

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA

WATER RESOURCES - TOXIC ALGAE

**A report from the Senate Standing Committee on
Environment, Recreation and the Arts**

DECEMBER 1993

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Cover: *Anabaena circinalis*

Inset: Algal bloom on the Darling River, November 1991

Photographs by D Eastburn and R Banens

Murray-Darling Basin Commission

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Terms of Reference

On 7 May 1992, the Senate referred to the Committee an inquiry on Water Resources - Toxic Algae. The terms of reference were as follows:

- a) The management of water, water use and water quality and the agencies involved, including those in Commonwealth, State/Territories and Local Government; and
- b) the impacts of agricultural, industrial and domestic use of and inputs to Australia's inland waterways, including rivers, tributaries, streams, creeks, lakes and underground waterways,

and, in keeping with ecologically sustainable development, the Committee inquire particularly into:

- c) whether flows allocated for environmental needs should be required in regulated rivers, or licence to divert should be restricted to enable adequate flows to be maintained;
- d) the extent to which nutrients should be reduced by removal of wastewater, feedlot runoff, irrigation flows and agricultural runoff; and
- e) the impact of these issues on continued sustainable farming, and the economic and social impacts on rural communities,

commencing with an inquiry into the impact of toxic algae upon Australian waterways.

Recommendations

Sewage Treatment

Recommendation 1

The Committee recommends in relation to sewage treatment works as a matter of urgency that:

- relevant local authorities be advised by the Commonwealth and State/Territory governments of the amount of possible funding available and the realistic timeframe for the provision of government funds to upgrade sewerage systems; and
- current funding mechanisms be revised to ensure that local governments are encouraged to take preventative actions where it is economically and environmentally beneficial to do so (Paragraph 2.10).

Recommendation 2

The Committee recommends that, following receipt of the forthcoming ARMCANZ report, a review of policies at all levels of government be conducted to ensure the consideration of alternative sewage treatment options when upgrading sewerage systems (Paragraph 2.11).

Recommendation 3

The Committee recommends the implementation of policies by the relevant authorities at all levels of government stipulating achievable minimum effluent standards for point source nutrient pollution (Paragraph 2.12).

Recommendation 4

The Committee recommends that the development of the National Water Quality Management Strategy include an urgent review by the responsible authorities of the efficiency of existing sewerage systems to establish their performance levels relative to their capacity to remove nutrients (Paragraph 2.13).

Recommendation 5

The Committee recommends that the development of the National Water Quality Management Strategy include urgent attention being given by responsible authorities to situations where effluent overflows or bypasses sewage treatment plants (Paragraph 2.14).

Recommendation 6

The Committee recommends that the development of the National Water Quality Management Strategy include information relating to the successful use of treated sewage for irrigation being circulated to local communities who might take advantage of this approach (Paragraph 2.15).

Recommendation 7

The Committee recommends that the development of the National Water Quality Management Strategy include provision for a full environmental impact assessment being conducted prior to establishing any land disposal site for sewage (Paragraph 2.16).

Phosphates in Detergents

Recommendation 8

The Committee recommends that existing and proposed campaigns to achieve lower phosphate levels in detergents through marketing strategies be continued (Paragraph 2.19).

Recommendation 9

The Committee recommends that if a significant reduction in levels of phosphorus in detergents has not been achieved within two years then legislation be enacted to reduce levels or to ban phosphates in detergents (Paragraph 2.22).

Recommendation 10

The Committee recommends that if the reduction in the levels of phosphorus in detergents is to be addressed through legislation then the manufacturers be given reasonable time to develop new or improve existing products (Paragraph 2.26).

Recommendation 11

The Committee recommends that a national approach be adopted in relation to truth in labelling for detergent manufacturers in relation to phosphate levels (Paragraph 2.26).

Septic Tanks

Recommendation 12

The Committee recommends that as part of the development of the National Water Quality Management Strategy, ARMCANZ take steps to ensure that there is a mandatory requirement to have septic tanks de-sludged on an annual basis as a condition of installation (Paragraph 2.30).

Urban Runoff

Recommendation 13

The Committee recommends that as part of the development of the National Water Quality Management Strategy, the provision of dual reticulation systems for the use of 'grey water' be considered in the development of new housing estates on a national basis (Paragraph 2.31).

Recommendation 14

The Committee recommends that as part of the development of the National Water Quality Management Strategy, adequate treatment of storm water runoff to prevent nutrient pollution of waterways be incorporated as an integral part of the planning of new urban developments (Paragraph 2.33).

Data on Nutrient levels

Recommendation 15

The Committee recommends that all data collected by government instrumentalities in relation to nutrient levels be made available to other agencies and the public (Paragraph 2.66).

Water Allocations

Recommendation 16

The Committee recommends that as part of the development of the National Water Quality Management Strategy, no further irrigation water entitlements be issued in any area until it has been established that there is adequate water available to meet the environmental requirements of the downstream sections of the waterway after existing allocations have been used (Paragraph 2.73).

Unregulated Flows

Recommendation 17

The Committee recommends that the Commonwealth Government use its influence to facilitate the urgent consideration of further controls on the unregulated sections of major waterways to ensure the passage of environmental flows and water for downstream users (Paragraph 2.76).

Off-Allocation Flows

Recommendation 18

The Committee recommends that as part of the development of the National Water Quality Management Strategy, urgent attention be given to feasibility of the continued use of off-allocation flows, and that the communities concerned be advised accordingly (Paragraph 2.76).

Recommendation 19

The Committee recommends that as part of the development of the National Water Quality Management Strategy, urgent attention be given by the responsible authorities to the feasibility of meeting existing water allocations in the future, including those that have been granted but not yet used, and that the communities concerned be advised accordingly (Paragraph 2.76).

Environmental Flows

Recommendation 20

The Committee recommends that the Commonwealth Government use its influence where possible to facilitate the introduction of environmental allocations nationally after consideration of the legal, social and economic implications (Paragraph 2.79).

Flood Plains

Recommendation 21

The Committee recommends that as part of the development of the National Water Quality Management Strategy, the approval of future developments be dependent on an assessment of the impact on downstream flood plains (Paragraph 2.80).

Public Concerns

Recommendation 22

The Committee recommends that contingency plans be required to outline the procedures to be carried out at local, State/Territory and Commonwealth levels in the event of algal blooms (Paragraph 3.22).

Recommendation 23

The Committee recommends that as part of the development of the National Water Quality Management Strategy, water managers and health departments be provided with sufficient information in relation to the treatment of algal blooms for them to be able to make timely decisions in relation to the management of water bodies (Paragraph 3.22).

Recommendation 24

The Committee recommends that communities be informed of the reasons for decisions taken by water managers and health departments to address toxic algal blooms in their areas (Paragraph 3.22).

Public Warnings

Recommendation 25

The Committee recommends that:

- a set of guidelines outlining the procedures and responsibilities of water managers and health authorities to provide adequate public warnings be developed; and
- a comparative study of the effectiveness of various warning mechanisms be undertaken and water managers be advised of the full range of options available (Paragraph 3.27).

Recommendation 26

The Committee recommends that it be part of the procedures for advising the public of the presence of algal blooms that notification should also be given when the danger has subsided (Paragraph 3.28).

Monitoring

Recommendation 27

The Committee recommends that a national set of guidelines in relation to the monitoring of algal blooms be adopted as soon as practicable (Paragraph 3.35).

Recommendation 28

The Committee recommends that the Commonwealth Government give consideration to providing the necessary resources for the collation and analysis of the available historical data on algal blooms, nutrient levels and flow rates (Paragraph 3.40).

Recommendation 29

The Committee recommends that consideration be given to the establishment of a number of long-term national reference monitoring sites (Paragraph 3.41).

Legislation

Recommendation 30

The Committee recommends that the development of new legislation or other regulatory measures be required to demonstrate that due consideration has been given to the link between the natural resource industries and the environment (Paragraph 4.7).

Regulatory Mechanisms

Recommendation 31

The Committee recommends that as part of the National Water Quality Management Strategy, regulatory mechanisms be reviewed to ensure that the respective responsibilities and roles of various government agencies are clearly defined (Paragraph 4.8).

Incentive Schemes

Recommendation 32

The Committee recommends that as part of the National Water Quality Management Strategy, consideration be given to the effectiveness of incentive schemes for improving agricultural techniques in relation to maintaining water quality (Paragraph 4.10).

Community Awareness

Recommendation 33

The Committee recommends that as part of the National Water Quality Management Strategy, the state of community awareness in relation to algal blooms be assessed so that specific problem areas can be identified (Paragraph 4.28).

Preventative Action

Recommendation 34

The Committee recommends that as part of the National Water Quality Management Strategy, a review be conducted of government policies to establish whether there is potential to provide incentives for members of the community to undertake preventative actions in relation to maintaining water quality (Paragraph 4.44).

National Water Quality Management Strategy

Recommendation 35

The Committee recommends that the guidelines for the National Water Quality Management Strategy be based on environmental criteria as well as physio-chemical factors (Paragraph 4.61).

Recommendation 36

The Committee recommends that the guidelines for the National Water Quality Management Strategy be sufficiently flexible to accommodate the natural variability in Australian freshwater ecosystems (Paragraph 4.61).

Recommendation 37

The Committee recommends that the development of performance indicators to measure the effectiveness of outcomes of proposed strategies in relation to water quality be an integral part of integrated catchment management (Paragraph 4.62).

Integrated Catchment Management

Recommendation 38

The Committee recommends that adequate funding of integrated catchment management bodies be ensured, possibly as a proportion of the total expenditure on resource management (Paragraph 4.64).

Recommendation 39

The Committee recommends that community representatives be elected by their communities to positions on integrated catchment management committees (Paragraph 4.67).

Government Policies

Recommendation 40

The Committee recommends that the relevant government agencies be required to demonstrate that due consideration has been given to the impact of individual policies on other government or community programs in accordance with a multi-objective approach to management of resources (Paragraph 4.73).

Recommendation 41

The Committee recommends that the relevant government agencies be required to demonstrate that due consideration has been given to the integrated catchment approach in the implementation of economic and regulatory measures (Paragraph 4.76).

Research Funding

Recommendation 42

The Committee recommends that the current level of Commonwealth Government funding for research be maintained if not increased, and that consideration be given to long-term funding security for approved research projects (Paragraph 4.92).

CHAPTER 1

INTRODUCTION

1.1 When blue-green algae (cyanobacteria) occur in excessive numbers in water supplies they can have detrimental effects on human health, stock and the environment and can cause severe economic losses to aquaculture, fishing and tourist industries. The occurrence of toxic blue-green algae blooms is a world wide phenomenon¹ and among those causing concern are species of *Nodularia*, *Anabaena*, *Aphanizomenon*, *Oscillatoria* and *Microcystis*.²

1.2 Algal blooms were reported in the Darling River in 1830³ and in Lake Alexandrina, South Australia in 1878.⁴ In 1903 one case of 'Barcoo Fever' in Queensland was attributed to blue-green algae.⁵ Algal blooms have been a regular feature in areas such as Chaffey Dam near Tamworth,⁶ Lake Alexandrina in South Australia⁷ and Peel Harvey Inlet in Western Australia,⁸ but have been dealt with on a local basis. In November 1991 algal blooms in New South Wales extended over 1000 kilometres of the Darling River⁹ and a State of Emergency was declared because of the severity of the situation. This incident focussed the

1 National Herbarium of New South Wales, Submission No.4, p.1.

2 Jackson A, Runnegar M, Falconer I and McInnes A (1985) 'Cyanobacterial (Blue-green algae) Toxicity of Livestock', in *Plant Toxicology* Ed. Seawright A, Hegarty M, James L and Keeler R, Queensland Poisonous Plants Committee, Yerongpilly Qld, p.500.

3 'What can be done about toxic algal blooms?' *Ecos* 72 Winter 1992: 14-19, p.14.

4 Francis G (1878) 'Poisonous Australian Lake,' *Nature*, 2 May 1878, pp.11-12

5 Queensland Water Quality Task Force, *Interim Report on Freshwater Algal Blooms in Queensland*, 31 July 1992, p.7; Hayman, J (1992) 'Beyond the Barcoo - probable human tropical cyanobacterial poisoning in outback Australia', *Medical Journal of Australia* 157: 794-96.

6 Sinclair, Evidence, 5 August 1993, p.735.

7 Burch, Evidence, 12 August 1993, pp. 769-70.

8 Bursill, Evidence, 12 August 1993, p.770.

9 Cullen, Submission No.42, p.2.

attention of the community and governments on what had finally become recognised as a national problem.

1.3 In some areas in recent years there has been a common perception of a sharp increase in the incidence of toxic algae in Australia¹⁰ which may reflect the increased media attention.¹¹ As a result of continued public concern, on 7 May 1992 the Senate Standing Committee on Environment, Recreation and the Arts was given a reference to inquire into Australia's water resources. The Committee was required to inquire into:

- a) The management of water, water use and water quality and the agencies involved, including those in Commonwealth, State/Territories and Local Government; and
- b) the impacts of agricultural, industrial and domestic use of and inputs to Australia's inland waterways, including rivers, tributaries, streams, creeks, lakes and underground waterways,

and in keeping with ecologically sustainable development, the Committee was to inquire particularly into:

- c) whether flows allocated for environmental needs should be required in regulated rivers, or licence to divert should be restricted to enable adequate flows to be maintained;
- d) the extent to which nutrients should be reduced by removal of waste water, feedlot runoff, irrigation flows and agricultural runoff; and
- e) the impact of these issues on continued sustainable farming, and the economic and social impacts on rural communities,

10 District Council of Meningie, Submission No.3, p.2; Chaffey Dam Catchment Management Advisory Committee, Submission No.25, p.1; Van Dok, W, Hart, B and Boyle, R (1991) *Algal Problems in Victoria*, Water Studies Centre, Monash University, December 1991, p.1.

11 New South Wales Blue-Green Algae Task Force, Final Report, *Blue-Green Algae*, August 1992, p.18.

commencing with an inquiry into the impact of toxic algae upon Australian waterways.

