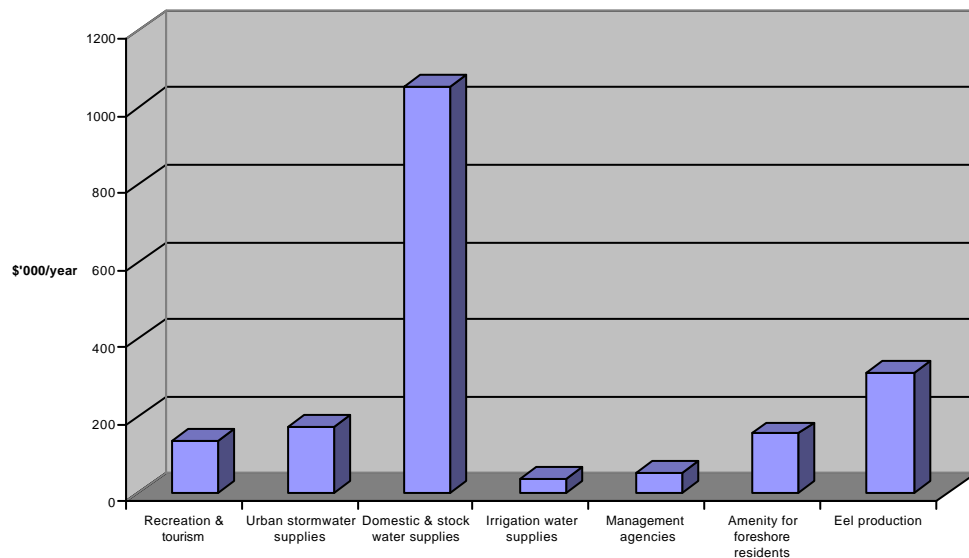
An economic benefit cost analysis has been done to assess the impact of blue-green algal blooms. Uncosted benefits are summarised in Table 4. It is not possible to calculate costs of all impacts of high nutrient loads in waterbodies. For example, the impacts on environmental and public health, the image of the region as a “clean food” producer and the image of the region as a tourist destination.

The quantified costs of high nutrient loads related to blue-green algal blooms in the Glenelg-Hopkins region are dominated by the costs associated with domestic and stock water supplies (\$1.05M), farm dams being the major component of this cost. The second greatest quantified impact (\$300,000) is to the eel production industry. The remaining impacts of blue-green algal blooms are to the value of amenities to foreshore users and managing agents, urban water supplies, recreation and tourism and irrigation water supplies with a combined impact of \$540,000. The economic cost is not spread evenly throughout the community but is felt more keenly by some groups, as summarised in Figure 10.

The total costed benefit to the region of implementing the GHNMP is \$1.9m per annum. The actions that contribute to the uncosted benefits, listed on page 28, are believed to have significant implications in the Region.

Figure 10: Estimated \$/year, due to algal blooms, if No Action is taken in the Glenelg-Hopkins Region.

Source: Read et al, 1999.



SELECTING THE PREFERRED OPTION

Three options were considered to achieve the goal and objectives of this plan. The options are discussed below.

Option 1 - do nothing. This option involves adopting none of the plans recommendations and accepting a \$1.9 m loss per year (Read *et al.*, 1999). This is likely to increase over time with a continued decrease in water quality in the region.

Option 2 – do everything. This option involves adopting all of the plans recommendations regardless of available benefit cost data. While this option would deliver a low benefit cost ratio, substantial uncosted benefits would accrue. All options are costed and outlined in Appendix 5.

Option 3 - most effective activities. A primary criteria for selecting activities as part of this option was benefit cost ratios; However the quantitative analysis of the benefits of nutrient management in the Glenelg-Hopkins region is limited to evaluating the reduction in expected value of damages from toxic blue-green algal blooms. This would be achieved by implementing the plan. Therefore, it was necessary to select activities for this option on the basis of a range of priority setting criteria as listed below.

The activities outlined in Option 3 have been selected using the following guidelines:

- Activities that protected environmental values and minimised risks to areas as identified in Appendix 6;
- Priority areas with high occurrence of blue-green algae blooms;
- Priority areas with high nutrient levels and export rates;
- Actions delivering the highest benefit cost ratios;
- Consultation with the Waterways Implementation Committee about the most beneficial programs for nutrient reduction;
- Programs complimentary to current on-ground works as identified by the Waterways Implementation Committee in the Glenelg Regional Catchment Strategy;
- Activities that are consistent with integrated catchment management;
- Complimentary programs that address water quality and the whole health of the catchment.

IDENTIFYING THE BEST OPTION

Option 3 has been selected for developing the action plans that follow in this plan because it has a high benefit cost ratio, is complimentary to other programs and includes priorities identified by and integrated with other water quality reports.

The “do nothing” Option (Option 1) leaves the region exposed to higher incidence of blue- green algal blooms that affect our capacity to use both economically and recreationally, our water and waterways. This exposure has been calculated at \$1.9m per annum (see benefit cost analysis). This also leads to high risk of deterioration of environmental values associated with key assets in the region - see Appendix 6.

Option 2, “do everything”, delivers the maximum benefit to the catchment but has a very low benefit cost ratio for addressing nutrient problems in the region.

Option 3 offers a balance between Options 1 and 2 and is considered a sound investment of the funds available for this program. The actions recommended in Option 3 are supported by current knowledge of the causes of blue-green algae and high nutrient loads and the effectiveness of best management practices. Table 4 gives an overview of the six programs and supporting action plans for each as part of the Glenelg-Hopkins Nutrient Management Plan. Each action for the plan is summarised in Table 6 (page 28).

Priority sub-catchments have also been identified during the development of the plan. Priority sub-catchments have been identified as areas with:

- high nutrient concentrations;
- active erosion;
- occurrence of multiple algal blooms;
- poor water quality;
- relatively high environmental significance;
- high salinity.

LINKS TO OTHER RELEVANT STRATEGIES

The Glenelg-Hopkins Nutrient Management Plan links to other strategies that have been developed for the region. The following information outlines the links of different strategies to particular programs in this Plan.

Glenelg-Hopkins CMA Waterways Strategy

- Gully Erosion Control - treatment of gully heads
- Streambank Stabilisation - revegetation (filter strips)
- River Restoration Plans - rehabilitation of priority sub-catchments
- Monitoring - water quality monitoring
- Plan Co-ordination - implementation of GHNMP

Glenelg-Hopkins Rabbit Action Plan

- Gully Erosion Control - rabbit eradication prior to revegetation
- Streambank Stabilisation - rabbit eradication prior to revegetation

Glenelg Regional Catchment Strategy

- Monitoring - development of water quality monitoring network
- Stormwater Education Program - community education program
- Farm Nutrient Management - reduction in nutrient levels in waterways
- Intensive Animal Industries - management of intensive industries
- Forest and Public Lands - protection and enhancement of native species

Glenelg-Hopkin Native Vegetation Plan

- Forest and Public Lands - protection of native species
- Gully Erosion Control - enhancement of native vegetation

Victorian Biodiversity Strategy

- Forest and Public Lands - protection of native species

Glenelg-Hopkins Weed Action Plan

- Gully Erosion Control - weed control
- Streambank Stabilisation - weed control
- River Restoration Plans - weed control

Table 4: Summary of Action Programs

	Program		Action Plans	Costed benefit:cost ratio to reducing BGA blooms	Non-costed economic benefit of nutrient reduction	Non-costed social benefit of nutrient reduction	Non-costed environmental benefit of nutrient reduction	Equivalent annual cost over 30 yrs (\$ p.a.)	Outcomes
1	Dryland Agriculture	1.1	Gully Erosion Control	0.25	Protection of private land	Protection of native vegetation	Protection of wildlife reserves	1,556,000	Decrease in nutrient and sediment runoff
		1.2	Streambank Stabilisation	0.14	Protection of private land	Protection of remnants	Increase in native vegetation	1,908,000	Increased stream stability and improved water quality
		1.3	River Restoration	NC	Improved water quality	Community empowerment	Protection of riverine environs	240,000	Co-ordinated approach to river management
		1.4	Management of Intensive Animal Industries	0.04	Effective effluent reuse	Community empowerment	Improved water quality	1,105,000	Increased adoption of BMPs on farms – reduction in nutrient runoff
		1.5	Farm Nutrient Management	0.36	Efficient fertiliser application	Increased awareness of nutrient management	Improved water quality	67,000	Improved effluent management – reduction of pollutant export from dairy sheds
2	Forest	2.1	Forest and Public Land Activities	0.55	Improved roading	Awareness of private forestry practices	Protection of remnant vegetation	85,000	100% compliance with Code of Forest Practice
3	Urban	3.1	Stormwater Education Program	1.18	Reduced littering	Prevention of litter in stormwater	Improved water quality	53,000	Nutrient export reduced in priority urban areas
		3.2	Stormwater Management	NC	Improved litter management	Prevention of litter in stormwater	Improved water quality	200,000	Stormwater management plans produced and implemented in priority towns
		3.3	Wastewater System and Infrastructure	0.04	Increased recreation	Improved human health	Improved water quality	1,440,000	Decrease in nutrient exports from treatment plants
4	Research & Investigation	4.1	Coordinated Research and Investigation Program	NC	More efficient fertiliser application	Increased understanding of nutrient export	Improved nutrient management	To be costed	Increased understanding of nutrient contributors in the catchment
5	Monitoring	5.1	Monitoring and Evaluation of Action Plans	NC	Improved water quality	Awareness of water quality	Improved water quality	40,000	Identify where the gaps are in monitoring and develop a benchmark for water quality in the region
6	Coordination	6.1	Coordination and Implementation of Plan	NC	Reduction in BGA blooms	Awareness of nutrients to the contribution of BGA blooms	Improved water quality	55,000	Ensure implementation of the GHNMP

WHO SHOULD PAY?

Cost-sharing for the implementation of this plan follows the Victorian Government’s Cost-Sharing Guidelines for Nutrient Management (NRE, 1997). These are based on the premise that ‘no-one has the right to cause damage to waterways and everyone has a duty of care to ensure that their activities have a minimal impact on waterways’. CMA cost-shares for waterway health related activities are able to come from tariff replacement funding.

The guidelines are based on the following principles:

- The prime responsibility for paying the cost of a nutrient management activity rests with the individual, industry or authority that is responsible for the related nutrient contribution.
- Beneficiaries of nutrient management are encouraged to share in the cost.
- Government may share in the cost to facilitate the uptake of nutrient management so that broader environmental, economic and social objectives are met.

Table 5 summarises contributors of nutrients in different industries and the beneficiaries if action to control nutrient concentrations is addressed.



Figure 11: Basalt Plains - on-ground works in the region are targeting areas to increase bank stability (2000).

Table 5: Contributors and Beneficiaries

	Contributors	Beneficiaries
Agricultural Land Activities	Landholders	Landholders, downstream users, community, environment
Forested Land Activities	Private forestry, NRE (forestry on public land)	Tourists, downstream users, community, environment
Urban Activities	Urban dwellers, urban industry, local government	Downstream users, tourists, community, urban dwellers, urban industry, local government, environment
Sewage Upgrades	Water authorities (community & industry that uses the service), septic-tank owners	Downstream users, community, industry, septic tank owners, environment

PROGRAMS

Table 6: Summary of Action Plans for each Program

	Program		Action Plans		Activities	Priority	
1	Dryland Agriculture	1.1	Gully Erosion Control	1.1.1	Implement gully erosion control program in the priority subcatchments: Casterton Tablelands and Undulating Alluvial Plains.	High	
				1.1.2	Implement gully erosion control program in the medium priority sub-catchments: Dundas Tablelands, Friable Earths, Western region and South West Sands.	Medium	
		1.2	Streambank Stabilisation	1.2.1	Implement bank stabilisation in the following priority sub-catchments: Casterton Tablelands and Undulating Alluvial Plains.	High	
				1.2.2	Implement bank stabilisation, fencing and revegetation actions in the following sub-catchments: Dundas Tablelands, Friable Earths, Western Region and Basalt Plains area.	Medium	
		1.3	River Restoration Plans	1.3.1	Develop Restoration Plans for the following rivers: Grange Burn, Fiery, Burrumbeet and Brucknell Creek, Moyne, Wannon, Glenelg, Merri and Crawford.	High	
				1.3.2	Implement Restoration Plans for the following rivers Grange Burn, Fiery, Burrumbeet and Brucknell Creek, Moyne, Wannon, Glenelg, Merri and Crawford.	High	
		1.4	Management of Intensive Animal Industries	1.4.1	100% adoption of waste management on Dairy farms by applying programs to adopt Best Management Practice guidelines – high priority areas include Brucknell Creek.	High	
				1.4.2	Ensure adoption of current industry Code of Practice and BMPs for new and existing IAIs.	Low	
				1.4.3	Ensure compliance of current industry Code of Practice and BMPs for new and existing IAIs.	Low	
		1.5	Farm Nutrient Management	1.5.1	Apply extension programs to encourage adoption of better nutrient management on farms. Emphasis on dryland agriculture, dairy farms and horticulture.	Medium	
				1.5.2	Landholder adoption and implementation of BMP's on farms in the region.	Medium	
2		Forests	2.1	Forests, Parks and Public Land Activities	2.1.1	Continue to conduct audits to facilitate 100% compliance with the Code of Forests Practices for Timber Production on public land.	High
					2.1.2	Conduct audits to facilitate 100% compliance with the Code of Forests Practices for Timber Production on private land.	High
					2.1.3	Prepare Catchment Roding Improvement Plan for Shire roads.	Medium

	Program		Action Plans		Activities	Priority
3	Urban	3.1	Stormwater Education Program	3.1.1	Drain stencilling and stormwater education with schools and community in priority areas: Warrnambool, Ararat, Ballarat, Portland, Hamilton.	High
		3.2	Stormwater Management	3.2.1	Prepare Stormwater Management Plans for priority urban towns: Warrnambool, Ararat, Hamilton, Ballarat, Portland.	Medium
				3.2.2	Implement works as recommended in the individual SWMP.	Medium
		3.3	Wastewater System or Infrastructure	3.3.1	Upgrade of Sewage Treatment Plants (STPs) to meet SEPP – WoV and Memorandum of Understanding requirements.	High
				3.3.2	Assessment of need for sewerage small towns: Dunkeld, Lake Bolac and Skipton.	High
4	Research and Investigation	4.1	Co-ordinated research and investigation program	4.1.1	Develop and implement a co-ordinated research and investigation program.	High
				4.1.2	Support current nutrient program on nutrient loss from pastures.	Medium
				4.1.3	Investigate the apparent increase in nutrient loads in the Brucknell Creek.	High
				4.1.4	Investigate the apparent increase in nutrient loads in the Stony Creek and Crawford, Moyne and Merri Rivers.	Medium
				4.1.5	Investigate the impact of raised bed cropping on nutrient contributions.	Low
				4.1.6	Investigate the impact of blue-gum plantations on nutrient concentrations.	Low
5	Monitoring	5.1	Monitoring	5.1.1	Initiate a review of current algal bloom reporting .	High
				5.1.2	Review current water quality monitoring gauging stations in the catchment and develop good baseline data.	High
				5.1.3	Implement funding for continued monitoring in the region.	Medium
				5.1.4	Ensure continued Waterwatch monitoring.	High
6	Plan Coordination	6.1	Coordination of the Plan	6.1.1	Co-ordinate implementation of Nutrient Management Plan across the catchment.	High

1. Dryland Agriculture Program

Dryland Agriculture is the major landuse in the region with dairy predominant in the south of the region, owing to higher rainfall, and grazing and cropping industries predominant in the north. Throughout the region, erosion (the movement of organic and soil particles) is the primary cause of nutrient migration. In the south of the region, where more intensive agriculture is practiced, manure and fertiliser runoff (where nutrients are in solution) contribute significantly to nutrient migration.

Consequently the dryland agriculture program concentrates on reducing erosion and runoff which can be achieved through on-ground works and awareness. Awareness programs aim to increase the adoption of best management practice on farms, based on current understanding.

The action plans identified for dryland agriculture are:

- 1.1 Gully Erosion Control
- 1.2 Streambank Management
- 1.3 River Restoration Plans
- 1.4 Management of Intensive Animal Industries
- 1.5 Farm Nutrient Management

Gully erosion and streambank stabilisation works have already begun in many priority areas, see page 34. Maps 5 & 6 indicate the areas of high priority for this work as identified by loads, landuse and existing waterways management works plans.

Some research is needed to identify nutrient contribution from raised bed cropping and blue-gum plantations. This is discussed in more detail in 'Research and Investigation' (Program 4).