1.5 Although the impact of toxic algae upon Australian waterways is the main consideration of this report, all of these issues are interrelated and shall be dealt with accordingly. This report provides a brief summary of the physical and chemical factors attributed to causing outbreaks of algal blooms in chapter 2. Chapter 3 looks at the implications in terms of the health effects, the public concern generated and the economic and environmental issues. This chapter also covers the techniques for prediction, monitoring, management and control of algal blooms. Chapter 4 looks at the roles of the three levels of government and the community in a national approach to management of algal blooms and in respect to integrated catchment management. Chapter 5 provides a summary and conclusions.

1.6 The serious implications for the economy and the level of public concern have resulted in the allocation of substantial resources to research and management of algal blooms. During the course of this inquiry, the Committee has seen evidence of significant developments in the cooperation and coordination of State/Territories, local and Federal governments with the community in some areas, although more needs to be done. Notwithstanding this national approach, it is important to put algal blooms in perspective in relation to other water resource issues. This report addresses those issues.

Conduct of the Inquiry

1.7 The terms of reference were advertised in newspapers with a national coverage in May 1992. The Committee received 104 submissions and a number of supplementary submissions which are listed in Appendix 1.

1.8 The Committee examined 95 witnesses at 15 public hearings representing 51 individuals or organisations (See Appendix 2). The hearings commenced in Canberra on 11 September 1992. Before the public hearing in Shepparton on 24 September 1992, the Committee visited the Murray-Darling Freshwater Research Centre and the sewage treatment works. The next day the Committee held a public hearing in Melbourne. Following a visit to Perth on 22 October 1992, the Committee inspected the Peel Harvey Inlet, Mandogalup vegetable

areas, Mundijong sheep assembly areas, Pinjarra and Dawesville Channel.

1.9 The first hearing for 1993 was held in Melbourne on 27 July 1993. A series of hearings was then held in Sydney on 2 August 1993, Windsor, Dubbo and Walgett on 3 August 1993, Cubbie Station and Dalby on 4 August 1993 and Moree and Tamworth on 5 August 1993. Further hearings were held in Adelaide on 12 August 1993 and Canberra on 27 August 1993. A round table conference was held on 26 November 1993 to discuss with experts and representatives of key agencies the priorities and future directions of algal bloom management.

Acknowledgments

1.10 The Committee wishes to thank all the people who contributed to the inquiry by preparing written submissions, by giving oral evidence or by assisting with the arrangements for public hearings and inspections. The Committee is grateful for the interest shown and the advice provided. Although it was not possible to invite all of those who made submissions to give oral evidence or to mention all submissions in the report, the Committee took into account all of the material provided in the preparation of its report.

CHAPTER 2

CAUSES OF ALGAL BLOOMS

Introduction

2.1 A great deal of information has been gained in recent years about the chemical and physical features which promote the development of algal blooms, although significant information gaps still persist. It is essential that, if management strategies are to be developed enabling the cost effective control of algal blooms, further research be done into a number of critical areas which are still little understood. Areas such as the dynamic instream processes in relation to nitrogen to phosphorus gradients and the physio-chemical basis for environmental flow issues require further attention.

2.2 Blue-green algae can assimilate nutrients while near the bottom of the water body and have the capacity to form vacuoles (i.e. internal cavities) which float the organism to the upper zone where light is more abundant; the photosynthetic processes then collapse the vacuoles allowing the algae to sink to the lower nutrient rich zones. This enables these organisms to utilise optimum levels of both light and nutrients. Blue-green algae also have the capacity to 'overwinter' in the form of akinetes or other resting phases¹² which may remain viable during unfavourable conditions.¹³ These features, as well as the capacity to fix nitrogen, give the cyanobacteria a strong competitive edge over other organisms, particularly under stratified conditions in calm, nutrient rich waters, enabling them to form blooms.

Chemical Features

2.3 The elements carbon, hydrogen and oxygen which are required for algal growth are readily available in water. Other essential elements include nitrogen and phosphorus. There is also evidence that nitrogen

12 'Akinetes' are asexual reproductive or resting cells which develop a thick wall around a concentrated food reserve.
National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.8.

13 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.36.

to phosphorus ratios are important.¹⁴ Many blue-green algae can fix nitrogen but rely on dissolved phosphorus in the water. Genera such as *Anabaena* can fix atmospheric nitrogen, while *Microcystis* cannot. *Microcystis* blooms such as those in Lake Mokoan could be controlled by limiting the available nitrogen.¹⁵ Phosphorus is, however, the main avenue of control because of the sensitivity of both nitrogen fixing and non-nitrogen fixing species.

Sources of Phosphorus

2.4 The principal sources of phosphorus are the sediments, soil erosion, agricultural runoff, fertiliser applications, industrial effluent, urban runoff and sewage treatment plants. Total phosphorus levels in New South Wales rivers increased 5 per cent annually for the past 18 years prior to 1992.¹⁶ Horticulture, urbanisation and septic tanks have significantly contributed to the eutrophication of lakes in the Perth area.¹⁷ Total phosphorus levels exceeded 200 $\mu\text{g/l}$ (micrograms per litre) during the 1991-92 Darling/Barwon algal blooms.¹⁸ There is considerable evidence that the development of algal blooms reflects the increased levels of phosphorus in waterways.

2.5 The control of phosphorus levels may be addressed from two approaches: the control of nutrients within the water body (sediment release, precipitation) or the control of sources within the catchment (soil erosion, fertiliser, sewage). In Japan, England and Germany both catchment and in-lake controls are used simultaneously.¹⁹ In relation to the control of nutrients within the water body, Agriculture and

14 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, pp.42/70; Murray Darling Basin Commission *Algal Management Strategy. Technical Advisory Group Report*, April 1993, p.3.

15 Cullen, Submission No.42, p.3.

16 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.119.

17 Environmental Protection Authority, Western Australia, Submission No.43, p.3.

18 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.60.

19 Burns, Supplementary Submission 31(a), p.2.

Resource Management Council of Australia and New Zealand (ARMCANZ) workshop in 1993 considered there to be inadequate information to be able to predict the fluxes in nutrient levels in water bodies²⁰ thus making the control of sources within the catchment the primary avenue of control in many situations.

2.6 The critical levels of phosphorus sufficient to support the development of algal blooms appear to differ depending on the local environment. Professor Cullen was of the view that if the level of total phosphorus could be reduced to less than 50-80 micrograms per litre ($\mu\text{g/l}$) during the low flow periods in summer, this might reduce the frequency of algal blooms.²¹ The Ballarat Water Board and the West Moorabool Water Board reported the possibility of algal bloom occurrence increasing when phosphorus levels exceeded 25 $\mu\text{g/l}$.²² In Denmark, in shallow nonstratified water bodies, the threshold for algal blooms was five times that required in deep stratified water bodies where 20 $\mu\text{g/l}$ was sufficient for algal bloom development.²³ Reducing the levels of phosphorus may not achieve a reduction in the incidence of algal blooms if the phosphorus levels achieved are still above the critical threshold²⁴ sufficient to support the development of algal blooms.

Point Sources

2.7 The Committee was told that point sources of phosphorus played a much greater role in the development of algal blooms in Australian inland waters than that released from the sediments.²⁵ The major point sources included sewerage works, septic tanks, urban runoff, irrigation drains, industrial waste and animal industries, such as feed lots, dairies, poultry farms and piggeries.

20 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

21 Cullen, Submission No.42, p.2.

22 Ballarat Water Board and West Moorabool Water Board, Submission No.44, p.3.

23 Australian National Industries Ltd, Submission No.39, p.10.

24 Wealands, Evidence, 25 September 1992, p.222.

25 Bayly, Submission No.60, p.1.

(a) *Sewerage Systems*

2.8 Phosphorus from sewage is more readily available to the algae than that from non-point sources. In Western Australia, only 20 per cent of phosphorus in rivers is attributed to point sources²⁶ while almost 60 per cent of the phosphorus entering the Darling system in the dry season is from sewage.²⁷ Reduced phosphorus levels can be achieved by use of best available technology and improved operator strategies.²⁸ The technology of effluent treatment is available and it is now a matter for funding priorities.²⁹

2.9 There are 69 sewage treatment plants on the Murray-Darling and some of the large municipalities contribute substantial amounts of phosphorus. For example, Toowoomba sewage produces 75 tonnes of phosphorus per annum.³⁰ Only three of these treatment plants have the capacity to remove phosphorus.³¹ ANI-Kruger Pty Ltd estimated that the phosphorus input into the river system could be reduced by 374 tonnes by improved treatment plants at the ten cities which produced the most phosphorus.³² The Federal and State/Territory governments are currently working on a joint program to upgrade these facilities.³³

26 Environmental Protection Authority, Western Australia, Submission No.43, p.2.

27 Bayly, Submission No.60, p.1.

28 National Water Quality Management Strategy. *Water Quality Management in the Rural Environment. A reference document.* August 1992. Australian Water Resources Council, p.16.

29 Australian National Parks and Wildlife Service, Submission No.82, p.6.

30 Clewitt, Evidence, 4 August 1993, p.675.

31 CSIRO, Submission No.72, p.11.

32 Towns, Evidence, 2 August 1993, p.519. The ten cities were: Toowoomba, Orange, Bathurst, Tamworth, Dubbo, Gunnedah, Moree, Inverell, Narrabri and Dalby.

33 Minister for Primary Industries and Energy, The Hon S Crean: Address to the AWRC and ANZECC National Conference on Water Quality Management and Ecologically Sustainable Development: Delivering the Opportunities. Adelaide 3-4 December 1992, p.6.

2.10 The Committee was told that there was a perception that various government monies would be available for the installation and upgrading of sewage treatment works and that decisions would not be made by councils until that was resolved.³⁴ The Committee was concerned that this might result in significant delays in the upgrading of sewage treatment works. It may be that the current funding mechanisms are acting as a disincentive to local governments to undertake preventative actions by delaying decisions until the situation is sufficiently critical to ensure Commonwealth and State/Territories financial assistance.

Recommendation 1

The Committee recommends in relation to sewage treatment works as a matter of urgency that:

- . relevant local authorities be advised by the Commonwealth and State/Territory governments of the amount of possible funding available and the realistic timeframe for the provision of government funds to upgrade sewerage systems; and**
- . current funding mechanisms be revised to ensure that local governments are encouraged to take preventative actions where it is economically and environmentally beneficial to do so.**

2.11 The Committee was also told that there was a tendency for governments to focus on the lowest installation cost rather than the operating aspects when deciding on a suitable treatment plant.³⁵ The Agriculture and Resource Management Council of Australia and New Zealand is preparing design and operations manuals for alternative low cost sewerage options. This approach will be effective in situations where the system will be adequate for future development in the area, where there is a low rate base and the community accepts alternative technologies.

34 Towns, Evidence, 2 August 1993, p.520.

35 Towns, Evidence, 2 August 1993, p.520.

Recommendation 2

The Committee recommends that, following receipt of the forthcoming ARMCANZ report, a review of policies at all levels of government be conducted to ensure the consideration of alternative sewage treatment options when upgrading sewerage systems.

2.12 The stipulation of an achievable minimum effluent standard is an outcome oriented approach which encourages the use of the best available technology for point sources.³⁶ Considerable success has been recorded with the Lower Molonglo sewage treatment works achieving a level of <0.3 milligrams per litre (mg/l) phosphorus.³⁷ Phosphorus removal can also be achieved by using ferric salts or lime but this is expensive and may be unsuitable because of the increased salinity.³⁸ Current biological techniques for phosphorus removal are unreliable but show future potential.³⁹

Recommendation 3

The Committee recommends the implementation of policies by the relevant authorities at all levels of government stipulating achievable minimum effluent standards for point source nutrient pollution.

2.13 The Committee was told that the effectiveness of existing treatment works would also be improved if the operators could use the equipment more skilfully.⁴⁰ The National Water Quality Management Strategy includes guidelines for effluent from sewerage systems but the Committee is also concerned that should include a review of existing systems.

36 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.16.

37 Commonwealth Environment Protection Agency, Submission No.93, p.13.

38 Bayly, Submission No.60, p.1.

39 Bayly, Submission No.60, p.2-3.

40 Cullen, Evidence, 27 August 1993, p.859.

Recommendation 4

The Committee recommends that the development of the National Water Quality Management Strategy include an urgent review by the responsible authorities of the efficiency of existing sewerage systems to establish their performance levels relative to their capacity to remove nutrients.

2.14 There is also a need to consider effluent that is never treated but overflows or bypasses sewage treatment plants.⁴¹ The Committee was also told that the Sydney sewerage system frequently overflows.⁴² This problem is of particular concern to the Committee.

Recommendation 5

The Committee recommends that the development of the National Water Quality Management Strategy include urgent attention being given by responsible authorities to situations where effluent overflows or bypasses sewage treatment plants.

2.15 Other methods to deal with waste discharge include land disposal, such as irrigated wood lots. Towns such as Walgett and Collarenebri do not discharge sewage into the river system.⁴³ The Moree Plains Shire Council re-uses the effluent to irrigate Greenbah Oval and is looking at proposals for the golf course and other properties.⁴⁴ The Shepparton Water Board has trial agroforestry projects⁴⁵ and the Gunnedah Shire Council proposes to use effluent for irrigation of parks and fields and commercial ventures⁴⁶.

41 Cullen, Evidence, 27 August 1993, p.860.

42 Higgins, Evidence, 2 August 1993, p.487.

43 Austin, Evidence, 3 August 1993, p.634.

44 Jones, Evidence, 5 August 1993, p. 697.

45 Shepparton Water Board, Submission No.97, p.10.

46 Gunnedah Shire Council, Submission No. 101, p.1.

Recommendation 6

The Committee recommends that the development of the National Water Quality Management Strategy include information relating to the successful use of treated sewage for irrigation being circulated to local communities who might take advantage of this approach.

2.16 Land disposal of sewage may not always be appropriate, as it may pollute ground water⁴⁷ and its suitability depends on the soil type and the height of the water table.⁴⁸ In situations where land disposal options are being contemplated, it is essential that the capacity of the receiving system be known and the sustainability of the system be considered to ensure that ground water supplies are not contaminated. There must be suitable land available in an appropriate location, and wet weather runoff must be able to be controlled.

Recommendation 7

The Committee recommends that the development of the National Water Quality Management Strategy include provision for a full environmental impact assessment being conducted prior to establishing any land disposal site for sewage.

2.17 The Australian Water Resources Council (AWRC) has looked at a number of alternative low cost sewerage options⁴⁹ for small communities, and Minister for Primary Industries and Energy, the Honourable Simon Crean has announced a program of stand-alone sewerage systems.⁵⁰ The Queensland Department of Primary

47 New South Wales Blue-Green Algae Task Force, Submission No.53, p.4.

48 Bayly, Submission No.60, p.1.

49 Wealands, Private Briefing, 26 November 1993, p.8.

50 McDonald, Private Briefing, 26 November 1993, p.7.

Industries and Zootech are researching the possible use of culture of zooplankton to sewage lagoons to produce fish food.⁵¹

(b) *Detergents*

2.18 A significant proportion of phosphorus in sewage comes from laundry detergents, and the national average level of phosphorus in Australian laundry detergents is 5.3 per cent.⁵² The costs of removing phosphorus from effluent rise rapidly as target levels are lowered and quantities of phosphorus increase⁵³ and it may be less expensive to remove phosphorus from detergents rather than phosphates from effluent. New South Wales has taken steps to collect more data on the contribution of total phosphorus from detergents.⁵⁴ The Committee was told that 30-50 per cent of total phosphorus in sewage was from detergents, according to the Sydney Water Board's figures.⁵⁵ The New South Wales Government has now signed an agreement with the detergent industry in relation to truth in labelling, and a move towards new products entering the market not having more than the 5 per cent phosphorus level.⁵⁶

2.19 Other countries have achieved lower phosphate levels through marketing strategies which apply public pressure on the manufacturing companies.⁵⁷ The New South Wales Government is undertaking a phosphorus awareness campaign which will involve all three levels of government and the community. In 1994 these programs will be launched in a number of centres throughout the state.

51 Minister for Industry, Technology and Regional Development, Submission No.89, p.5; Zootech (Australia), Submission No.68, p.7.

52 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.125.

53 CSIRO, Submission No.72, p.11.

54 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.127.

55 Cullen, Evidence, 27 August 1993, p.859.

56 Minister for Land and Water Conservation, Media Release, 23 November 1993, p.1.

57 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.124.

Recommendation 8

The Committee recommends that existing and proposed campaigns to achieve lower phosphate levels in detergents through marketing strategies be continued.

2.20 Encouraging the voluntary use of low phosphorus detergents is a way of involving the community to 'do their bit' for the environment and can extend public awareness to the careful use of fertilisers, herbicides and pesticides. There is a concern, however, that if phosphorus is removed from detergents, communities may think that the problem is solved, particularly if there are successive years of high rainfall during which algal blooms are less frequent.⁵⁸

2.21 There was some support for a national approach to the determination of acceptable levels of phosphates in detergents.⁵⁹ The ARMCANZ aims to develop a strategy by April 1995 to minimise the impact of phosphorus in detergents.⁶⁰ The Committee urges the hastening of the ARMCANZ-Australian and New Zealand Environment and Conservation Council (ANZECC) joint process to resolve this matter.⁶¹ The Committee is concerned that continued publicising of opposing views by government agencies will confuse the public and have an adverse effect on the Integrated Catchment Management (ICM) movement.

2.22 The introduction of legislation in relation to phosphate levels in detergents may assist facilitation of a national standard determined by agreement between the States and Territories. Several countries have legislated for low phosphate levels in detergent. For example, an amendment to the *Canada Water Act* (RSC 1985C11) limiting phosphorus in laundry detergents to 2 per cent has resulted in

58 Blackmore, Evidence, 27 August 1993, p.912.

59 Blackmore, Evidence, 27 August 1993, p.913.

60 Agriculture and Resource Management Council of Australia and New Zealand *Phosphates in Detergents*. Report on ARMCANZ Resolutions, pp.1-2.

61 ARMCANZ and ANZECC are currently working together to develop a national approach to dealing with phosphorus levels in detergents.

significantly reduced algal blooms in Lake Erie.⁶² In contrast the Committee was told that the banning of phosphates in detergents in Italy did not result in improved water quality.⁶³

Recommendation 9

The Committee recommends that if a significant reduction in levels of phosphorus in detergents has not been achieved within two years then legislation be enacted to reduce levels or to ban phosphates in detergents.

2.23 The Committee was told that the removal of phosphorus from detergents is the quickest way of reducing the phosphorus input into waterways⁶⁴ and may provide savings on the additional treatment of sewage to remove phosphorus.⁶⁵ It was suggested to the Committee that the introduction of a levy on detergents was a possible source of revenue⁶⁶ which could be used for remedial work on research as well as act as a disincentive to use detergents with high phosphorus contents.

2.24 Algal blooms usually appear during low flow periods when the major source of nutrients is sewage treatment plants. The impact of reducing phosphorus levels in detergents may be greater than expected on the basis of average nutrient loads particularly if campaigns are targeted at communities in sensitive rural areas.⁶⁷ Before regulation could be implemented there would need to be sufficient information on the impacts and the cost benefits of that approach.

2.25 There was some concern that the removal of phosphate from detergents might be counter-productive if it required greater use of

62 Jones, Submission No.11, p.2.

63 Murray River Management Board and Murray Irrigation Area and Districts Management Board, Supplementary Submission No. 52(a), p.2.

64 Banens, Evidence, 27 August 1993. p.912.

65 Higgins, Evidence, 2 August 1993, p.485.

66 Lambert, Evidence, 27 August 1993, p.892.

67 Banens, Evidence, 27 August 1993, p.912.

surfactants which, might have detrimental environmental impacts.⁶⁸ However, Professor Jones reported that apparently environmentally safe substitutes had been used in Canada.⁶⁹ Some Australian detergents contain relatively safe substitutes such as zeolite, sodium silicate and sodium carbonate. There is some concern about the ecological implications of some alternative additives.⁷⁰

2.26 Australian detergent manufacturers may need 3-4 years to develop their own phosphorus free detergent. They need to be sent a clear signal as soon as possible in relation to levels of phosphorus⁷¹ and in relation to truth in labelling.⁷² If suitable Australian products are to be developed, consideration should be given to the development of industries, such as the zeolite industry, which produce substitute products. The time needed for the industry to develop appropriate products does not preclude the implementation of legislation which could formalise a phasing in period.

Recommendation 10

The Committee recommends that if the reduction in the levels of phosphorus in detergents is to be addressed through legislation then the manufacturers be given reasonable time to develop new or improve existing products.

Recommendation 11

The Committee recommends that a national approach be adopted in relation to truth in labelling for detergent manufacturers in relation to phosphate levels.

68 Commonwealth Environment Protection Agency, Submission No.93, p.13.

69 Jones, Submission No.11, p.3.

70 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report.* April 1993, p.42.

71 Cullen, Evidence, 27 August 1993, p.875.

72 Agriculture and Resource Management Council of Australia and New Zealand. *Phosphates in Detergents.* Report in Progress on ARMCANZ Resolutions, p.3.

2.27 The debate over the best approach to dealing with phosphorus levels in detergents is very polarised and is causing considerable confusion within the community. Even if phosphorus is removed from detergents there will still need to be treatment of effluent to remove other phosphorus inputs, and the removal of phosphorus from detergents must be considered as part of an integrated management approach.

(c) *Septic Tanks*

2.28 Septic tanks were identified as one of the significant contributing factors to the eutrophication of lakes in the Perth area.⁷³ Professor Cullen pointed out that two thirds of the people in the Murray-Darling Basin used septic tanks.⁷⁴ The New South Wales State Algal Coordinating Committee is studying the impact of nutrient leakage from septic tanks on waterways.⁷⁵ Research is currently being done in Victoria to determine the impact of leakage from septic tanks on ground and surface waters.⁷⁶

2.29 It was suggested to the Committee that there should be a mandatory pumping out of septic tanks and this could be policed by a requirement to show the receipt when paying the annual rates.⁷⁷ In Victoria, the *Water Act 1989* provides power to inspect and de-sludge septic tanks and to charge the cost to the owner. The policing of these operations is carried out by local councils and is effective where controls are enforced.

2.30 The Committee was told that part of the problem was that septic tanks fell under the jurisdiction of health and engineering agencies which are usually separate from the water and sewerage authorities, and the successful implementation of these controls depended on cooperation between these agencies. This situation should be addressed

73 Environmental Protection Authority, Western Australia, Submission No. 43, p.3.

74 Cullen, Evidence, 27 August 1993, p.859.

75 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.10.

76 Blackmore, Evidence, 27 August 1993, p. 913.

77 Cullen, Evidence, 27 August 1993, p.876.

as soon as further information becomes available on the impact of leakage from septic tanks.

Recommendation 12

The Committee recommends that as part of the development of the National Water Quality Management Strategy, ARMCANZ take steps to ensure that there is a mandatory requirement to have septic tanks de-sludged on an annual basis as a condition of installation.

(d) Urban Runoff

2.31 There is now considerable concern about nutrient levels in urban runoff, and several approaches to potential use of stormwater are being considered. Urban water supplies are currently treated to a high standard but only 20 per cent is needed at this standard.⁷⁸ One approach to the re-use of runoff from domestic properties is to use 'grey water' to flush toilets and to water gardens. Dual reticulation systems are being installed for this purpose in new development areas, such as Rouse Hill in Sydney.⁷⁹

Recommendation 13

The Committee recommends that as part of the development of the National Water Quality Management Strategy, the provision of dual reticulation systems for the use of 'grey water' be considered in the development of new housing estates on a national basis.

2.32 The first flush events clear the dirt from the roads, gutters and parks into stormwater drains which flow directly into waterways. It has been suggested that the diversion of storm water to sewers would reduce levels entering waterways from urban runoff. Nutrients

78 Clark R (1990) Water Resources Investigations, Engineering and Water Supply Department. *Water Conservation for Adelaide: Looking into the Future*, shortened version of Proceedings of 63rd National Conference Royal Australian Institute of Parks and Recreation, Adelaide, 30 September 1990.

79 Cauchi, Evidence, 3 August 1993, p.558.

associated with particulate material in storm water may be treated by slowing down the water and possibly passing it through wetlands, which would enable sedimentation to occur.⁸⁰ This could be achieved by constructing holding tanks sufficiently large to retain the first ten minutes of rainfall.⁸¹

2.33 Urban integrated catchment management may also reduce input levels from garden fertilisers.⁸² Substantial amounts of water are involved in urban runoff. For example, it has been estimated that the total run off of Adelaide is about the same as the water used.⁸³ The Commonwealth Environment Protection Agency has produced a discussion paper which considers the nature and impacts of storm water, and management and the environmental values of the receiving water.⁸⁴

Recommendation 14

The Committee recommends that as part of the development of the National Water Quality Management Strategy, adequate treatment of storm water runoff to prevent nutrient pollution of waterways be incorporated as an integral part of the planning of new urban developments.

(d) Other Point Sources

2.34 Significant reductions in input of nutrients to waterways can also be achieved as a result of the treatment of industrial waste and animal industries (feedlots, dairies, poultry farms, piggeries) by positioning polluting activities and aerial spraying of fertilisers away from waterways. Irrigation can also have a point source contribution

80 Hart, Evidence, 27 July 1993, p.418.

81 Cauchi, Evidence, 3 August 1993, p.542.

82 Waterways Commission, Western Australia, Supplementary Submission No. 56(a), p.2.

83 Australian Conservation Foundation, Supplementary Submission No.75(a), p.23.

84 Commonwealth Environment Protection Agency (1993) *Urban Storm Water a Resource to Valuable to Waste*. February 1993.

through irrigation return drains in addition to the diffuse contribution as runoff from irrigated fields.⁸⁵

Diffuse Sources

2.35 The major diffuse sources of phosphorus include agriculture, farming and forestry. One of the gaps identified by ARMCANZ workshop in 1993 was the prediction of nutrient export characteristics in rural areas.⁸⁶ The Campaspe Region Water Authority also attributed significant nutrient input to fertilisers, farming methods (including overstocking) and the proximity of farms to waterways.⁸⁷

(a) Sediments

2.36 Phosphorus can be released from the sediments, particularly in anoxic conditions, and through biological activity.⁸⁸ Substantial quantities of nutrients are leached from the sediments into the water for many years after the external supply of nutrients has ceased⁸⁹ and there may be a considerable time lapse between the introduction of nutrient to the water body and the development of algal blooms.⁹⁰ Near Bourke, the concentrations of phosphorus in the sediments of the Darling River could be 100-fold those in the water.⁹¹ The major source of phosphorus in Chaffey Dam was found to be the tertiary basalts in

85 Wardle, Evidence, 2 August 1993, p.509.

86 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

87 Campaspe Region Water Authority, Submission No.32, p.2.

88 Cullen, Submission No. 42, p.3; CSIRO, Submission No.72, p.7.

89 Bowmer K (1981) Nutrient Enrichment Eutrophication: Cause of problem plant growth - possibilities for regulation. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs), NSW Department of Water Resources, Sydney pp.491-501, p.493.

90 Engineering and Water Supply Department, South Australia, Submission No.49, p.7.

91 CSIRO, Submission No.72, p.7.

the uplands of the catchment.⁹² High phosphorus levels may occur if a large catchment area drains into the water body.⁹³ In the Chaffey Dam catchment high phosphorus levels were said to occur in pristine native timber areas:⁹⁴ the soils in these areas are high in apatite (calcium fluorophosphate).⁹⁵

2.37 Acceptable levels of phosphorus input will vary according to existing levels in the soil and the amount entering the system from other sources. The variation in freshwater ecosystems in Australia requires flexible guidelines to address the site specific assimilatory capacities for phosphorus rather than a single set of standards.⁹⁶ There may be situations where the amount of phosphorus entering the system from the sediments is sufficiently high that reduced input levels from other sources will have no impact on algal bloom development for decades.⁹⁷

2.38 Research in South Australia indicates that an 80 per cent reduction in the amount of phosphorus transported from the soil can be achieved by the use of calcium salts to modify the soil chemistry.⁹⁸ The Committee was told that this project had not progressed to field trials due to the lack of funding.⁹⁹

92 Donnelly, T (1993) *The Major Sources in the Chaffey Catchment, NSW*. Consultancy Report No.92/20. Submitted to the Chaffey Dam Advisory Committee, March 1993, p.24.