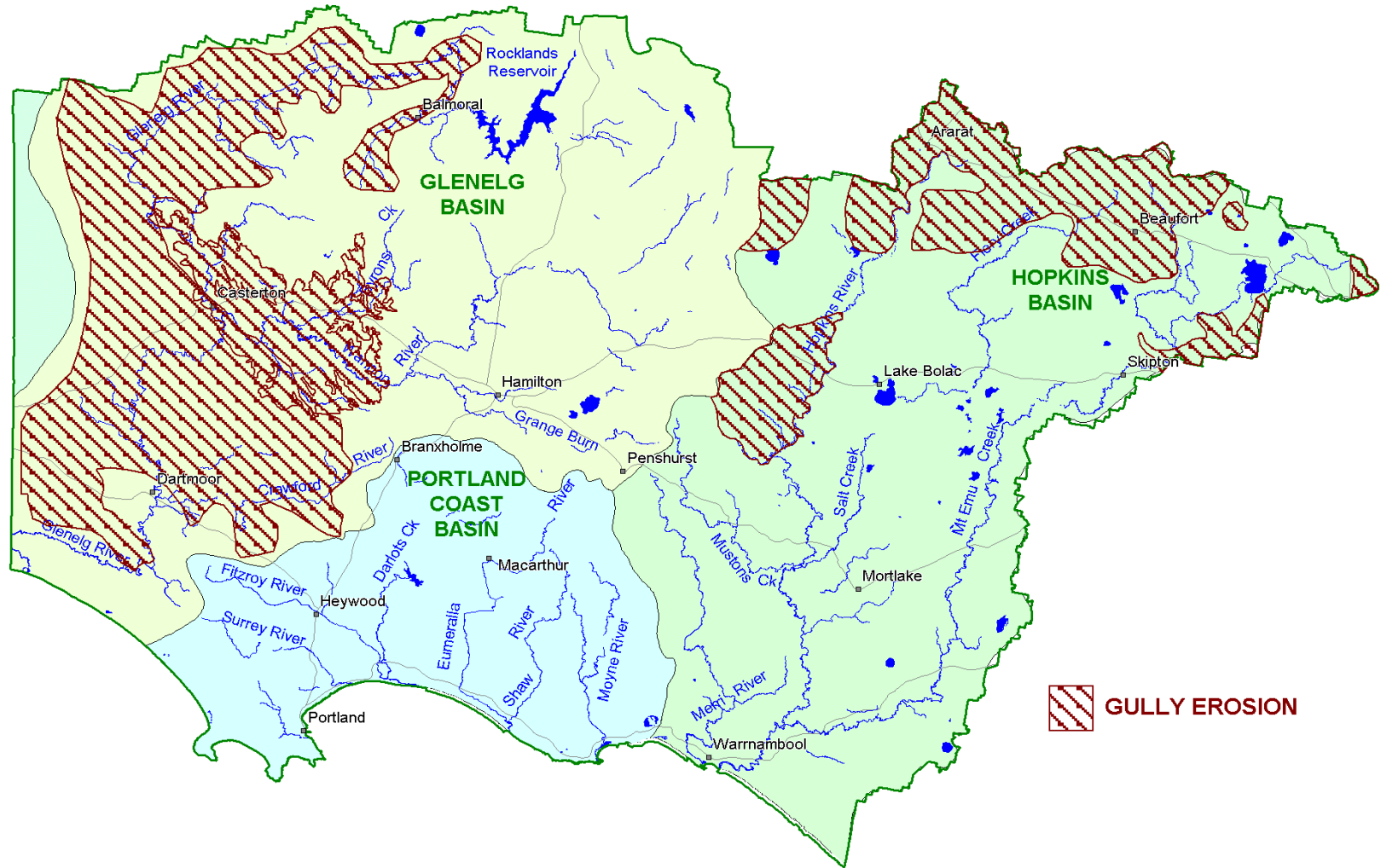
Most rivers in the region flow to the sea, however the Burrumbeet and Grange Burn flow to lakes and reservoirs where algal blooms have been reported. Action for the region's rivers focuses on developing and implementing river restoration plans.

For Action Plans 1.4 & 1.5 the plan recommends awareness campaigns to foster best practice in nutrient management and on-ground works.



Figure 12: Hopkins River, Chatsworth - old trees such as the one pictured are now scarce along the Hopkins River.

Map 5: Gully Erosion Control Priority Areas



1.1 Gully Erosion Control

Control measures for gully erosion aim to reduce the migration of nutrients such as phosphorus by moderating the direct action of water on the soils. One method of reducing the movement of soil particles by water is to moderate its speed.

Control measures include:

- Fence land classes;
- Build diversion banks, rock structures, silt-traps and grass waterways;
- Fence out gullies and revegetate with native species;
- Control rabbits;
- Manage pastures (matching grazing pressure with pasture growth);
- Establish perennial pasture (to maximise ground cover at the autumn break);
- Use minimum tillage and stubble retention in cropping areas;
- Use Best Management Practices for cultivation;
- Design and maintain farm tracks so that flow is not channelled into streams;
- Reclaim areas currently affected by erosion.

Gully erosion control in the region is estimated to cost \$1.6m (equivalent annual cost). The control actions are targeted to primarily, Undulating Alluvial Plains and Casterton Tablelands. In general, control areas are at the upper reaches of the catchment and in high priority RMU's that have highly erodible soils and where gully erosion is greatest. Through the actions addressing gully erosion in the plan, it is estimated the region will reduce the export of TP (Total Phosphorus) by 72 tonnes over 30 years. This reduction in nutrient migration will reduce the occurrence of algal blooms, bringing \$436,000 to \$833,400 benefits to the region.

Gully erosion control works have begun in the Mid Wannon catchment (Cavendish, Wannon and Coleraine), Ararat Hills (Ararat), Casterton Tablelands (Casterton) and Mid Hopkins catchment (Glenthompson and Chatsworth).



Figure 13: Casterton revegetation.

Table 7: Gully Erosion Control Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
1.1.1	Implement gully erosion control program in the priority sub-catchments: Casterton Tablelands, Undulating Alluvial Plains.	Decrease in nutrient and sediment run-off. Increased adoption of BMP's.	6.6Mill	589,000	10 yrs	High	Primarily: Landholders Secondary: GHCMA, DNRE	0-50% GHCMA ¹ 50-100% Landholders	Areas marked and assessed through the GHCMA mapping information database. <ul style="list-style-type: none"> • 150 gullies treated • 50% treated over 5 years
1.1.2	Implement gully erosion control program in the medium priority sub-catchments: Dundas Tablelands, Friable Earths, Western region and the South West Sands.	Decrease in nutrient and sediment run-off. Increased adoption of BMP's.	10.8Mill	967,000	10 - 25 yrs	Medium	Primarily: Landholders Secondary: GHCMA, DNRE	0-25% GHCMA ¹ 25-100% Landholders	<ul style="list-style-type: none"> • As above • 370 gullies treated • 50% treated over 20 years

*NPV - Net Present Value - a sum of all costs expected over the next 30 years

Equivalent annual cost - amount required if the cost is to be recouped each year

1. A combination of tariff replacement funds and/or other funding sources if available

1.2 Streambank Management

Control measures for streambank stabilisation aim to reduce the migration of nutrients through bank and instream erosion plus intercept and retain migrating nutrients from the land to waterways.

Control measures include:

- bank stabilisation;
- fencing and;
- revegetation.

Streambank Stabilisation in the region is estimated to cost \$2m (equivalent annual cost). The control actions are targeted to (Map 6):

- Soil type;
- Rate of soil erosion;
- Density of the vegetation within;
- Stream width;
- Area of the catchment above;
- Slope of the land;
- Intensity of runoff.

Through the actions addressing streambank stabilisation in the plan, it is estimated the region will reduce the export of TP (Total Phosphorus) by 39 tonnes over 25 years. This reduction in nutrient migration will reduce the occurrence of algal blooms, bringing \$246,000 to \$442,800 benefits to the region.

This Action Plan emphasises the link between land management and stream management issues to provide an integrated program of sedimentation and erosion management within the catchment.

Map 6: Streambank Stabilisation priority areas in the GHCMA region.

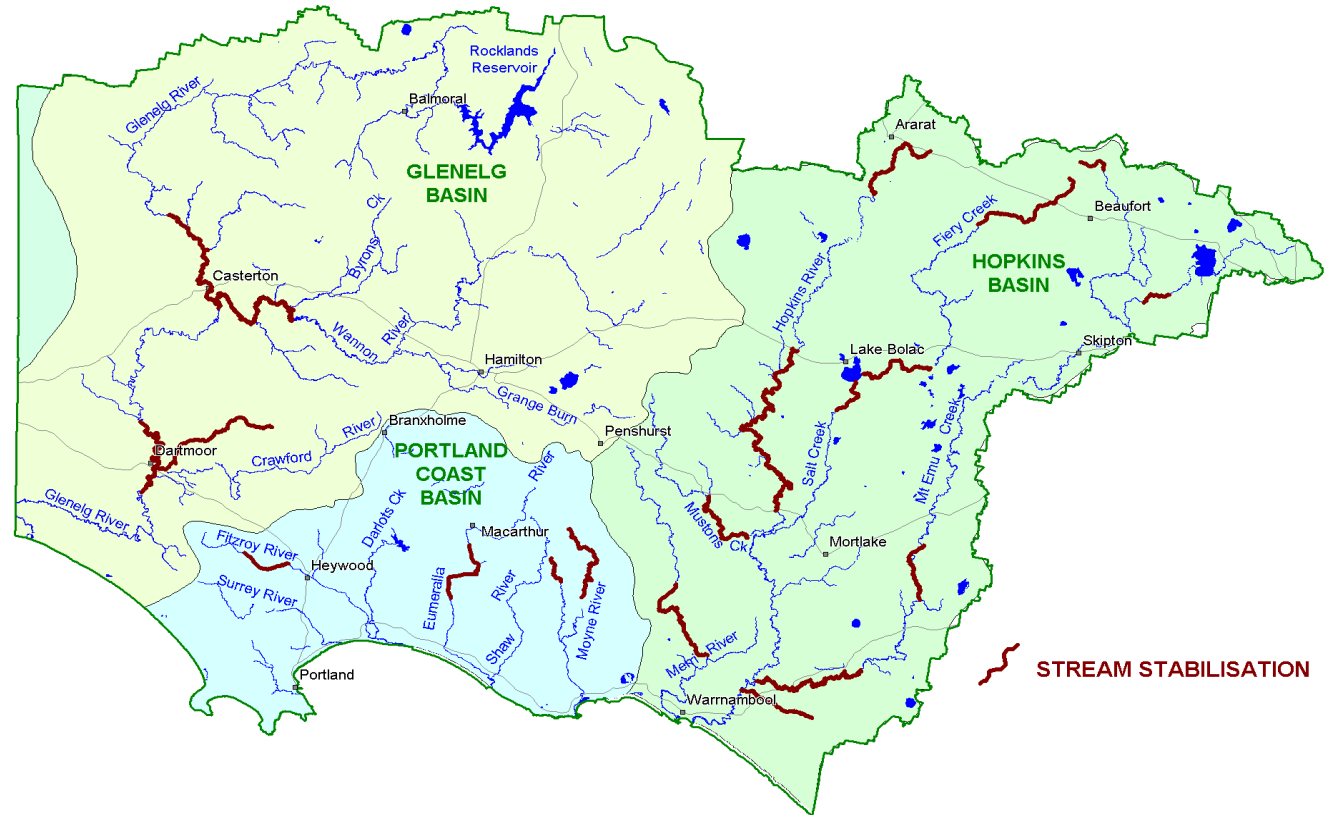


Table 8: Streambank Stabilisation Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
1.2.1	Implement bank stabilisation, fencing and revegetation actions in the following priority areas: Casterton Tablelands and Undulating Alluvial Plains.	Increased stream stability and improved water quality. 12.9 tonne reduction in TP.	2.8 Mill	604,000	10 yrs	High	Primarily: Landholders Secondary: GHCMA/NRE	0 - 50% GHCMA+ 50 - 100% Landholders	Monitor works in the following sub-catchments: Chetwynd River and the Upper and Mid Reaches of the Glenelg River, priority areas in the catchment. 250km of streambank stabilised and fenced per annum.
1.2.2	Implement bank stabilisation, fencing and revegetation actions in the following sub-catchments: Dundas Tablelands, Western Region and Basalt Plain areas.	Increased stream stability and improved water quality. 26.4 tonne reduction in TP.	6 Mill	1.3 Mill	10 - 25 yrs	Medium	Primarily: Landholders Secondary: GHCMA/NRE	0-25% GHCMA+ 25-100% Landholders	As above and monitoring of works in the following sub-catchments: Wannan River, Fiery and Salt Creeks and the Moyne and Eumeralla Rivers. 250km of stream bank stabilised and fenced per annum.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

+A combination of tariff replacement funds and/or other funding sources, if available.

1.3 River Restoration Plans

River restoration plans promote a whole-of-catchment approach to the management of public and private land. The purpose of a river restoration plan (Action 1.3.1) is to develop management goals and prioritise management actions for the restoration of waterways in priority sub-catchments. Priority sub-catchments are identified as rivers with high nutrient levels and poor stream stabilisation. A river restoration plan provides information for the whole length of the river which in turn will identify hot spots for nutrient management.

Due to the very different and unique characteristics of each river specific sub-catchment river restoration plans have become important and a high priority in the region

River restoration plans are a high priority as they address not only areas with known high nutrient loading and a higher incidence of algal blooms, but also address areas with high erosion, high salinity and poor stream stabilisation.

Table 9: River Restoration Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV	Equivalent annual cost#					
1.3.1	Develop River Restoration Plans for the Grange Burn, Fiery, Burrumbeet and Brucknell Creeks, Moyne, Glenelg, Wannon and Crawford Rivers.	Priority works identified. Co-ordinated approach to river management.	240,000	240,000	5 yrs	High	Primarily: GHCMA Secondary: Local Government NRE	50-100% GHCMA 0-50% State	Four plans completed after 2 years.
1.3.2	Implement River Restoration Plans for the priority rivers outlined in Action 1.3.1.	Increased co-ordination of river management. Works completed.		TBC ¹	On-going	High	Primarily: GHCMA	30% GHCMA 20% State 20% Local Government 30% Landholders	River Restoration Plans developed outlining high priority actions.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

1. TBC - To be costed.

1.4 Management of Intensive Animal Industries

Waste from Intensive Animal Industries (IAIs) can be a significant point source of nutrients into our waterways. While effluent collected at the point source may account for <10% of the total manure deposited on the farm, it has the potential to enter waterways in a concentrated flow if not managed effectively.

The Glenelg-Hopkins CMA, EPA, DNRE and the dairy industry are working together to identify how all dairy farmers can maintain effective dairy waste management in the region. There are nutrient benefits available to dairy farmers when effluent and manure is used to supplement or replace current fertilizer use for growing pasture and fodder crops. Extension programs can encourage practice change in landholders to use effluent nutrients to their benefit and to employ sound methods of managing effluent collection and storage. Current dairy effluent from some farms finds its way into streams, and there is a need to contain and monitor effluent discharges on farms.

The *State Environment Protection Policy (SEPP)– Waters of Victoria* (1988) requires that waste is retained within the boundary of the property. All dairies should manage waste to ensure compliance with that policy through appropriate practices that minimise and contain waste. Where possible, waste should be used as an on-farm source of nutrients and organic matter, to add value to farm products. Best Management Practice guidelines are currently being developed for effective dairy effluent management (DNRE 2000).

Of the IAIs, dairy is the most predominant industry in a list that includes piggeries, poultry and feedlots. With many landowners looking to diversify there is the possibility that there may be an increase in IAIs.

Table 10: Management of Intensive Animal Industries Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
1.4.1	100% adoption of waste management on dairy farms -Brucknell Creek is a high priority sub-catchment.	Improved effluent management. Reduction of pollutant export from dairy sheds. Nutrient reduction of 7.3 tonnes TP	11 Mill	1.1 Mill	10 Yrs	High	Primarily: Landholders Secondary: Industry EPA DNRE - Extension Programs	0-100% Landholders 0-20% GHCMA	100% compliance for dairy sheds in the Glenelg-Hopkins region. 20% compliance in the first year
1.4.2	Regulate adoption of current industry Code of Practice & BMPs for new and existing IAIs.	Reduction in nutrient export from IAIs.		TBC	On-going	Low	Primarily: Landholders Industry	100% Landholders	Relevant industry to monitor compliance with Codes.
1.4.3	Regulate compliance of current industry Code of Practice & BMPs for new and existing IAIs.	Reduction in nutrient export from IAIs.		TBC	On-going	Low	Primarily: EPA Industry Local Government	TBN	As above.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

1.5 Farm Nutrient Management

Whole Farm Planning (WFP) has been embraced as an effective method of integrating diverse environmental and productivity issues at the land manager level. WFPs should ideally reflect local sub-catchment plans plus land and water policies for the region and incorporate farm financial planning, which are integral components of sustainable agriculture. In this way it is possible for a WFP to knit together the wider catchment priorities with those of the farm and represents a powerful tool for beneficial natural resource outcomes. From a nutrient management perspective, WFPs offer an effective way to integrate reduction activities, such as soil erosion control, filter strips establishment and protection of areas prone to erosion such as stockyards, gateways and water troughs.

The “changing techniques” activities below incorporate an extension component to support landholder practice change to effective nutrient management. Extension programs already provide support for this change (Read *et al.*, 1999) particularly FarmBi\$, that includes a nutrient management program for farms which could be used more widely in the Glenelg-Hopkins catchment.

The “additional works” activities below aim to encourage implementation of practices that reduce nutrient migration and consequently minimise the occurrence of blue-green algal blooms.

The actions in this program recognise that each farm is unique and that each farm requires an appropriate mix of activities to minimise nutrient migration. For example a farm may adopt a combination of improved grazing and fertiliser management, restriction of access to waterbodies by livestock, improved native vegetation cover and the establishment of perennial pastures and filter strips.

The GHNMP will concentrate on extension of information to landholders, farm contractors and the link between their own actions and algal blooms that occur off-site in waterways and waterbodies. Moyne Shire region has been identified as a priority area due to high nutrient levels in the waterways and the change in diversity of land use. Greater diversity of landuse is occurring due to higher annual rainfall.



Figure 14: Filter strips - many landholders are planting filter strips to reduce runoff into streams (2000).

Table 11: Farm Nutrient Management Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
1.5.1	Apply extension programs to encourage adoption of better nutrient management on farms, emphasis on dryland agriculture, dairy farms and horticulture in the Moyne Shire.	Increased adoption of BMP on farms. 4 tonne reduction in TP.	2 Mill	67,000	On-going	Medium	Primarily: DNRE - Extension staff Secondary: Landholders	50-100% State 0-50% Federal ¹	150 farms visited and advice delivered on BMP (nutrients).
1.5.2	Implementation of BMPs in Moyne Shire <ul style="list-style-type: none"> • Appropriate fertiliser application to maintain vegetation cover; • Appropriate stocking rates; • Restriction of stock to waterways; • Establishment of perennial pastures or trees on highly erodable areas. 	Increased use of extension programs. Reduction in nutrient run-off . Planting of filter strips in high eroding areas- stockyards, gateways and troughs.		TBC	On-going	Medium	Primarily: Landholders	100% Landholder ²	Conduct survey to monitor rate of BMP adoption in the region and aim to link on-farm actions to the occurrence of algal blooms.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

1. Funding secured for one year.

2. Possibility of some funding from Government in future years in very high priority activities which have the greatest public benefits.