93 Environmental Protection Authority, Western Australian Submission No.43, p.2.

94 Chaffey Dam Catchment Management Advisory Committee, Submission No.25, p.2.

95 Garrard, Evidence, 5 August 1993, p.737-8.

96 Hart, Submission No.61, p.4.

97 Bowmer, Submission No.63, p.1.

98 Bursill, Evidence, 12 August 1993, p.756.

99 Bursill, Evidence 12 August 1993, p.756.

(b) *Fertilisers*

2.39 The costs and benefits of fertiliser use are not widely known,¹⁰⁰ therefore an analysis of current farming practices may be beneficial in some localities. The rate of nutrient leaching from soil depends on seasonal water runoff, ground cover and slope and can therefore be reduced by improved farming practices.¹⁰¹ A survey conducted by Rose, Southwell and Sledge in the Hawkesbury River catchment found that some local landowners rejected claims that agricultural runoff was a contributing factor, and some had little understanding of the causes and effects of algal blooms.¹⁰² Most irrigators obtained their information on irrigation and fertilisation techniques from their equipment suppliers, rather than from consultants in the extension service.¹⁰³

2.40 Substantial benefits can be gained by adjusting the frequency and quantity of fertiliser to match optimum plant usage, soil type and condition in order to minimise leaching of nutrients. The South Australian Farmers Federation suggested that the cost of fertiliser monitoring could be shared by community members.¹⁰⁴ CSIRO was using satellite imagery to determine superphosphate needs and it is expected that this type of technology would facilitate the process.¹⁰⁵

2.41 Surveys in Western Australia have shown that farmers previously had little technical advice in determining optimum fertiliser use.¹⁰⁶ The Western Australian Government provides free soil testing and advice on timing and quantities of fertiliser use as a long term strategy

100 Mues C and Collins D (1993) 'A review of Commonwealth land care initiatives - promoting sustainable farming systems'. *Outlook 93*. Canberra, 2-4 February 1993, p.1.

101 McClement, Evidence, 4 August 1993, p.678.

102 Rose, Southwell and Sledge, Submission No.1, p.5.

103 Wardle, Evidence, 2 August 1993, p.512.

104 Day, Evidence, 12 August 1993, p.817.

105 CSIRO, Submission No.72, p.9.

106 Western Australian Department of Agriculture Catchment Management, South Coast Estuaries Project Group, Catchment Landcare Centre, *Reducing the nutrient load from rural sources of Albany's Harbours*. p.i.

to address this problem, and up to 16 per cent reduction of phosphorus has been recorded in the Peel Harvey Estuary.¹⁰⁷ The Western Australian experience demonstrates the willingness of the farming community to participate when provided with factual information on their specific needs.¹⁰⁸

2.42 The Committee was told that although a lot of plant nurseries, particularly the larger ones, were recycling water because of the increase in water rates, there was still a problem of nutrient input from small retail suburban nurseries because the runoff went into stormwater drains.¹⁰⁹ The Committee was told that the introduction of a slow release fertiliser by nurseries had significantly reduced fertiliser runoff¹¹⁰ from those properties. The industry is approaching this problem through an accreditation program.¹¹¹

2.43 The NSW Irrigators' Council pointed out that only 9 percent of combined phosphorus and nitrogen in waterways in the Murray-Darling Basin derived from irrigated agriculture and that improved practices designed to further reduce the amounts getting into waterways.¹¹² Irrigated agricultural production was estimated to be worth \$4.5 billion annually¹¹³ of which \$2.7 billion was exported.¹¹⁴ There is a strong economic argument for the continuation of irrigation as the multipliers for this industry are large compared with other sectors of the economy (output multiplier of 6.09, employment multiplier of 4.74).¹¹⁵ Irrigated land is seven times more productive than dryland farming and may

107 Environmental Protection Authority, Western Australia, Submission No.43, p.3.

108 CSIRO, Submission No.72, p.9.

109 Scott, Evidence, 2 August 1993, p.450.

110 Scott, Evidence, 2 August 1993, p. 463.

111 Peters, Evidence, 2 August 1993, p. 452.

112 NSW Irrigators' Council, Submission No.17, p.10.

113 NSW Irrigators' Council, Submission No.17, p.3.

114 Australian Irrigation Council, Submission No.58, p.1.

115 NSW Irrigators' Council, Submission No.17, p.3.

reduce development pressure on the 'more fragile and marginal agricultural lands'.¹¹⁶

2.44 On the other hand, phosphorus levels are significantly higher in irrigation areas than that in dry land pastures.¹¹⁷ The Department of Water Resources in New South Wales has strict guidelines to prevent tail waters from re-entering the river.¹¹⁸ Further, the Committee was told that the cotton industry does not use phosphorus in its farming procedures¹¹⁹ and a significant proportion of tail waters from cotton farms is recirculated.¹²⁰ The irrigation industry is currently supporting research into storm water runoff from farms.¹²¹

2.45 The NSW Government provides rebates as incentives to develop 'whole farm plans'.¹²² The concept of Best Management Practices is being promoted as part of the National Water Quality Management Strategy. It aims to maintain or improve agricultural viability while protecting the environment, and it covers nutrient runoff.¹²³ This concept encompasses 'the development of practical resource management guidelines for the sustainable management of natural resources at local and regional levels'.¹²⁴ The Committee was told that a lack of adequate information on the relative contributions of different nutrients to the waterways results in a reluctance to accept control

116 Australian Irrigation Council, Submission No.58, p.4.

117 Cullen, Submission No.42, p.4.

118 McCutcheon, Evidence, 3 August 1993, p. 608.

119 Baker, Evidence, 2 August 1993, p.492.

120 Australian Cotton Foundation, Submission No.66, pp.7, 11.

121 Macquarie Valley Irrigators Association, Submission No.65, p.9.

122 O'Kane, Evidence, 24 September 1992, p.154.

123 National Water Quality Management Strategy. *Water Quality Management in the Rural Environment. A reference document.* August 1992. Australian Water Resources Council, p.8.

124 National Water Quality Management Strategy. *Water Quality Management in the Rural Environment. A reference document.* August 1992, Australian Water Resources Council, p.9.

measures, particularly when the outcome of the controls is uncertain.¹²⁵

(c) Soil Erosion

2.46 Soil erosion is a significant source of phosphorus. It was suggested to the Committee that incentives must be provided to encourage the implementation of measures to reduce soil erosion.¹²⁶ A good example of this was areas with intensive irrigated crop production which usually have gentle slopes to reduce soil movement.¹²⁷ It was suggested that appropriate measures might include tax incentives for landholders and funding for local and regional planning for conservation farming.¹²⁸ The Committee was given examples of farmers self-regulating in relation to the use of pesticides and feedlot complexes¹²⁹ and it was suggested that this approach could also be applied in this case. In South Australia, the *Soil Conservation and Landcare Act 1989* requires Soil Boards to prepare district plans by 1995.¹³⁰

(d) Absence of Riparian Strips

2.47 Overgrazing of riverbanks was considered a significant problem in some areas.¹³¹ Fencing of streams in sensitive catchments may reduce damage to stream bank vegetation.¹³² Stock and pest grazing on floodplain vegetation have been able to destroy regenerating native

125 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

126 McClement, Evidence, 4 August 1993, p.679.

127 McClement, Evidence, 4 August 1993, p.678.

128 McClement, Evidence, 4 August 1993, p.679.

129 McClement, Evidence, 4 August 1993, p.679-80.

130 West Broughton Soil Conservation Board, *District Plan and Three Year Program*, June 1992, p.13.

131 Smith, Evidence, 5 August 1993, p.708.

132 Cullen, Evidence, 27 August 1993, p.871.

vegetation and reduce the capacity of the floodplain to utilise nutrients.¹³³ Nutrients are also added to the system by animals' defecation and released from mud by wallowing animals.¹³⁴ In order to be fully effective riparian strips must be of sufficient width and quality to ensure sustainability.¹³⁵

2.48 In Denmark, the measure has been adopted of fencing off a 20 metre strip from stock,¹³⁶ however, the cost of this in Australia may be prohibitive. The situation may be partially addressed by providing stock with drinking troughs away from the river's edge. It was also suggested that the fencing of streams may have the economic benefit of fewer stock losses.¹³⁷

2.49 Community groups could be encouraged to participate in planting programs, such as Landcare and the National Corridor of Green. The Commonwealth Government will provide \$3.1 million over the next four years for a 'National Corridor of Green' along the Murray River.¹³⁸ The Committee was told that re-vegetating the river banks would not only help to assimilate nutrients but also reduce the erosion of banks, which can be exacerbated by rapid fluctuations in water levels associated with irrigation flows.¹³⁹ Bank erosion causes turbidity and nutrient input into waterways, and therefore the implementation of strategies to reduce or prevent this is highly desirable.

2.50 It was pointed out to the Committee that the allocation of buffer strips may cause economic problems on farms as it may mean the sacrifice of some productive land.¹⁴⁰ This raises the question of who

133 South Australian River Murray Wetlands Management Committee, Submission No.51, p.2.

134 Queensland Herbarium, Submission No. 24, p.5.

135 Murray-Darling Basin Ministerial Council. *Algal Management Strategy for the Murray Darling Basin*. Draft August 1993, p.16.

136 Cullen, Submission No.42, p.5.

137 Cullen, Evidence, 27 August 1993, p.872.

138 Greening Australia Ltd, Supplementary Submission 99(a), p.2.

139 Snowy River Improvement Trust, Submission No.59, p.2.

140 Sinclair, Evidence, 5 August 1993, p.750.

pays for the fencing and any loss of productivity. In some situations they may serve as an effective option, and there are other benefits such as providing wildlife corridors.

(e) *Loss of Wetlands*

2.51 Wetlands can also play a substantial role in reducing nutrient levels in waterways while having aesthetic and wildlife conservation benefits. Wetlands established further up the catchment can reduce nutrients entering waterways, thus saving on water treatments.¹⁴¹ In the wetlands on the Onkaparinga River (South Australia) it would appear that 90 per cent of the phosphorus may settle out with the particulate material or may be removed by bacteria.¹⁴² In other areas, if the phosphorus is associated with very fine clay particles, then the amount of sedimentation would be less.¹⁴³

2.52 Other areas are looking at the construction of wetlands. For example, wetlands were established at Carcoar in 1992.¹⁴⁴ The Moree Plains Shire Council has received funding to establish a wetland near the Mungindi treatment plant¹⁴⁵ but construction has been held up by the State.

2.53 The role of water plants in preventing algal blooms is not entirely clear, but they grew densely in the Darling River until recently.¹⁴⁶ Certain water plants, such as *Typha*, have been used successfully in the Netherlands for the treatment of waste water, and are capable of removing substantial amounts of nutrients as well as having a high value as stock fodder.¹⁴⁷ Water plants can also inhibit algal growth

141 Hart, Evidence, 27 July 1993, p.420; Garrard, Evidence, 5 August 1993, p.750.

142 Bursill, Evidence, 12 August 1993, p.765.

143 Bursill, Evidence, 12 August 1993, p.765.

144 White, G (1992) *Carcoar Wetland - An instream wetland system for nutrient removal*. New South Wales Department of Water Resources.

145 Jones, Evidence, 5 August 1993, p.698.

146 Bowmer, Evidence, 11 September 1992, p.96.

147 Weir, Submission No. 21, p.3.

by producing allelopathic substances¹⁴⁸ and by competing for nutrients. Information is still needed on the best plant species, the best location within the catchment, whether to fence and what size the buffer zones should be.¹⁴⁹

2.54 The acceptance of wetlands was not universal, and the Committee was told that the removal of phosphorus by wetlands might also be seen as producing a phosphate rich pothole which may cause a problem for the future.¹⁵⁰ Wetlands may remove nutrients from the waterway in summer and release them in winter when other conditions are less favourable for the development of algal blooms.¹⁵¹ This type of problem must be addressed for each location.

2.55 Research is also needed into the relative effectiveness of permanent and temporary wetlands in nutrient uptake in various regions, as this has been shown to vary from one location to another.¹⁵² Wetlands are not a suitable option in high flow areas.¹⁵³

2.56 Wetlands also provide a refuge for zooplankton which feed on the algae,¹⁵⁴ and research has established a link between phosphorus recycling by zooplankton and blue-green algae.¹⁵⁵ The importance of

148 Moss B, Stanfield J and Irvine K (1990) 'Problems in the restoration of a hypertrophic lake by diversion of nutrient-rich inflow.' *Verhandlungen-Internationale Vereinigung für theoretische und angewandte Limnologie* 24:568-572. Stuttgart Germany

149 Hart, Submission No.61, p.5.

150 Sinclair, Evidence, 5 August 1993, p.749; CSIRO, Submission No.72, p.12.

151 Cullen, Evidence, 27 August 1993, p.868.

152 Suter, Evidence, 12 August 1993, p.784.

153 McComb, Evidence, 22 October 1992, p.353.

154 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.51.

155 Ejsmont-Karabin J and Spodniewska I (1990) 'Influence on phytoplankton biomass in lakes of different trophic by phosphorus in lake water and its regeneration by zooplankton'. *Hydrobiologia* 191:123-128.

these phenomena in the overall scheme is not known, as wetlands can also provide a 'seed' source to the main waterways.¹⁵⁶

Comments on Phosphorus Levels

2.57 Although phosphorus levels are believed to contribute significantly to algal bloom formation, there are significant gaps in the information available, including: whether phosphorus is always the primary cause; actual sources and relative contributions of various pollution sources; how much is derived from sediments; time taken for nutrients to accumulate; the chemical processes which release nutrients from sediments and whether anything can be done to purge the sediments to remove phosphorus.¹⁵⁷ The assimilatory capacity of the water body for the further introduction of phosphorus will vary according to the existing levels in the sediments and their solubility and the amount entering the system from other sources. Nutrient monitoring of water bodies should include known and potential contributors to the nutrient load.