2. Forests, Parks and Public Land Program

Forests, Parks and Plantations

About 30% of the Glenelg-Hopkins region is covered in parks or forests. Sediment runoff from roads through forests and parks is considered to be a major source of nutrients from the forested areas of most catchments (Read *et al.*, 1999).

Audits of public native forest harvesting operations are conducted on a selective basis in the Glenelg-Hopkins region. In the western region two Forest Management Areas out of the total six Forest Management Areas are audited each year. Guidelines in the Code of Forests Practice (DNRE, 1996) mitigate erosion and sediment movement from roads and coupes. The application of the Code of Forest Practice would minimise sediment loss from coupes in public forest areas.

The Code of Forest Practice applies to both public and private forests and plantations and defines the requirements to protect water quality. The Code provides guidelines for timber harvesting, roading design and construction, stream and drainage line crossings, wet weather restrictions, maintenance of buffer strips and filter strips along streams and drainage lines. As yet, there has not been a similar formalised auditing system implemented for private forestry, although individual shires may undertake such audits on an “as needs” basis.

The formerly public owned softwood pine plantations have been privatised and there has been an increase in the amount of blue gum plantations in the region. Most of these plantations are managed to produce pulpwood. Unlike the forests on public land (Parks and State Forests), the shorter rotation in the plantations on private land means that there is potential for more frequent soil disturbance. This is much less, however, than would be experienced under alternative land uses. Further, relatively high application rates of fertiliser and pesticides are being used with the short term rotation plantations.

In summary, to minimise nutrient runoff, it is important that:

- road drainage and runoff areas are properly constructed to direct water into well vegetated areas and that those works are well maintained, particularly in close proximity to waterways and waterbodies;
- BMP's be adopted for fertiliser and other applications;
- appropriate buffers are maintained between logging operations and waterways and waterbodies.

Roads

Roads and erosion of roads were estimated to contribute about 55 % of the total nutrient loads from forested areas (Read *et al.*, 1999). Further, it was proposed that the adherence to BMP for road and forestry operations would lead to a 20% reduction in nutrients exported within the catchment from forestry operations.

Roads within public and private native forests and plantations are managed under the Code of Forest Practice. Roads within parks and other roads governed by local authorities are not managed under the Code of Forest Practice. A similar code should be applied to these areas for issues such as remodelling of old eroding sections of road and the stabilisation of some actively eroding gullies.

The implementation of Best Management Practice Guidelines for Road and Forestry Operations has a high benefit cost ratio. It is important to continue implementing the Code for Forest Practice to private forests.

Table 12: Forests, Parks and Public Land Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
2.1.1	Continue to conduct audits to monitor 100% compliance with the <i>Code of Forests Practices for Timber Production</i> on public land.	100% compliance with the Code in the region.	1.2 Mill	40,000	On-going	High	Primarily: NRE – Forest Services	100% NRE – Forest Services	Compliance to the Code audited in a regular rotation throughout the Glenelg-Hopkins region.
2.1.2	Conduct audits to monitor 100% compliance with the <i>Code of Forests Practices for Timber Production</i> on private land.	100% compliance with the Code in the region. Nutrient reduction of 3 tonne of TP.	1.2 Mill	40,000	On-going	High	Primarily: Local Government, Forestry Industry	100% Forestry Industry & Local Government	Compliance to the Code audited in a regular rotation throughout the Glenelg-Hopkins region.
2.1.3	Prepare Catchment Roding Improvement Plan for shire roads and roads within forests and parks.	Reduction in nutrient contributions from roadways.		45,000	1 year	Medium	Primarily: Local Government Secondary: NRE–Forest Services Parks Victoria VicRoads, Private Managers	Costs shared between -Local Government -DNRE -Parks Victoria -VicRoads -Private Managers	Assessment of current road conditions and address areas of concern.

*NPV - Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

3. Urban Program

Urbanisation increases the amount of runoff in the catchment by increasing the amount of sealed surfaces, including roads and footpaths, thereby reducing the amount of water infiltrating the soil, and through drainage systems designed to take water away swiftly. These features of urbanisation increase the velocity of the water, flood volumes and peak discharges, which all combine to increase the amount of pollutants carried by the flow. Stormwater contains fine and coarse particles and dissolved material pollutants including litter, vegetation, oil and grease, heavy metals (from vehicle emissions), and materials from vehicle wear (tyres and brakes, etc.). Urban nutrient movement is generally associated with industrial discharge, animal wastes, seepage from septic tanks and in sewer areas with sewer overflows (Chiew *et al.*, 1997).

The point sources, above, occur throughout the year and are particularly detrimental when flows are low (summer) as they fuel excessive weed and algal growth.



Figure 15: Drain stencilling - awareness program informing the community where stormwater flows to.

Action Plan 3.1, the stormwater community education program, would facilitate changes by encouraging the adoption of measures that reduce nutrient inputs. The Waterwatch program has already developed and delivered a stormwater awareness program in the region, which concentrated on school groups and the local community. Action 3.1 will be implemented in conjunction with Action 3.2 by the Shire Councils and Glenelg-Hopkins CMA in Warrnambool, Hamilton, Ararat, Wendouree (Ballarat), and Portland. The benefits of this partnership include the improved use of resources and better co-ordination of strategic planning across the region.

Action Plan 3.2 addresses the management of stormwater by local government and aligns with the Victorian Stormwater Action Program (VSAP), overseen by the Victorian Stormwater Advisory Committee (VSAC). VSAP, which was launched in June 2000, will assist local government and catchment managers to adopt improved environmental practice for urban stormwater management. Local government will develop and implement Urban Stormwater Management Plans (SWMPs) which, if approved, will attract funding from a 3 year, \$22.5 million State Government budget.

Action Plan 3.3 addresses wastewater systems and the upgrading of Sewage Treatment Plants (STP) to meet the State Environment Protection Policy (Waters of Victoria), Industrial Waste Management Policy and Industrial Waste Management Strategy. The key objectives of these policies are to: maximise the reuse of treated wastewater, discharge waste to land in preference to water, and conserve water resources.

3.1 Stormwater Community Education Action Plan

Stormwater management “best practices” are detailed in recent publications (EPA, MWC, NRE and MAV 1998) and have two aims: to limit changes to water quality and quantity at or near the source (source control), and to intercept or remove pollutants after they have entered waterways (stormwater treatment). Examples of Best Management Practices include (EPA, 1998):

- Use low phosphate detergents;
- Contain the runoff from car and machinery washing, which may have high loads of both detergent and sediment;
- Apply appropriate fertiliser rates to minimise nutrient in runoff from lawns and gardens;
- Use organic and slow-release fertilisers for lawns and gardens;
- Dispose of dog faeces appropriately.

Minor isolated events in households across the region can produce a significant cumulative effect upon regional water quality. Community extension offers a significant method to change attitudes and behaviour and improve ‘source control’.

Implementation of the stormwater community education action plan is estimated to reduce the export of Total Phosphorus (TP) by 11 tonnes. This reduction in nutrient mitigation will reduce the occurrence of algal blooms, bringing \$63,000 to \$113,400 benefits to the region.

Table 13: Stormwater Community Education Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost					
3.1.1	<p>Stormwater community education program:</p> <ul style="list-style-type: none"> • Drain stencilling and stormwater education with schools; • Assist schools in urban environmental program. <p>Program to be run initially in Ballarat, Hamilton, Warrnambool, Ararat, Portland.</p>	<p>Nutrient export to be reduced in priority areas as identified.</p> <p>Reduction of 11 tonnes of TP.</p>	90,000	53,000	On-going	High	<p>Primarily: Shire Council GHCMA - Waterwatch Program.</p> <p>Secondary: Schools and community groups.</p>	<p>50% Shires 50% CMA 0-50% State+</p>	<p>Survey current community awareness of stormwater quality and current household practices.</p> <p>The focus will primarily be on major towns (as listed) within two years, minor towns within five years.</p>

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

+Victorian Stormwater Action Program.

3.2 Stormwater Management Plans

With the release of the Urban Stormwater Best Practice Environmental Guidelines and the commencement of the three year Victorian Stormwater Action Program, the GHCMA is working with several shire councils in the region in developing stormwater management plans.

All shire councils manage and have responsibility for, stormwater systems in the region and influence stormwater quality through street cleaning, waste collection and road maintenance. The development of stormwater management plans will develop strategies to improve water quality by installing drain screens, outfall structures and wetlands, and will select actions by benefit cost analysis and public amenity criteria. SWMP's will be developed for all urban areas in the catchment region.