2.58 The biological responses to the reduced levels of phosphorus vary significantly¹⁵⁸ and it is therefore difficult to predict the environmental impact of the strategies to reduce these levels. The reduction of phosphorus levels in many cases can be achieved by the awareness of facts and governments need to increase the level of public awareness of the potential sources of phosphorus. Communities must appreciate that algal blooms are the visible manifestation of the presence of high nutrient levels. To get the phosphorus levels below critical values there must be a multiple approach to nutrient reduction or there will be limited success. Some landholders will not cooperate unless there is an apparent equity. It is important that strategies do not divide the community into urban and rural factions, as a successful approach will need the cooperation of the entire community.

2.59 Too much emphasis should not be placed on any one phosphorus source and there is a need to identify the current levels and the contributions from different sources. The Committee was told that in Germany, Japan and England approaches to the control of phosphorus

156 Suter, Evidence, 12 August 1993, p.782.

157 CSIRO, Submission No.72, p.7.

158 Jones, Submission No.11, p.4.

levels in water bodies include legislative controls on phosphorus in detergents, land use and agricultural practices, licensing controls on industrial and sewage discharges and aeration of lakes and reservoirs.¹⁵⁹

2.60 Further information may result in the development of new management strategies¹⁶⁰ or change in emphasis or priority. CSIRO's Catchment Management Support System provides training courses on the technology to determine the nutrient generation rates within a catchment, which provides information to determine the priorities for corrective action.¹⁶¹ This computer simulation model provides useful information on annual loads in the system which will assist in the development of targets.¹⁶²

2.61 BHP Company Limited were working on a system to continuously measure nutrients in water.¹⁶³ This would provide information on sources and identify key areas with nutrient problems. It would also give advanced warning of conditions conducive to bloom development where more intensive monitoring could be implemented.

Pesticides

2.62 The Australian Cotton Foundation research organisation spent \$6 million per year, 40 per cent of which was devoted to environmental considerations.¹⁶⁴ One of the main concerns of the Australian Cotton Foundation was pesticide residues, but their effects on the food chain for blue-green algae was unknown. Most samples taken in the Upper Darling System had pesticide levels below the limit of detection and the

159 Burns, Supplementary Submission No.31(a), p.2.

160 CSIRO, Submission No.72, p.7.

161 Blackmore, Evidence, 27 August 1993, p.903.

162 Blackmore, Evidence, 27 August 1993, p.909.

163 Minister for Industry Technology and Regional Development, Submission No.89, p.7.

164 Baker, Evidence, 2 August 1993, p.493.

feasibility and economics of reducing levels would need to be investigated.¹⁶⁵

Other Chemical Factors

2.63 Other factors may be important, such as trace elements, iron and molybdenum, because of their role in nitrate reduction and nitrogen fixation,¹⁶⁶ although little is known about their influence on blue-green algal blooms. High pH (range 8.6-9.7) also favours bloom development.¹⁶⁷

Chemical Factors - Conclusions

2.64 There is still considerable work to be done to clarify the links between chemical attributes of water and the development of algal blooms under Australian conditions. There is a need to monitor the levels of nutrients, identify significant sources to enable the assessment of priorities, and implement strategies to reduce ambient levels in the most cost effective manner. There also is a need to establish the threshold levels at which nutrient levels are critical in a variety of water body types. The 1993 ARMCANZ workshop considered further research was needed to determine target nutrient levels for water bodies that would reduce or prevent the development of algal blooms.¹⁶⁸

2.65 The CSIRO Catchment Management Support System provided a computer simulation of nutrient generation rates within catchments.¹⁶⁹ The next stage was to look at the longevity,

165 Water Resources Technical Services Division. *Central and North Western Regions Water Quality Program 1991/92. Report on Pesticide Monitoring*, March 1993, p.28.

166 Rueter J and Peterson R (1987). 'Micronutrient effects on cyanobacterial growth and physiology'. *New Zealand Journal of Marine and Freshwater Research* 21: 435-445.

167 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.22.

168 Agriculture and Resource Management Council of Australia and New Zealand. *Establishing Priorities for National Algal Bloom Research*, April 1993, p.11.

169 Blackmore, Evidence, 27 August 1993, p.909.

transportation and fate of those nutrients and subsequent availability and the influence of flow regimes.¹⁷⁰

2.66 The Committee was concerned, however, that the Nepean Hawkesbury Catchment Management Council was unable to get information on nutrients in the river system, although this information had been collected by government instrumentalities. The extent to which other catchment committees had similar problems is not known. A vital part of the process is the release of information to the community to provide feedback on the success or failure of the steps taken in the implementation of the integrated catchment management approach.

Recommendation 15

The Committee recommends that all data collected by government instrumentalities in relation to nutrient levels be made available to other agencies and the public.

Physical Features

2.67 A number of physical environmental features also affect the development of algal blooms, and these include the flow rate of water, light, turbidity and temperature. Under certain physical conditions, blue-green algal species have a competitive advantage over other species of algae and therefore a number of these factors provide potential mechanisms for controlling these species.

Flow rates

2.68 Australian natural waterways are characterised by irregular and extreme flow regimes. Progressively flows have been determined more and more by irrigation, urban and industry requirements.¹⁷¹ The control of the volume, duration and frequency of river flow also provides a mechanism for managing blue-green algae blooms as increased flow rate and turbulence inhibit bloom development. For example, the low

170 Blackmore, Evidence, 27 August 1993, p.909.

171 CSIRO, Submission No.72, p.10.

turnover of water in the Chaffey Dam is considered to contribute to the increased frequency of algal blooms¹⁷² and the relative absence of algae in other storage dams was attributed to the high turnover rate.¹⁷³ The influence of retention time requires further research.¹⁷⁴

Water Allocations

2.69 The National Resource Management Strategy which the Murray-Darling Basin Commission is currently implementing is the first time the four State governments (Queensland, New South Wales, Victoria and South Australia) have come up with a generic policy for flow management.¹⁷⁵

2.70 The four States in the Murray-Darling Basin have had different policies on water allocation. Although South Australia stopped further allocations in 1968, and New South Wales and Victoria in the 1980s, there is quite a lot of water allocated which has not been used.¹⁷⁶ The Committee was told that there are also a number of outstanding applications for licenses.¹⁷⁷

2.71 Up to 85 per cent of the average yearly volume of water in the Murray-Darling Basin may be diverted for irrigation.¹⁷⁸ The Committee was told that the over-allocation of water in the Dumaresq,

172 Chaffey Dam Catchment Management Advisory Committee, Submission No.25, p.3.

173 Baker, Evidence, 2 August 1993, p.496.

174 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae* August 1992, p.135.

175 Blackmore, Evidence, 27 August 1993, p.910.

176 Blackmore, Evidence, 27 August 1993, p.910.

177 Culgoa-Balonne Minor Distributory System Water Users' Association, Supplementary Submission No.37(a), p.1.

178 Gutteridge, Haskins and Davey, *An Investigation of the Nutrient Pollution in the Murray-Darling River System*, Murray Darling Basin Commission, January 1992.

Barwon and MacIntyre rivers was so great that existing allocations were only realised in 35 per cent of years.¹⁷⁹

2.72 Mr Bursill told the Committee:

There are four points that I would like to make in relation to the blue-green algae issue. The first is on flow regulation. It is my belief that the flow issue is a critical one for managing this problem. I believe that the over-allocation of water to irrigation in the upstream areas of the Murray-Darling Basin has been the major factor that led to the bloom in 1991 and the continuing problems that they are having there.¹⁸⁰

2.73 In order to reintroduce natural variability in river flow, New South Wales is reviewing future water allocations and mechanisms for managing unregulated flows.¹⁸¹ In the interim, a moratorium could be imposed on additional abstraction licenses.¹⁸² The effective measurement of water extraction would require a time/event/flow meter on every licence and other major water users¹⁸³ but may partially address the problems in the regulated sections of the river. The Committee was also told that in some areas there is a need to have surveillance for illegal pumping.¹⁸⁴

179 Blainey, Evidence, 2 August 1993, p.478.

180 Bursill, Evidence 12 August 1993, p.755.

181 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.111-112.

182 National Fishing Industry Council Ltd, Submission No.64, p.1.

183 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.113.

184 Doohan, Submission No. 28, p.4.

Recommendation 16

The Committee recommends that as part of the development of the National Water Quality Management Strategy, no further irrigation water entitlements be issued in any area until it has been established that there is adequate water available to meet the environmental requirements of the downstream sections of the waterway after existing allocations have been used.

2.74 The Cubbie Station project design enables the landholder to use flood waters under license to keep water on-farm in deep storages.¹⁸⁵ The 'off-allocation flows' are used by landholders in the Barwon/Darling; however, this is creating problems for farmers downstream, and the New South Wales Department of Water Resources has been requested to regulate the diversion of this water.¹⁸⁶ Unlimited off-allocation water use is considered no longer acceptable by some.¹⁸⁷

Unregulated Sections

2.75 Only those sections of the river which can be reasonably supplied with water are currently being regulated¹⁸⁸ which can result in the uptake of environmental flows and the water to be used by consumers further downstream by users in the unregulated river sections. The New South Wales Department of Water Resources is developing an unregulated flows policy and an interim plan is being trialled for the north west rivers.¹⁸⁹ The use of unregulated flows is particularly a problem in some tributaries where it is used for on-farm storage and this was adding to the problems as summer freshes did not reach the lower catchments.¹⁹⁰

185 Cubbie Station, Submission No.36, p.5

186 NSW Irrigators' Council, Submission No. 17, p.16.

187 New South Wales Blue-Green Algae Task Force, Submission No.53, p.4.

188 Arnott, Evidence, 5 August 1993, p.710.

189 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.8.

190 NSW Irrigators' Council, Submission No.17, p.16; Culgoa Balonne Minor Distributary System Water Users' Association, Submission No.37, p.6.

2.76 This raises the question as to whether governments need to guarantee water supplies to future water allocations, and whether the existing unregulated section should be subjected to similar restraints as the regulated sections. This would ensure the passage of environmental flows through those sections of the river.

Recommendation 17

The Committee recommends that the Commonwealth Government use its influence to facilitate the urgent consideration of further controls on the unregulated sections of major waterways to ensure the passage of environmental flows and water for downstream users.

Recommendation 18

The Committee recommends that as part of the development of the National Water Quality Management Strategy, urgent attention be given to feasibility of the continued use of off-allocation flows, and that the communities concerned be advised accordingly.

Recommendation 19

The Committee recommends that as part of the development of the National Water Quality Management Strategy, urgent attention be given by the responsible authorities to the feasibility of meeting existing water allocations in the future, including those that have been granted but not yet used, and that the communities concerned be advised accordingly.

Environmental Flows

2.77 In determining optimal flow rates, environmental factors such as fish breeding riverine corridors, floodplains and wetland requirements should be considered. The timing of water releases can be critical for the survival of these ecosystems. One aspect of environmental flows is the flow rate of water required to prevent and to flush developing algal

blooms. The use of environmental flows raises the question of who owns and polices the environmental flows.¹⁹¹

2.78 The Murray-Darling Basin Commission and the States are developing a policy on instream environmental requirements within the concept of integrated catchment management.¹⁹² The New South Wales Department of Water Resources is also developing an environmental flows policy¹⁹³ and is implementing a program of Environmental Contingency Allowance which will provide water for environmental and water quality requirements.¹⁹⁴

2.79 The Committee appreciates that the environmental requirements may not be synonymous with the flushing of algal blooms and an ecosystem approach is essential. The long term flow regime must be able to sustain the riverine ecosystem, and the improved health of the water ways and riverine corridors should reduce the need for flushes to deal with algal blooms.

Recommendation 20

The Committee recommends that the Commonwealth Government use its influence where possible to facilitate the introduction of environmental allocations nationally after consideration of the legal, social and economic implications.

Flood Plains

2.80 The Committee was told that little is known about the needs of flood plains for inundation.¹⁹⁵ Floods have been shown to boost the populations of key species on the river plains, and in the absence of

191 Heeps, Evidence, 25 September 1992, p.205

192 Blackmore, Evidence, 27 August 1993, p.910.

193 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.110.

194 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.8.

195 Donovan, Evidence, 2 August 1993, p.480.

regular flooding gaps in the population structure are becoming apparent.¹⁹⁶ The Western Total Catchment Management Committee in New South Wales is looking at the effects of flooding on the economic and social activities of the community downstream from Whyenbah.¹⁹⁷ Further developments which impact on the quality or quantity of water flow should only be permitted after the impact on downstream flood plains is assessed.

Recommendation 21

The Committee recommends that as part of the development of the National Water Quality Management Strategy, the approval of future developments be dependent on an assessment of the impact on downstream flood plains.

Additional Flows

2.81 Additional flows have been used for flushing of blooms or potential blooms. However, there is a need to adopt flexible management strategies for individual flow events.¹⁹⁸ It is considered that 2 000 ML/day for five days is sufficient for the Barwon-Darling system;¹⁹⁹ 10 000 ML/day in the River Murray in South Australia reduced algal blooms which still occurred at 7 000 ML/day.²⁰⁰ The duration of the protection resulting from 'flushing' is not known and this mechanism depends on water availability.²⁰¹ Adequate flow rates are necessary after an algal bloom to purge the area of the nutrients

196 Jensen, Evidence, 12 August 1993, p.777.

197 Treweeke, Evidence, 4 August 1993, p.661.

198 Culgoa-Balonne Minor Distributary Water Users' Association, Submission No.37, p.11.

199 New South Wales Government, Submission No.53, p.5.

200 Engineering and Water Supply Department, South Australia, Submission No.49, p.6.

201 New South Wales Blue-Green Algae Task Force, Submission No.53, p.5-6.

which will be released on the decay of the algal mass and which would otherwise be available for a future bloom.²⁰²

2.82 This approach can also have disadvantages: for example, significant changes in the water height e.g. 1-3 metres, stress aquatic organisms through temperature and chemical changes.²⁰³

The District Council of Meningie, however, reported that despite high flow rates in the Murray River and the use of dilution flows, there had been subsequent occurrences of toxic algae.²⁰⁴ The use of additional flows is expensive and may not be efficient, even if sufficient water is available. The time delay in getting the water to the affected area may make this approach unworkable, and if the water needs to pass through unregulated sections of the river it may not reach the intended area.