Table 14: Stormwater Management Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
3.2.1	Prepare stormwater management plans for: Warrnambool, Ararat, Hamilton, Ballarat, Portland.	Reduced nutrient loads entering waterways from urban areas.	\$6 mill	\$200,000	2 Years	Medium	Primarily: Local Government Secondary: CMA	0-50% CMA 0-50% State 50%Local Government	Four plans completed in the first year and one in the following year.
3.2.2	Implement work as recommended in the individual SWMP.	New works adopting SWMP recommendations.		TBC	On-going	Medium	Primarily: Local Government Secondary: EPA & GHCMA	0-50% State 50-100% Local Government	Local Government to implement SWMP with assistance from GHCMA and EPA.

*NPV Net Present Value - a sum of all costs expected over the next 30 years

Equivalent annual cost - amount required if the cost is to be recouped each year

3.3 Wastewater System and Infrastructure

Presently, wastewater treatment plants (WWTP) in the region contribute 14% of the total phosphorus load from licensed point sources and predominantly discharge to land. In the past WWTP outfalls have been discharged into waterways and this is still practiced where rainfall exceeds the 90% level or discharge is treated to higher tertiary standard. Both types of discharge to waterways require EPA agreement.

This Action Plan is in two parts, firstly upgrading WWTPs to meet State standards and secondly to assessing the need to sewer towns presently without WWTP. The upgrading options for WWTPs include tertiary treatment, total land disposal and maximising reuse which solely or in combination can reduce nutrient discharge to waterways.

The Water Authorities are presently examining a variety of upgrading options including purifying lagoon effluent and nutrient removal through the use of reed beds in tertiary treatment.

Action 3.3.2 addresses new sewerage services. The Victorian Government has made a commitment to provide a fairer and more consistent approach to the delivering and charging for new sewerage services across regional Victoria. The Government is providing \$22.5 million over three years to help water authorities reduce the cost to customers in 60 schemes across the State with the provision that a new town sewerage system has full community, EPA and Council support. The Government is also providing \$4 million in financial relief grants to households, which would still face financial hardship from plumbing costs to connect either new water or sewerage schemes.

Table 15: Wastewater System and Infrastructure Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
3.3.1	Upgrading of WWTP's to meet SEPP – Waters of Victoria and Memorandum of Understanding requirements.	Decrease in nutrient export from treatment plants. Reduction in 5.5 tonne of nutrient TP.	42 mill	1.4 mill	3 years	High	Primarily: Water Authorities Secondary: EPA	Cost-sharing as per Memorandum of Understanding.	Completion of the works and licensing will be monitored by the EPA.
3.3.2	Acting on the need to sewer small towns: Dunkeld ¹ , Lake Bolac.	Reduce nutrient concentrations entering waterways in the surrounding regions and groundwater infiltration. Reduction in 2.7 tonne of nutrient TP.	3.5 mill	455,896	5 years	High	Primarily: Local Government EPA Secondary: Water Authorities	As above.	Completion of the works and licensing will be monitored by the EPA.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

1. Community consultation has begun in Dunkeld.

4. Research and Investigation Program.

This Program identifies gaps in our current understanding of catchment processes and nutrient sources and recommends research activities to provide improved data for future plans. The recorded nutrient loads in the region were modelled against the Catchment Management Support System using relevant estimates and data.

For example current data on phosphorus (P) loss have been collected in paddocks but it is unclear how phosphorus availability changes from paddock to stream and then along wetlands and streams. Action 4.1.2 offers an opportunity to better understand this process, which, in turn, may uncover improved ways to prevent phosphorus migration to waterways.

Actions 4.1.2 to 4.1.5 address significant gaps in our understanding of the following issues:

- Raised bed cropping and its impact on nutrient loads;
- Blue gum plantation forestry and its impact on nutrient loads;
- The relationship between nutrient concentrations and the occurrence of algal blooms;
- The persistence of algal toxins when applied to agricultural land;
- The impact of algal blooms on wool and beef production;

Costs and appropriate cost-sharing arrangements for each action will be determined but will most commonly be shared between the GHCMA, State and Industry. This arrangement will ensure the vital knowledge to focus actions effectively on reduction of algal blooms can be generated.

Table 16: Research and Investigation Program

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
4.1.1	Develop and implement a co-ordinated research and investigation program.	Greater partnerships developed between leading agencies and research centres.		TBC	5 Years	High	Primarily: GHCMA in partnership with NRE	TBN	Greater understanding of different farming techniques on water quality.
4.1.2	Support for current project on nutrient loss from pastures (a sustainable grazing systems key project).	Support current Southwest component of the project.		64,000	5 Years	Medium	Primarily: GHCMA DNRE-Extension and Research	TBN	Understanding of nutrient loss from pastures in the region.
4.1.3	Investigate the increase in nutrient concentrations in the Brucknell Creek.	Increased understanding of nutrient contributors in the catchment.		TBC	On-going	High	Primarily: GHCMA	TBN	Benchmarking developed for nutrient loads in identified waterways.
4.1.4	Investigate the increase in nutrient concentrations in Stony Creek, Crawford and Merri Rivers.	Increased understanding of nutrient contributors in the catchment.		TBC	Ongoing	Medium	Primarily: GHCMA	TBN	Benchmarking developed for nutrient loads in identified waterways.
4.1.5	Investigate the impact of raised-bed cropping on nutrient contributions.	Increased understanding of nutrient contributors in the catchment.		TBC	2 Years	Low	Primarily: GHCMA & DNRE - Agriculture Victoria	TBN	Development of BMPs for raised bed cropping.
4.1.6	Investigate the impact of blue-gum plantations on nutrient concentrations.	Increased understanding of nutrient contributors in the catchment.		TBC	2 Years	Low	Primarily: GHCMA & DNRE - Agriculture Victoria	TBN	Development of BMPs for blue gum plantations.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

5. Monitoring Program

This program will ultimately allow assessment on the Plan's effectiveness in reducing nutrient loads entering waterways and thus reducing the occurrence of algal blooms in the Glenelg-Hopkins region. It provides a broader monitoring program that supplements the monitoring activity scheduled in Actions 1.4 and focuses on bloom frequency and regional water quality.

Monitoring results of water quality and bloom occurrence will allow feedback on the Plans impact and feed data into future planning activities. It is important that a broader resource monitoring program is undertaken to monitor changes in bloom frequency and regional water quality.

Table 17: Monitoring Program

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
5.1.1	Initiate a review of current algal bloom reporting and development of a database in the region.	Develop a greater understanding of the frequency of all algal blooms in the catchment.		TBC ¹	On-going	High	Primarily: Water Authorities, Dept of Human Services, NRE, Shires, GHCMA	To be negotiated	Comprehensive database developed for the continued recording of algal blooms.
5.1.2	Review current water quality monitoring gauging stations in the catchment.	Identify where the gaps are in monitoring and develop a benchmark for water quality in the region. Monitor/evaluate successful implementation of the GHNMP.		\$40,000	1 Year	High	Primarily: GHCMA NRE, EPA	100% GHCMA, NRE & EPA	Information on water quality is linked to landuse changes and projects being undertaken in the region. Water Quality monitoring meets evaluation needs of the GHCMA
5.1.3	Implement monitoring program.	Continued data collection and interpretation of nutrient levels.	1.2 M	\$40,000	On-going	Medium	Primarily: GHCMA NRE	To be negotiated	Long term monitoring information collected for water quality parameters.
5.1.4	Ensure continued Waterwatch monitoring.	Increase awareness of Water Quality issues.	3.6 M	\$120,000	On-going	High	Primarily: GHCMA Secondary: Water Authorities	50% Federal 50% Local	Increase community involvement in monitoring.

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

1. TBC - To be costed.

6. Plan Co-ordination Program

This program describes the co-ordination of the plan and supports the Glenelg-Hopkins CMA in assessing the implementation of the Plan. The co-ordination has 6 major roles:

- Ensure co-ordination between Agencies and other Stakeholders;
- Assist development of a works program to address the Plans' priorities (see pg 52-53);
- Provide technical information and advice on water quality issues to agencies and landholders;
- Prepare and coordinate funding bids which will address priorities;
- Compile annual reports on implementation of the Plan (see pg 52-53);
- Undertake review of the plan at five year intervals.

Table 18: Plan Co-ordination Action Plan

	Action	Outcomes	Cost (\$)		Time frame	Priority	Implementation Responsibility	Cost Share	Milestones
			30-year NPV*	Equivalent annual cost#					
6.1.1	Coordinate implementation of Plan across three CMA basins.	<p>Provide technical information and advice on water quality issues to agencies and landholders.</p> <p>Prepare and coordinate funding bids, which will address priorities.</p> <p>Compile annual reports on the implementation of the Plan.</p> <p>Undertake reviews of the Plan at five-year intervals.</p> <p>Assist development of the works program to address the Plan's priorities.</p>	1.6 Mill	55,000	On-going	High	<p>Primarily: GHCMA</p> <p>Secondary: DNRE</p>	50-100% State 0-50%GHCMA	<p>Targets set in Plan are met.</p> <p>Plan is reviewed and updated at 5yr intervals.</p> <p>Maintain input into the 5 year rolling business plan.</p>

*NPV Net Present Value - a sum of all costs expected over the next 30 years.