2.83 The Committee was given the example of where Pian Creek has been identified as a source of blue-green algae and requests were made to the Department of Water Resources to ensure continuous flows in that waterway.²⁰⁵ The potential to meet the demand for these additional flows is dependent on the amount of water available. In most areas of Australia, water is not available and the potential to expand water storage capacity is restricted to the less economically viable dam sites.²⁰⁶ This approach would impose environmental costs, such as the loss of valley areas and a reduction in natural flows.²⁰⁷

Future Requirements

2.84 Nationally, 75 per cent of harnessed water is used by irrigators,²⁰⁸ who have outlaid substantial capital in the expectation of future levels of water supply.²⁰⁹ Water allocation to irrigators is

202 Jones, Submission No.11, p.4.

203 Bowmer, Evidence, 11 September 1992, p.141.

204 District Council of Meningie, Submission No.3, p.4.

205 Austin, Evidence, 3 August 1993, p.627.

206 Australian Irrigation Council, Submission No.58, p.6.

207 Australian Irrigation Council, Submission No.58, p.8.

208 Australian Irrigation Council, Submission No.58, p.6.

209 MacIntyre Valley Cotton Growers Association Inc, Submission No.96, p.1.

becoming increasingly restricted by the environmental and community needs, and the irrigators are concerned that previous over-allocation of water may have jeopardised the reliability of future supplies in some catchments.²¹⁰ There was, therefore, an expectation on the part of irrigators that the requests for environmental flows should be scientifically justified.²¹¹ The Council of Australian Governments will consider the question of environmental flows in February 1994, and the ARMCANZ is preparing a report on the issue which outlines what each State/Territory is doing.

2.85 The Dumaresq-Barwon Border Rivers Commission is currently using a daily step integrated quality-quantity model of the border rivers. After the completion of the community consultation process currently being undertaken, this model will enable the prediction of economic and environmental impacts of various resource development scenarios.²¹² This will enable the Commission to determine flow allocations for the intersecting streams while taking into account the social, economic and environmental needs of the wider Murray-Darling Basin.²¹³

2.86 Future requirements may need to be met through the trading of transferable water entitlements, which have been introduced in some areas.²¹⁴ Other possible reforms include water pricing policies with lower tariffs or rebates as incentives for improved farming practices; surcharges for environmental flows required to dilute discharges; and the use of integrated planning in which water surplus can be used by adjacent farms.²¹⁵

2.87 Improved agricultural techniques will reduce water wastage, and through increased productivity will provide social and economic benefits.²¹⁶ The Committee was told that many plant nurseries are

210 NSW Irrigators' Council Submission, No.17, p.13.

211 Australian Irrigation Council, Submission No.58, p.3.

212 Hutton, Evidence, 27 August 1993, p.917.

213 Hutton, Evidence, 27 August 1993, p.917.

214 NSW Irrigators' Council, Submission No.17, p.15.

215 Campaspe Region Water Authority, Submission No.32, p.6.

216 Engineering and Water Supply Department, South Australia, Submission No.49, p.9.

already recycling water because of the rise in water rates.²¹⁷ Some taxation incentives are available under Sections 51(1) and 75(b) and (d) of the *Income Tax Assessment Act 1936* to assist primary producers with soil and water conservation management.

2.88 The irrigation and farming industries have been doing a great deal of research into the most efficient use of the water available. The National Irrigation Research Fund has produced a national strategy, *Irrigation Research and Development in Australia*, which suggests that a national levy on water used by irrigators could provide some of the funds for research and development.²¹⁸ For example, developments such as the use of neutron probe moisture meters, enabling more efficient water scheduling, have been introduced by some irrigators.²¹⁹

Urban Water Users

2.89 A great deal can also be done to reduce water use in urban areas. Education awareness may be beneficial but other measures include appropriate pricing schemes, use of 'grey' water for gardens and toilets, imposing stricter water restrictions during droughts, and encouraging the use of water-efficient appliances, such as shower roses and installation of tanks. The Committee was told that property based charges should be replaced with access plus usage charge²²⁰ as this would provide a greater incentive to use less water.

Flow Rates - Conclusions

2.90 In some circumstances, increased flow rates may provide a quick short term solution once more is known about the environmental requirements and tolerance of each waterway. However, this approach may also be politically more difficult and may be at risk during drought as it reduces the amount of water available for agricultural needs.

217 Scott, Evidence, 2 August 1993, p.449.

218 National Irrigation Research Fund. *Irrigation Research and Development in Australia. A National Research Strategy*. Prepared by S Wood and L Banks, June 1991, p.21.

219 Australian Cotton Foundation, Submission No.66, p.6.

220 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992,p.10.

Adequate flow rates are environmentally beneficial in a number of other respects: maintaining fish populations; maintaining wetlands which stabilise river banks and reduce soil erosion; preventing the formation of intermittent pools of low quality, deoxygenated water suitable for breeding mosquitos and other pests requiring the use of insecticides;²²¹ and increasing the nutrient capacity of the ecosystem.²²²

2.91 The flow rates required to prevent algal blooms is an important consideration in determining environmental flow requirements. Flow rates suitable for flushing blue-green algae may not be conducive to the other environmental requirements. In the Macquarie Valley, requirements for environmental flows have been given priority access to surplus flows.²²³ Insufficient is known of the benefits of floods to the environment and to agriculture, and a multidisciplinary approach to the whole system is needed to ensure adequate water is available for flood plains.²²⁴

2.92 Given the variability of the structure of river beds there are a number of factors to be considered in determining optimal flow regimes. There are also 'fundamental questions' to be answered in relation to the flow rates required to prevent the development of anoxic sediments²²⁵ and the Committee was told that a better understanding of the relationship between algal growth and flow rates is needed. Changes in flow regimes in the Murray River have expanded the permanent wetlands but reduced the extent of the 'more productive temporary wetlands'.²²⁶ The environmental flow requirements for the downstream sections can be used as dilution flows or wetlands

221 Weir, Submission No.21, p.1.

222 Humphries, Evidence, 22 October 1992, p.340.

223 Macquarie Valley Irrigators Association, Submission No.65, p.7.

224 Culgoa-Balonne Minor Distributary System Water Users' Association, Submission No.37, p.7.

225 National Project Manager, Algal Bloom Research ARMCANZ, Submission No.33, p.7.

226 South Australian River Murray Wetlands Management Committee, Submission No.51, p.2.

throughflow in upstream areas,²²⁷ provided the timing is suitable for both uses.

Temperature

2.93 Blue-green algal bloom development is also usually associated with warmer temperatures, which may increase the buoyancy of some species,²²⁸ although this is not always the case. The tolerance of blue-green algae species to temperature extremes differs markedly.²²⁹ A toxic algae bloom was recorded at Melton Reservoir at 8°C,²³⁰ and in Ballarat while snow was falling.²³¹ Blooms have been recorded in ice covered lakes in Canada and Finland.²³²

2.94 High temperatures can cause thermal stratification of deeper water bodies, which locks nutrients in the bottom layer where they can be accessed by blue-green algae.²³³ Temperature also affects the solubility of gases and hence algal growth.²³⁴ In Danish lakes, temperature and turbulence have been found to influence the persistence of algal blooms.²³⁵ Temperature changes may act

227 Engineering and Water Supply Department, South Australia, Submission No. 49, p.5.

228 Klemer A and Barko J (1991) 'Effects of mixing and silica enrichment on phytoplankton seasonal succession'. *Hydrobiologia* 210:171-181.

229 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.37.

230 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.7.

231 Ballarat Water Board and West Moorabool Water Board, Submission No.44, p.3.

232 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.17.

233 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.41.

234 Boney A (1989) *Phytoplankton* (2nd Ed), Edward Arnold Publishers Melbourne.

235 Australian National Industries Ltd, Submission No.39, p.11.

synergistically with other factors such as light.²³⁶ Although algal blooms occur more frequently in the summer months they can also occur in winter during low flow conditions.

Light

2.95 Algal photosynthesis is dependent on the angle, duration and intensity of sunlight. Blue-green algae form phycobiliprotein pigments which are suited for the light regime under water,²³⁷ so lower light levels may be advantageous to these genera of algae. Floating blue-green algal cells shade competitors. However, in high light intensity the algae on the surface are killed by photooxidation.²³⁸ A shallow photic zone may also benefit zooplankton, which may hide from predatory fish in the low light depths.²³⁹ However, light control has limited potential as a mechanism for algal bloom prevention. Shading of rivers by planting trees in riverbanks or covering small water bodies may have limited success.

Turbulence

2.96 Turbulence depends on the morphology of the water body, wind and water currents. Blue-green algal blooms are more buoyant and can remain near the surface in calmer waters²⁴⁰ and the degree of turbulence determines the length of time the algal cells remain in the photic zone,²⁴¹ and therefore affects the growth rate. Turbulence may also increase nutrient uptake by the algal cells, and therefore growth

236 Roberts R and Zoharty T (1987) 'Temperature effects on photosynthetic capacity, respiration and growth rates of bloom-forming cyanobacteria'. *New Zealand Journal of Freshwater Research* 21:391-399.

237 Bowmer K (1981) 'Nutrient Enrichment Eutrophication cause of problem plant growth - possibilities for regulation'. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs) NSW Department of Water Resources, Sydney pp.491-501, p.496.

238 Water Studies Centre, Submission No.30, p.2.

239 Shapiro, J (1990) 'Biomaniipulation: the next phase - making it stable'. *Hydrobiologia* 200/201:13-27.

240 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.40.

241 'What can be done about algal blooms' *Ecos* 72 Winter 1992 pp.14-19, p.15.

may occur at lower nutrient concentrations than in static water bodies.²⁴² In Danish lakes, the degree of turbulence was also found to influence the persistence of algal blooms.²⁴³ The ARMCANZ workshop considered that insufficient was known about the sensitivity of blue-green algae to turbulence.²⁴⁴

Turbidity

2.97 Turbidity is a major factor in limiting algal growth rates because it reduces the amount of light available but contributes significant levels of nutrient. The clearing of land should require prior approval by catchment management authorities. Sedimentation will reduce turbidity levels in slow flowing waterways, creating more suitable conditions for algal growth.²⁴⁵ Turbidity levels most favourable to algal growth are 30-50 NTU.²⁴⁶ Saline ground waters may clear turbidity thus promoting algal growth when seeping into water bodies.²⁴⁷

Comments

2.98 Research is being done to identify the extent and causes of algal blooms to enable the monitoring of trends which will assist in the

242 Bowmer K (1981) 'Nutrient Enrichment Eutrophication cause of problem plant growth - possibilities for regulation'. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs) NSW Department of Water Resources, Sydney pp.491-501, p.496.

243 Australian National Industries Ltd, Submission No.39, p.11.

244 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

245 Meningie Progress Association, Submission No.22, p.3.

246 NTU: Nephelometric Turbidity Unit (a measure of turbidity).
Bain D (1992) *Algae and Low Flows in the River Murray* Extract p.7;
National Rivers Authority (1990) *Toxic Blue Green Algae Water Quality Services* No.2. pp.128; Geddes M (1988) 'The role of turbidity in the limnology of Lake Alexandria, River Murray, South Australia; comparisons between clear and turbid phases', *Australian Journal of Marine and Freshwater Research* 39:201-209.

247 CSIRO, Submission No.72, p.7.

prediction and management of future blooms. A more accurate estimation of the extent of the problem will assist in risk assessment and the allocation of resources. There is a need to define the relationship between algal growth and flow rates, the interaction between flow rate and nutrient levels and a minimum threshold flow rate to make this a successful approach. The Murray-Darling Basin Agreement specifies a minimum monthly expected or entitlement flow, but this is not guaranteed in adverse conditions.²⁴⁸

2.99 There is a need for an integrated approach to considering the chemical, physical and biological environmental facts in researching the cause of algae bloom development in a range of water bodies.²⁴⁹ Many of the chemical and physical factors discussed in this section have a significant effect on blue-green algal growth, and therefore offer potential avenues for management and control. This should be balanced against the needs of the entire range of environmental processes and life history of fauna and flora utilising the aquatic ecosystems.

2.100 The piecemeal approach to water allocation is a historical problem. The role of all levels of government is now to ensure the use of resources in the interests of society as a whole.²⁵⁰ The aim should be clean, healthy and resilient water systems within an acceptable timeframe, although different environmental targets may be appropriate for different uses. Nutrients stored in the sediments will continue to support toxic blooms even when the pollution levels are markedly reduced, but this must not be used to justify inaction.

248 Engineering and Water Supply Department, South Australia, Submission No.49, p.4-5.

249 Australian Water Resources Council, Algal Bloom Research Management. *Algal bloom research in Australia: a progress report of current status and key issues*. November 1992, p.9.

250 National Landcare Program Discussion Paper. *Sustainable National Resource Management - Integration of Primary Industries and Energy Programs*. Department of Primary Industries and Energy. April 1992, p.7.

CHAPTER 3

IMPLICATIONS AND MANAGEMENT OF ALGAL BLOOMS

Effects of Algal Blooms

3.1 In the year 1992/93, a total of 140 algal blooms were recorded in Queensland, New South Wales, Victoria and South Australia.²⁵¹ Monitoring at Chaffey Dam, for example, has shown that blooms are not only increasing in frequency, but also duration and toxicity.²⁵²

3.2 The disruptive impact of algal blooms appeared to be less in 1992/93 than in previous years, although recreational areas were closed more frequently.²⁵³ Domestic water supplies still have different levels of treatment, some of which are able to remove the algal cells while others merely disinfect the water, thus killing the algae and releasing the toxins.²⁵⁴ The Committee was told that the Aboriginal community at Cummeragunja pump their water supply directly from the river.²⁵⁵

3.3 The effects of algal blooms include the aesthetic effects, the taste and odours in water supplies. Taste can be detected at 2000 cells/ml.²⁵⁶ Odours and taste of blue-green algae are difficult to remove in conventional sewage treatment plants.²⁵⁷ The 1993 ARMCANZ workshop pointed out that insufficient is known about the factors which control the production of taste and odour compounds and

251 *National Algal Scoreboard 1992/93*. Water Forum. Agriculture and Resource Management Council of Australia and New Zealand, p.1.

252 Sinclair, Evidence, 5 August 1993, p.736, 747.

253 *National Algal Scoreboard 1992/93*. Water Forum. Agriculture and Resource Management Council of Australia and New Zealand, p.4.

254 New South Wales Blue-Green Algae Task Force, Final Report, Blue Green Algae, August 1992, p.76.

255 Bailey, Evidence, 2 August 1993, p.527.

256 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.99.

257 Gutteridge Haskins and Davey Pty Ltd, Submission No.18, p.1.

the potential effects of measures implemented to reduce algal growth on the production of taste and odour compounds.²⁵⁸

3.4 Other effects of algal blooms include the clogging of filters and other equipment, and changes in water pH may interfere with the efficiency of the water treatment process. The deoxygenation of water bodies can also be a problem after the more severe blooms. During the decay process, non-toxic algae can also deoxygenate the water and sulfur compounds, such as rotten egg gas may be formed causing the discolouration of water and producing pungent odours which discourage the recreational use of water bodies and may result in fish kills.²⁵⁹

3.5 Of greater consequence, however, is the formation of toxins. There are three types of toxins produced by blue-green algae - neurotoxins, hepatotoxins and lipopolysaccharides. *Anabaena* and *Aphanizomenon* may produce neurotoxins while *Nodularia*, *Anabaena*, *Cylindrospermopsis*, *Microcystis*, and *Oscillatoria* may produce hepatotoxins.²⁶⁰ Neurotoxins need to be above a threshold level to cause paralysis, but hepatotoxins cause cumulative damage to the liver.²⁶¹

3.6 Gastroenteritis, hepatitis and hepatoenteritis in humans in Australia, North America and Africa have been attributed to toxins present in *Microcystis*, a blue-green algae²⁶² which has been recorded

258 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.12.

259 Australian Water Resources Council, *Freshwater Algal Blooms Occasional Paper* prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.2.

260 Falconer I (1991) 'Tumor Promotion and Liver Injury Caused by Oral Consumption of Cyanobacteria' *Environmental Toxicology and Water Quality: An International Journal* 6:177-184, p.179.

261 Burch, Evidence, 12 August 1993, p.763.

262 Falconer I (1991) 'Tumour Promotion and Liver Injury caused by Oral Consumption of Cyanobacteria'. *Environmental Toxicology and Water Quality: An International Journal* Volume 6: 177-184, p.177.

in the Armidale water supply.²⁶³ The toxin microcystin is also being studied for its potential to promote tumour formation.²⁶⁴

3.7 One case of gastroenteritis was reported in Toowoomba in 1903²⁶⁵ although there were reports as early as 1887.²⁶⁶ A major outbreak was reported on Palm Island²⁶⁷ which may have been due to species of *Cylindrospermopsis*.²⁶⁸ Gastroenteritis and hepatoenteritis cases have been reported after both accidental intake during recreation and drinking infected water.²⁶⁹

3.8 Swimmers have reported respiratory allergies, rashes and lesions and eye irritations, and *Nodularia* lipopolysaccharides are known to cause dermatitis and respiratory allergy.²⁷⁰ During the Darling-Barwon algal bloom there was only one reported case of a male suffering from skin rash, conjunctivitis, diarrhoea and respiratory problems.²⁷¹ There have also been cases of atypical pneumonias as a result of people breathing aerosols from blooms.²⁷²

263 Falconer, Submission No.16, p.1.

264 Falconer I (1991) 'Tumour Promotion and Liver Injury Caused by Oral Consumption of Cyanobacteria'. *Environmental Toxicology and Water Quality: An International Journal* 6: 177-184.

265 Queensland Water Quality Task Force, *Interim Report of Freshwater Algal Blooms in Queensland*, 31 July 1992, p.7.

266 Proclu P (1993) 'Algal toxins and bellyaches beyond the Barcoo'. *Medical Journal of Australia* 158:433-434, p.433.

267 Falconer I (1988) 'Eutrophication by toxic blue-green algae. An increasing hazard in Australia'. *Australian Biologist* 1(4): 10-12, p.11; Byth S (1980) 'Palm Island mystery disease'. *Medical Journal of Australia* 2:40-42..

268 Falconer I (1993) Letters to the Editor. *Medical Journal of Australia* 158:433-4, p.434.

269 Falconer, Evidence, 12 August 1993, p.789.

270 Soong, F, Maynard E, Kirke K and C Luke (1992) 'Illness associated with blue-green algae'. *Medical Journal of Australia* 156: 67.

271 New South Wales Blue-Green Algae Task Force, Final Report, *Blue-Green Algae*, August 1992, p.32.

272 Cullen, Evidence, 27 August 1993, p.863.

3.9 Serious blooms in Queensland in 1992/93 resulted in the closure of a number of water storages for several months.²⁷³ Water supply operators in the past needed to unnecessarily close down supplies as a precaution because they were unable to test toxicity.²⁷⁴ The availability of an effective toxin measuring procedure may also result in undue public alarm when algal blooms are nontoxic, or lead to the use of unsafe and expensive treatments, such as copper sulfate.²⁷⁵

3.10 There are substantial gaps in our knowledge in relation to the identification and detection of toxins. Some toxins have not been identified or their levels of toxicity are still unknown; for other toxins adequate toxicity measurements are not available.²⁷⁶ There have been some recent advances in toxin detection methods, such as the identification of saxitoxins in *Anabaena*, and the methods of detecting hepatotoxins enable communities to better deal with those situations.²⁷⁷ Geosmin, microcystin and nodularin now have a detection threshold of $<1\mu\text{g/L}$.²⁷⁸ Temperature, light and nutrients may affect toxin production²⁷⁹ although light and nitrogen levels may have the strongest effects.²⁸⁰ The ability to detect and measure toxins in water bodies will enable research into the factors promoting their formation and therefore allow the prediction of toxic conditions.

273 Queensland Water Quality Task Force. *Interim Report on Freshwater Algal Blooms in Queensland*. 31 July 1992, p.11.

274 Clewitt, Evidence, 4 August 1993, p.675.

275 Burns, Submission No.31, p.4.

276 National Project Manager, Algal Bloom Research ARMCANZ, Submission No.33, p.10.

277 Bursill, Evidence, 12 August 1993, p.754.

278 'What can be done about toxic algal blooms'. *Ecos* (Winter 1992) 72:14-19, p.16; Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.21.

279 Sivonen K (1990) 'Effects of Light, Temperature, Nitrate, Orthophosphate and Bacteria on the Growth of and Hepatotoxin production of *Oscillatoria agardii* strains'. *Applied and Environmental Microbiology* 56(9):2658-2666.

280 Murray-Darling Basin Commission (1993) *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.17.

3.11 It was also pointed out that to test water for algal toxins the samples were taken from a highly concentrated scum which was not necessarily representative of the water being used in the domestic supply, a procedure which may result in the unnecessary closure of water supplies.²⁸¹ Canadian toxicity testing has shown that there can be a 'mosaic of toxicity' where adjacent samples may give differing toxicity results.²⁸² The reliability of limited testing may therefore not be sufficient to measure the potential danger. Accordingly, algal density may only be used as an indication of the potential danger.

3.12 Toxicity levels may change with the age of the blooms and with different environmental conditions. For example, the Committee was told that when water was released from Chaffey Dam toxins disappeared in the natural flow of the river.²⁸³ Further research is needed into the degradation rates of toxins released during the decay of the cells for Australian algal species.²⁸⁴ Work is also needed into the longevity of toxins in the water supply to determine when it is safe to start using the water again and for which uses it is safe. There is evidence that microcystins can persist in water without microflora for months and in the presence of bacteria for up to three weeks.²⁸⁵

3.13 There is some information available on the effects of acute doses of algal toxins, although more work needs to be done on the individual effects of specific toxins on humans. The National Health and Medical Research Council is currently preparing a report on the health effects of toxic algae, which will consider areas for further research and list these in order of priority.²⁸⁶

281 van Dok, Evidence, 27 July 1993, p.409.

282 National Herbarium of New South Wales, Supplementary Submission No.4(a), p.1.

283 Garrard, Evidence, 5 August 1993, p.748.

284 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.15.

285 Murray-Darling Basin Commission (1993) *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.18.

286 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.12.

3.14 Further research is also needed on the factors promoting the formation of toxins;²⁸⁷ the effects of long term ingestion of low level algal toxins;²⁸⁸ the increased hypersensitivity to subsequent doses,²⁸⁹ and the effects of total exposure may be as critical as acute exposure.²⁹⁰

3.15 The measurement of toxicity levels enables the development of better strategies for managing algal blooms. The most effective method of toxin concentration determination in the past has been by mouse bioassay, which can only be performed in a few laboratories. Bioassay, immunoassay, enzyme assay and chemical methods may also be used²⁹¹ and can give an indication of toxicity in less than a day.²⁹² The Committee was told that it took up to a week to obtain toxicity results, but Professor Falconer pointed out that samples were usually transported by bus²⁹³ and the laboratory time was less than 24 hours. Research needs to be done into means of enabling field identification of toxic strains. The New South Wales State Algal Coordinating Committee is preparing an algal toxins data base.²⁹⁴

3.16 The effect of algal blooms on potable water supplies is diminishing as water treatment methods are improved, and there is less need to turn off water supplies.²⁹⁵ A greater awareness has led to much closer

287 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.11.

288 Australian Water Resources Council. *Freshwater Algal Blooms*. Occasional Paper prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.9.

289 Soong F, Maynard E, Kirke K and C Luke (1992) 'Illness associated with blue green algae'. *Medical Journal of Australia* 156: 67.

290 CSIRO, Submission No.72, p.11.

291 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.86.

292 Burch, Evidence, 12 August 1993, p.764.

293 Falconer, Evidence, 12 August 1993, p.791.

294 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.7.

295 Johnstone, Evidence, 27 July 1993, p.395.

monitoring, which has enabled treatment of blooms before they reach levels which threaten public health.²⁹⁶ The Australian Centre for Water Quality Research is looking at the effectiveness of chlorination treatments on hepatoxins²⁹⁷; activated carbon treatments are sometimes used, and research is being done into ozone treatment of microcystins.²⁹⁸

3.17 Insufficient is known of the thresholds and dose response relationships of algal toxins.

3.18 Extensive deaths in wild and domestic birds and animals have been attributed to *Anabaena* blooms in Canada and North America, but most species of *Anabaena* in Australia are non-toxic, although toxic compounds may develop with time.²⁹⁹ There was little evidence of wildlife kills in the Darling River 1991-92 bloom, which may have been due to their tolerance, the removal of carcasses by carrion feeders, alternative water supplies, the small volume ingested, low toxicity levels, the susceptibility and age of the animals.³⁰⁰ Seasonal loss of condition or the effects of drought may also affect the tolerance levels of wildlife and stock. Little research has been conducted into the environmental implications of algal blooms other than the obvious fish kills and wild life losses.

3.19 Stock losses of 1600 sheep and cattle were attributed to the blue-green algal bloom in the Darling-Barwon 1991 blooms.³⁰¹ These types of stock losses have received considerable publicity. However, information on the adverse effects of the condition of stock and on

296 Johnstone, Evidence, 27 July 1993, p. 395.

297 Nicholson B, Rositano J, Humpage A and Burch M, (1993). 'Removal of algal toxins in water treatment processes'. Proceedings of Australian Waters and Waste Water Association Convention, 15, 18-23 April 1993. Gold Coast, Queensland.

298 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.23.

299 Falconer, I (1988) 'Eutrophication by toxic blue-green algae. An increasing hazard in Australia'. *Australian Biologist* 1(4): 10-12, p.11.

300 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.84.

301 Ibid, p.82.

reduced productivity, particularly resulting from long term exposure at sub-bloom levels, is required. Stock can also lose condition by avoiding nearby water during algal blooms,³⁰² and from having to walk considerable distances in search of clean water. Free range stock are difficult to move away from the river.³⁰³ Liver damage has been found in sheep which may be linked to the algal bloom.³⁰⁴ There are also concerns in relation to reduced milk production and residual toxins in meat products, fruit and vegetables.³⁰⁵ Other than the possibility of residuals in produce, the presence of algae does not appear to have any adverse effect on irrigation operations other than clogging the pumps, and may even contribute nutrients.³⁰⁶

3.20 Toxin accumulation in fish and shellfish and in other foods consumed by humans requires further investigation. Little is known about their toxicity to these animals and other wildlife, or their potential threat to humans ingesting these. Recent research has shown that mussels should not be consumed during toxic algae blooms.³⁰⁷ It is also reasonable to expect that liver of stock would accumulate toxins.³⁰⁸

Public concerns

3.21 Serious health effects are relatively rare and can be largely avoided by providing appropriate and timely advice to the public. The Committee was told that warnings released by the New South Wales Environment Protection Authority (EPA) in June 1993 about toxic

302 Ibid, p.82.

303 McCutcheon, Evidence, 4 August 1993, p.673-4.

304 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.82.

305 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.11.

306 Blainey, Evidence, 2 August 1993, p.477.

307 Falconer I, Choice A and Hosja W, (1992) "Toxicity of Edible Mussels (*Mytilus edulis*) Growing naturally in an Estuary During a Water Bloom of the Blue-Green Alga *Nodularia spumigena*." *Environmental Toxicology and Water Quality: An International Journal* 17: 119-123, p.119.