Equivalent annual cost - amount required if the cost is to be recouped each year.

Table 19: Implementation and Evaluation of Plan

Action Plans	Objectives	Outcomes	Timeframe (year)	Equivalent cost per year#	Annual Reporting	Expected Nutrient Reduction over 20 years
Gully Erosion Control	Reduce nutrient load contributions Reduce sediment load contribution	150 gullies treated 370 gullies treated	2001 - 2011 2011 - 2026	\$589,000 \$967,000	Report annually on the number of gullies treated in the region Audit over five years for success	22% reduction of nutrients (TP) entering waterways
Streambank Stabilisation	Reduce nutrient load contributions Reduce sediment load contribution	600km of streambank protected and riparian vegetation re-established 2000km of streambank stabilised and fenced	2001 - 2011 2011 - 2026	\$604,000 \$1.3 Mill	Report annually on the length of waterway protected and revegetated	11% reduction of nutrients (TP) entering waterways
River Restoration	To maintain and improve riverine environs	River restoration plans completed for high priority rivers: <ul style="list-style-type: none"> • Grange Burn • Burrumbeet Creek • Fiery Creek • Brucknell Creek • Moyne River • Wannon River • Crawford River • Glenelg River 	2001 - 2006	Approximate cost of a River Restoration Plan is \$30,000	Completion of at least one plan each year.	
Farm Nutrient Management	Increase awareness of the relationship between nutrient concentrations and algal blooms	50 farms visited each year and advice delivered on Best Management Practice (nutrients)	On-going	\$67,000	Report on the number of farms visited each year plus on farm works undertaken.	12% reduction of nutrients (TP) entering waterways
Management of Intensive Animal Industries	Reduce the risk of blue-green algal blooms Reduce nutrient load contributions	150 farms visited each year and advised on effective dairy effluent management 20% of Effective Effluent Systems in the region in 2001	2001 - 2006	\$1.1 Mill	Report on number of farms visited each year and installing effective effluent management systems	2.5% reduction of nutrients (TP) entering waterways
Forest and Public Land Activities	To reduce the risk of algae blooms in the region Reduce nutrient load contributions	Prepare Catchment Road Improvement Plans – on Shire roads Conduct audits to facilitate 100% compliance with the Code of Forests Practices – Public forests	2002 Ongoing	\$40,000 \$45,000	Improved drainage on eroding roads in the region – Number of Councils adopting plan Audit – sediment control on roads in the region Audits are conducted on a regular basis by NRE – Industry Audit reports on compliance produced annually	2% reduction of nutrients entering waterways (TP)

Action Plans	Objectives	Target	Timeframe	Equivalent cost per year	Annual Reporting	Expected Nutrient Reduction over 20 years
Urban Activities	To develop a greater understanding and awareness of the movement of nutrients in the catchment and reduce nutrient loads	Stormwater Education: drain stencilling completed in all towns in the catchment. Local Government implementation of Stormwater Management Plans	On-going On-going	\$53,000	Surveys conducted to identify current awareness. Report on the number of community groups involved in Stormwater Management 10 organisations visited each year	5% reduction of nutrients entering waterways (TP)
Research and Investigation	Develop a greater understanding of the movement of nutrients in the catchment Develop a greater understanding of the availability of nutrients to fuel algal growth	Greater understanding of nutrient movement Understand the movement of nutrients in relation to blue gums and raised bed cropping	On-going 2005	\$64,000 TBC	Monitoring program developed for Brucknell and Stony Creeks Partnerships formed with relevant organisations undertaking research into nutrient movement	
Monitoring	To maintain and improve riverine environments throughout the region Develop a greater understanding of the movement of nutrients in the catchment Develop a greater understanding of the availability of nutrients to algal growth	Review the current water quality monitoring stations in the region and implement a practicable monitoring program	On-going	\$40,000	The monitoring program is used to identify the changes in water quality with relation to on-ground works that are occurring in the region.	
Plan Co-ordination	To reduce the risk of blue-green algal blooms within the Glenelg-Hopkins catchment	Co-ordinate the implementation of the Glenelg-Hopkins Nutrient Management Plan across the region	On-going	\$55,000	Report annually on the implementation of the Nutrient Management Plan GHNMP is reviewed every five years	
TOTAL				\$4.95 Mill		54.5% reduction of nutrients entering waterways (TP)

#All costs will increase each year based on NPV.

CONCLUSION

This plan uses a practical approach that works through existing programs to reduce nutrient loading in the region over the next 30 years. Through 6 key Programs the Plan offers the community a method of reducing increasing the risk of regional BGA blooms.

The Glenelg-Hopkins Waterways Implementation Committee considers that the Plan will make a major contribution to environmental sustainability in the region. They welcome a wide range of community resources to implement the Plan and are pleased to be able to co-ordinate the Plan for the generations that follow.

This plan links closely to, and is complimentary to, the Salinity Action Plan, Waterways Strategy, Biodiversity Strategy, Regional Vegetation Strategy, Weed and Rabbit Action Plans.

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APPENDIX ONE

Table 20: Incremental Costs for Nutrient Management in the Glenelg-Hopkins Region

Incremental costs of nutrient reduction represents the costs of avoiding a one kilogram increment of TP or TN, and provide a guide to the cost effectiveness of each potential nutrient reduction activity. This allows a ranking of the relative priorities which should be afforded to each type of activity. However, it is also important to note that activities upstream of priority waterbodies may still be a high priority as the ‘incremental benefits’ of the activity may still mean that the overall benefit:cost ratio is good.

Nutrient Management Actions	Incremental costs (\$/kg/yr)	
	TP	TN
Urban stormwater education program	\$5	\$2
BMP for forests	\$11	\$1
Farm nutrient management	\$16	\$0
Gully erosion control - Medium	\$19	\$2
Sewage treatment plants	\$19	\$4
Gully erosion control - High	\$26	\$3
Streambank Stabilisation - High	\$47	\$8
Streambank Stabilisation - Medium	\$50	\$5
Intensive animal industries	\$152	\$20
Sewer small towns	\$424	\$1190

APPENDIX TWO

Table 21: Recorded Algal Blooms at waterbodies and waterways in the Glenelg-Hopkins region

Following are the waterbodies that have recorded algal blooms in the region.

Glenelg		
Location	Algae	Comments
Dunkeld	Anabaena	CuSO ₄ dosing
	Oscillatoria	CuSO ₄ dosing
Lake Hamilton	Anabaena & Microcystis	Monitored
Merino Basin	Phormidium	Monitored
Rocklands Res.	Botryococcus	Monitored
Hopkins		
Alexander Lake	Anabaena & Microcystis	Warning Signs
Brierly Basin	Anabaena & Pseudoanabaena	
Caramut Res.	Chroococcus	Monitored, 3 weeks
Caramut Water Supply	Ulothrix & Euglena	Monitored
Deep Lake	Microcystis	Warning Signs
Green Hill Lake, Ararat	Microcystis	Drinking, rec. facilities banned
Hopkins River Boonerah	Unicellular green	Monitored
Lake Burrumbeet	Microcystis & Oscillatoria	Closed to recreation
Lake Cartcarrong	Anabaena	
Lake Gellie	Oscillatoria	Warning Signs
Lake Gilleear	Anabaena	Warning Signs
Lake Terrinallum	Oscillatoria	Warning Signs
Mt Ewen Res.	Anabaena	CuSO ₄
Hopkins River	Anabaena	Monitored
Tank Hill Res.	Struastrum & Aphanizomenon	CuSO ₄
Portland		
Aringa Res.	Anabaena	Closed
	Anabaena	Closed to recreation

APPENDIX THREE

Table 22: Regional Management Units

Following is the area of each Regional Management Unit as defined in the plan.

RMU Region	Glenelg	Hopkins	Portland Coast	Total	Area %
<i>Basalt Plain</i>	2,100,000	6,100,000	2,300,000	10,500,000	41.0%
<i>Casterton Tableland</i>	800,000			800,000	3.1%
<i>Coast Complex</i>	640,000	62,000	280,000	982,000	3.6%
<i>Desert Sands</i>	85,000			85,000	0.3%
<i>Dundas Tableland</i>	940,000			940,000	3.7%
<i>Friable Earths</i>		270,000		270,000	1.0%
<i>Grampians</i>	1,600,000			1,600,000	6.3%
<i>South West Sands</i>	3,200,000		850,000	4,050,000	15.8%
<i>South West Wimmera Plains</i>	1,120,000			1,120,000	4.3%
<i>Stoney Rises</i>	21,000	820,000	440,000	1,280,000	5.0%
<i>Tertiary Plain</i>		210,000	72,000	282,000	1.1%
<i>Undulating Alluvial Plains</i>	1,800,000			1,800,000	6.7%
<i>Western Alluvial Plains</i>		180,000		180,000	0.7%
<i>Water Body</i>	60,000	69,000		129,000	0.4%
<i>West Coast Plain</i>		170		170	<0.1%
<i>Western Footslopes</i>		50,000		50,000	0.18%
<i>Western Hills</i>		500,000		500,000	1.8%
<i>Western Low Hills</i>	100,000	700,000		800,000	3.1%
<i>Western Mountains</i>		100,000		100,000	0.4%
<i>Western Terraces</i>	410,000	340,000		750,000	3.0%
<i>Wimmera Plains</i>	3,000			3,000	0.01%
Grand Total	12,390,000	9,400,000	3,900,000	25,600,000	100%

APPENDIX FOUR

ACKNOWLEDGEMENTS

The development of this plan, and the preceding draft plans for each basin, has involved the contribution of many people. Listed below are the individuals and organisations represented and involved in developing the Plan.

Glenelg-Hopkins Waterways Implementation Committee

Ken McLeod	Chairman
Gavin Jamieson	City Of Ballarat
Peter Forster	Community
Kevin Drinkell	Community
Paul Battista	Community
John Anderson	Community
John Sherwood	Deakin University
Greg Bell	DNRE
Hilary Turner	GHCMA
Ian Ross	GHCMA
Kevin Safe	Glenelg Water Authority
Peter Reeve	Warrnambool City Council
Gillian Holmes	Project Officer

Glenelg Nutrient Advisory Committee

Greg Bell	DNRE
Greg Creek	EPA Geelong
David Hedlam	VFF Geelong DC
Keith Jackson	DNRE
Rod James	VFF Geelong DC
Pam Leeming	Farmer Hamilton
Jane Rapkins	Waterwatch Co-ordinator
Don Robertson	VFF Hamilton DC
Ian Ross	Glenelg CMA Board
Kevin Safe	Glenelg Water Authority
Ian Stewart	Southern Grampians Shire
Garry Smith	Theiss Environmental
David Venning	VFF Hamilton DC
Cathy Wagg	DNRE (Project Officer)

Hopkins Waterways Committee

Cr David Bailey	Shire of Pyrenees
Micheal Boyd	DNRE
Pat Caruso	Southern Rural Water
Chris Harty	Shire of Corangamite
Clive Jamieson	Landholder
Richard Jamieson	VFF
Neville Oddie	Southern Rural Water
Cr Peter O'Rorke	Rural City of Ararat
Peter Reeve	Shire of Moyne
Glen Rundell	City of Warrnambool
Basil Ryan	Glenelg-Hopkins CMA Board
John Sherwood	Deakin University
Ian Stewart	Shire of Southern Grampians
Russell Worland	South West Water Authority

Community engagement was incorporated into the development of the plan through public meetings with approximately 40 people attending. The draft plan was available for comment for three months with 25 submissions being received during that period.

APPENDIX FIVE

Table 23: Benefit:cost ratios of options considered for the Plan

The following table illustrates the “Do Everything” option. From this table it can be seen that the most cost effective option has been chosen for the implementation of the Plan.

Actions	Equivalent annual cost over 30 years (\$ p.a.)	Percentage reduction in region’s total TP export	Benefit:Cost Ratios	Actions chosen in the final GHNMP
Gully control – High priority RMUs	\$589,000	18.4%	0.25	*
Gully control – Medium priority RMUs	\$967,000	13%	0.32	*
Gully control – Low priority RMUs	\$235,000	1.9%	0.16	
Streambank Fence/reveg – High priority RMUs	\$604,000	10.7%	0.14	*
Streambank Fen/reveg – Medium priority RMUs	\$1,300,000	8.3%	0.12	*
Streambank Fen/reveg – Low priority RMUs	\$109,000	0.2%	0.03	
Urban Stormwater Education Program	\$53,000	3.6%	1.18	*
Urban wetlands for stormwater	\$3,334,000	6.5%	0.03	
Sewer small towns	\$1,448,000	1.1%	0.01	*
Wastewater system and Infrastructure	\$2,700,000	1.1%	0.04	*
Septic tank BMPs	\$384,000	0.3%	0	
Dairy	\$1,105,000	2.1%	0.04	*
Farm nutrient management – changing technique	\$67,000	1.4%	0.36	*
Farm nutrient management – additional works	\$19,383,000	14.2%	0.01	
BMP for forests	\$33,000	0.9%	0.55	*

APPENDIX SIX

Table 24: Environmental Significance

The following information addresses the environmental significance of each regional management unit (RMU). The table also addresses the risk of deterioration associated with high nutrient levels in the catchment.

Regional Management Unit	Environmental Feature/Asset	Environmental Significance	Potential Environmental Risks	Priority
Basalt Plains	Woorndoo-Hopkins Wetlands ¹ Muddy Creek ² Hopkins River – Framlingham Forest ² Hopkins Falls ² Lake Linlithgow ² Brucknell Creek ³ Eastern Barred Bandicoot ⁴	Listed as a significant wetland Assists in the drainage of water from private land Public Land Reserve Scenic Reserve Lake Reserve High nutrient levels recorded (VWQMN) Listed as a threatened species	Threatened wetland May become extinct	High
Casterton Tablelands	Wannon River ²	High species diversity	Loss in species diversity	High
Coast Complex	Lower Glenelg River ¹² Port Fairy to Warnambool ²	Coastal Reserve Glenelg River – Heritage River with endangered species (pygmy perch, prickly back crayfish) Coastal Reserve Listed as a significant wetland	Loss of threatened species	High
Desert Sands				Low
Dundas Tablelands	Wannon River ²	Eroded, exposing the underlying Rocklands Rhyolite Extensive remnants of native vegetation	Loss of native vegetation	High
Friable Earths	Rocklands Reservoir ²	Highly erodible soils – increased sedimentation	Loss of water quality	High
Grampians	Grampians National Park ²	<ul style="list-style-type: none"> • Natural ecosystems • Water supply • Sites of geological, archaeological and historical significance 	Loss of wildlife	High
South West Sands	Lower Merri River Wetlands ¹⁵	Highly erodible soils	Increased sedimentation	Low
South West Wimmera Plains	Black Swamp ²	Freshwater Marsh - High species diversity	Loss of species diversity	Medium
Stoney Rises	Nerrin Nerrin Reserve ² Nerrin Nerrin Wetlands ¹	Wildlife Reserve Listed as a significant wetland	Loss of significant wetlands	High

Tertiary Plain	Hopkins River			Medium
Undulating Alluvial Plains	Hopkins River ⁵	Eroded Sites of Biodiversity Significance		Medium
Water Body	Tower Hill ² Lake Bolac ²	Wildlife Reserve – Geological Monument Recreational Body		High
West Coast Plain				Low
Western Alluvial Plains	Brucknell Creek ³			High
Western Foothslopes	Hopkins River ⁶	High gully erosion	Increased sedimentation	High
Western Hills	Fiery Creek ⁶			Medium
Western Low Hills	Hopkins River			Medium
Western Mountains				Low
Western Terraces	Crawford River ² Yambuk Lake ¹	Crawford Lake – Wildlife Yambuk Wetlands	Loss in species diversity	High
Wimmera Plains				Low

1. Directory of Important Wetlands in Australia
2. Land Conservation Council – 1990
3. Victorian Water Quality Monitoring Network
4. Flora and Fauna Guarantee Act – 1998
5. Moyne Shire Biodiversity Study – 2000
6. Rabbit Action Plan - 2000

APPENDIX SEVEN

Nutrient reduction targets are provided to give a guide of the possible decrease in nutrient loads entering the waterways. The following information provides the assumptions that will assist in reducing nutrients entering waterways. If the programs are not fully adopted by stakeholders, then the nutrient reduction target may not be achieved.

Table 25: Nutrient Reduction Targets

Program	Outputs	Nutrient Reduction Targets	Assumptions
Dryland Agriculture	<p>520 gullies treated over 25 years.</p> <p>2600km of streambank protected and riparian vegetation established.</p> <p>50 farms visited each year and advice delivered on BMPs (nutrients).</p> <p>100% of Effective Effluent Systems in the region over 5 years.</p>	<p>22% reduction in Total Phosphorus (TP) entering the waterways.</p> <p>11% reduction in TP entering the waterways.</p> <p>12% reduction in TP entering the waterways.</p> <p>2.5% reduction in TP entering waterways.</p>	<p>All gully heads treated to reduce the movement of sediments entering waterways.</p> <p>Streambanks are fenced off and vegetated to reduce erosion, through stock access. Vegetation provides a filter strip to reduce the impact of excess nutrients entering the streams.</p> <p>BMPs are adopted on-farm and are at least 15% efficient in reducing nutrient movement from paddock to waterways.</p> <p>All dairy farms in the region are compliant with SEPP-WoV and now effluent is leaving the property.</p>
Forests, Parks and Public Land	<p>Audits are conducted to facilitate 100% compliance with the Code of Forests Practices, for both private and public forestry.</p>	<p>2% reduction in TP entering waterways.</p>	<p>Private forestry is compliant with the Code of Forests Practices.</p>
Urban	<p>SWMP developed for each Shire Council in the region.</p>	<p>5% reduction in TP entering waterways.</p>	<p>Implementation of Stormwater Management Plans that are developed for each Shire Council in the region.</p> <p>Education of stormwater issues included in Council operations.</p>