308 Falconer, Evidence, 12 August 1993, p.796.

algae in the Hawkesbury area did not reach the community.³⁰⁹ Further, the Department of Health only received edited information that was two weeks old and on this basis felt they could not make a decision.³¹⁰ This situation has now been rectified by the New South Wales State Algal Coordinating Committee requiring the regional committees to report on a weekly basis.³¹¹

3.22 The Committee is concerned that an effective public health warning system is not in place in all regions which have potential threat from blue-green algal blooms. Responsible authorities must have sufficient timely information to enable the appropriate management decisions to be taken. The community must have confidence in decisions taken and should be informed of the reasons for those decisions. Contingency plans should provide procedures that may be necessary at the local, regional, State/Territory and national level. The most successful approach will be based on a local sense of 'ownership' and cooperation.³¹²

Recommendation 22

The Committee recommends that contingency plans be required to outline the procedures to be carried out at local, State/Territory and Commonwealth levels in the event of algal blooms.

Recommendation 23

The Committee recommends that as part of the development of the National Water Quality Management Strategy, water managers and health departments be provided with sufficient information in relation to the treatment of algal blooms for them to be able to make timely decisions in relation to the management of water bodies.

309 Cauchi, Evidence, 3 August 1993, p.554.

310 Cauchi, Evidence, 3 August 1993, p.554.

311 Smalls, Private Briefing, 26 November 1993, p.54.

312 Anderson, Evidence, 25 September 1992, p.202.

Recommendation 24

The Committee recommends that communities be informed of the reasons for decisions taken by water managers and health departments to address toxic algal blooms in their areas.

3.23 Media coverage is largely responsible for informing the public of the occurrence of blue-green algal blooms, and cooperation could be sought from television and radio stations to provide information on the subsidence of the blooms to alleviate local concerns and to assist the tourism and recreation industries. Media attention on algal blooms has focussed the community attention on the issue, enabling greater participation in remedial measures.

3.24 Some States have produced information sheets to inform the community on the possible risks and necessary action.³¹³ Some popular misconceptions may still need to be addressed in some areas, for example, there is a misconception that boiling water removes the toxins.³¹⁴ The Committee was told that public concerns are also being addressed by holding local meetings and seminars and having a 008 number available for the public in some areas.

Management of Algal Blooms

3.25 There is a need to manage algal blooms in the interim while long term management strategies are implemented and become effective. Short term strategies include the use of alternative water supplies, additional water treatment or the restrictive use of water storages.³¹⁵ There have been recent improvements in the management of algal blooms in water supplies which have alleviated the need to close down these supplies. There are particular difficulties, however, in managing

313 Engineering and Water Supply Department, South Australia, Submission No.49, Appendix; New South Wales Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.29.

314 'What can be done about toxic algae blooms'. *Ecos.* 72 Winter 1992:14-19. p. 16.

315 Queensland Water Quality Task Force, *Interim Report on Freshwater Algal Blooms in Queensland*, 31 July 1992, p.18.

recreation areas and determining whether the entire area should be closed if the scum only covers part of the area, because this may change with weather conditions.³¹⁶ The Committee was told that warning signs and verbal advice are often ignored.³¹⁷

Public Warning Systems

3.26 There is currently no common approach to providing a public warning system, as was evident in the Hawkesbury Nepean situation (discussed in 3.20). The failure to make the public aware of a toxic algae bloom may make authorities more liable for negligence. It is essential that there be a process in place which would clearly identify those responsible for particular actions.

3.27 Research needs to be done into the effectiveness of various warning mechanisms, such as the erection of signs or issue of press releases. The appropriate mechanism may vary from locality to locality.

Recommendation 25

The Committee recommends that:

- **a set of guidelines outlining the procedures and responsibilities of water managers and health authorities to provide adequate public warnings be developed; and**
- **a comparative study of the effectiveness of various warning mechanisms be undertaken and water managers be advised of the full range of options available.**

3.28 It is also important that the public be advised when the danger from the bloom has subsided. Tourist businesses and those having to find alternative water for stock may suffer substantial financial disadvantages during the duration of the bloom and should be advised when it is safe to use the water.

316 Johnstone, Evidence, 27 July 1993, p.393.

317 Johnstone, Evidence, 27 July 1993, p.402.

Recommendation 26

The Committee recommends that it be part of the procedures for advising the public of the presence of algal blooms that notification should also be given when the danger has subsided.

Monitoring

3.29 Long and short term strategies to control algal blooms cannot be successful without an adequate monitoring program. Early prediction of developing blooms is important, especially if the algae are to be treated with lower concentrations of algicides to avoid the release of substantial amounts of toxins on the death of cells.³¹⁸ The early detection of a developing bloom in the Lower Darling River in mid January 1992 was treated by flushing, preventing the onset of the bloom.³¹⁹

3.30 The Committee is concerned at the lack of coordination between and cooperation from government instrumentalities. For example, the Committee was told that in the Hawkesbury-Nepean catchment, the New South Wales EPA did water tests once a month, and the Water Board tested once a fortnight. The EPA results were not available to the local water management authority, and the Water Board released only edited information.³²⁰ The Committee strongly supports the current New South Wales State Algal Coordinating Committee's program to develop an extensive algal data base which will provide a formal mechanism for reporting algal blooms across the State.

3.31 ARMCANZ has a national data base on its agenda. The Committee is mindful that there may be problems with any attempt to maintain a central data base. Some agencies may be reluctant to provide information that may cause alarm in the public arena or may implicate the management practices of the agency. Agencies may also

318 Australian Water Resources Council *Freshwater Algal Blooms* Occasional Paper prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.5.

319 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.34.

320 Cauchi, Evidence, 3 August 1993, p.539.

be reluctant to fund monitoring programs which will be public for other authorities to use at no cost.

3.32 There is the issue of who owns the data; the group which collects it or the agency that funded the collection of the data. Should the public have an automatic right to access information collected with public funds, and who should pay the costs involved in making this information available to the public?

3.33 This situation may be different in the case of private companies which also collect data in situations where sewerage or irrigation systems are privatised. In cases where government instrumentalities have been corporatised or privatised could a user pays system be used as a mechanism to offset the costs of collecting the information as well as the costs of distributing the information? Costs of extensive monitoring programs are prohibitive. The possibility of an independent data collector who would make results available to agencies and the public was suggested to the Committee.³²¹

3.34 There was little change reported in the monitoring techniques over the last year, although some programs were expanded and intensified.³²² There is currently a great deal of disparity between and within monitoring programs in the States.³²³ The Commonwealth Environment Protection Agency has instigated a review of water quality monitoring in Australia with the aim of developing an effective and uniform monitoring network.³²⁴ Money will be available to the States/Territories involved in an integrated approach, which will monitor a common set of parameters.³²⁵ A national agreement on a set of guidelines for monitoring would significantly increase the analytic value of data available as well as establishing operational procedures.

321 Cullen, Evidence, 27 August 1993, p.862.

322 *National Algal Scoreboard 1992/93*. Water Forum. Agriculture and Resource Management Council of Australia and New Zealand, p.3.

323 Alexandra, Evidence, 27 July 1993, p.429.

324 Lambert, Evidence 27 August 1993, p.884.

325 Lambert, Evidence, 27 August 1993, p.884.

3.35 There should be a standard process of data collection, reporting, and evaluation in relation to frequency and position of blooms i.e. surface, subsurface, at the edge or centre of water bodies, to enable more meaningful comparisons, including error estimates. Data collection strategies should include more intensive monitoring during blooms to provide information for future research and management. An essential feature of successful monitoring programs is a quick turnaround for results if they are to be used for predictive and interactive management.³²⁶ Training of staff to identify and count algal cells will give immediate information rather than having to wait for reports from a central laboratory.

Recommendation 27

The Committee recommends that a national set of guidelines in relation to the monitoring of algal blooms be adopted as soon as practicable.

3.36 The New South Wales State algal coordinating committees make weekly reports on media coverage, public warnings, monitoring, availability of water supplies containing blooms at high alert levels. Some States have already issued detailed guidelines on sampling methods and specific actions required.³²⁷

3.37 The research into algal bloom causal factors will be assisted by the development of a comprehensive data base of comparative information on the frequency and location of blooms. There is a need for more comprehensive on site testing in some areas and for efficient procedures for laboratory identification of toxic species. Monitoring programs should include relevant data for water authorities, and where possible accommodate research needs and other water users.³²⁸

326 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report.* April 1993, p.33.

327 Clewitt, Evidence, 4 August 1993, p.691.

328 Australian Water Resources Council. *Algal Bloom Research Management. Algal Bloom Research in Australia. A progress report of current status and key issues.* November 1992, p.5-6.

3.38 It was suggested to the Committee that monitoring could extend to water phosphorus and nitrogen levels and pH, turbidity, odour, taste, temperature, light penetration and dissolved oxygen and other environmental factors which may assist in the prediction of algal bloom development. CSIRO is currently working on a solar powered automatic water quality analysis³²⁹ which may assist in this process. This will detect the presence of appropriate conditions for the development of algal blooms, and will provide information on phosphorus sources and other factors that may be useful indicators.³³⁰

3.39 The type of monitoring program will also depend on the intended use of the data. Information collected for the daily care of water supplies will not necessarily provide adequate information for assessing long term trends or for monitoring the effectiveness of management strategies. The objectives of monitoring programs should include measurement of nutrient levels and in-stream processes and feedback on the success or otherwise of management strategies.

3.40 There appears to be very little long term data available, and much of what is available has been collected and kept by individuals and authorities. Although the Committee appreciates the extent of the resources required to develop a central historic data base, this may provide a valuable insight to the cause and management of existing blooms and preventative strategies.

Recommendation 28

The Committee recommends that the Commonwealth Government give consideration to providing the necessary resources for the collation and analysis of the available historical data on algal blooms, nutrient levels and flow rates.

3.41 The existing network of permanent monitoring sites in the Murray-Darling Basin does not provide sufficient information on the development of algal blooms.³³¹ In some situations there may only

329 Commonwealth Environment Protection Agency, Submission No.93, p.8.

330 CSIRO, Submission No.72, p.11.

331 Murray-Darling Basin Commission (1993) *Algal Management Strategy. Technical Advisory Group Report*, April 1993, p.34.

need to be selective increases in the quality of existing monitoring programs to include long term data. Difficulties may be experienced in convincing managers of the benefits of long term monitoring, especially during a period of tight short term budgets. The Committee considers that potential benefits could be gained from establishing a number of sites nationally as references for long term monitoring. Analysis of existing long term data may be sufficient to justify the establishment of the reference sites.

Recommendation 29

The Committee recommends that consideration be given to the establishment of a number of long-term national reference monitoring sites.

3.42 Algal blooms might only become visible when wind concentrates the cells.³³² Local community participation can be effective in the early detection of blooms if people are fully informed and equipped with suitable testing kits and appropriate steps are taken to avoid unnecessary public alarm. The New South Wales State Algal Coordinating Committee is financing the development of an algal watch kit. Monitoring programs can play a significant role in community education through the data provided and their participation in the monitoring programs.

3.43 There have been successful community monitoring programs established in some states. The Ribbons of Blue Program is operating in Western Australia, Streamwatch in New South Wales and other groups in South Australia, Queensland and Tasmania.³³³

3.44 Another effective method of determining the extent of blooms is aerial photography.³³⁴ CSIRO also consider that it is possible to use airborne remote sensing to monitor the environmental conditions

332 Queensland Herbarium, Submission No.24, p.4.

333 Phillips, Evidence, 27 August 1993, p.895.

334 Bursill, Evidence, 12 August 1993, p.756.

leading to the development of blooms, and their extent and intensity.³³⁵

3.45 There is a need to develop more knowledge about the potential use of biological indicators which can give advance warnings of the deteriorating/improving health of our waterways. The use of biological indicators may require fewer resources and may be a feasible alternative to traditional expensive monitoring programs. Studies are currently being conducted by students from the Cooperative Research Centre for Freshwater Ecology, University of Canberra.³³⁶

Water Treatment

3.46 Comparative work is needed into the relative capacity of various techniques for the removal of toxins, odours and tastes from the water supply. Adsorption by activated carbon can be used to remove toxins³³⁷ but this may be costly.³³⁸ Further, the Engineering and Water Supply Department in South Australia tested the activated carbon filters used in the Darling bloom in 1991 and found them to be ineffective. They cautioned that the type of carbon, the manufacturing process, raw materials used and the possible interference by natural organic materials determined the effectiveness of these treatments.³³⁹ Measurement of the effectiveness of toxin removal can only be done when accurate toxin quantifying processes are in place.³⁴⁰

3.47 Contingency plans are now in place for many water supplies, and the nature of these depends on the availability of an alternative water

335 CSIRO. *Waterlink*. CSIRO Division of Water Resources Industry News. No. 12, August/November 1992, p. 5.

336 Cullen, Private Briefing, 26 November 1993, p.40.

337 Falconer I, Runnegar M, Builday T, Van L Huhn and Bradshaw P (1989) 'Using activated carbon to remove toxicity from drinking water containing cyanobacterial blooms'. *American Water Works Association Journal* 18: 102-105.

338 Gutteridge Haskins and Davey, Submission No.18, p.3.

339 Bursill, Evidence, 12 August 1993, p.757.

340 Australian Water Resources Council *Freshwater Algal Blooms* Occasional Paper prepared by Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.6.

supply, an effective water treatment system, the type of algae and the type and use of water.³⁴¹ For example, the Riverland Region in South Australia has produced a contingency plan with guidelines as to the action necessary depending on algal biomass.³⁴² Water authorities with adequate training can now monitor for potential problems and if concerned can send samples to experts for confirmation, thus providing a longer lead time to deal with developing blooms. It is essential that water managers who are responsible for the control of water supplies are provided with adequate information on water treatment as it becomes available to enable them to improve and refine existing management practices.

3.48 There is now general agreement on what level of algal density constitutes a bloom.³⁴³ Alert levels should be defined and monitoring should be sufficient to detect blooms in the early stages of development. Some quantitative guidelines have emerged on what levels of algal density constitutes a risk to the health of humans and stock, and these should include high and low concentrations as well as short term and long term effects.³⁴⁴ The risk and consequences of failure of potential algal control mechanisms was raised as a significant gap in knowledge in relation to the management of water bodies.³⁴⁵

3.49 Further progress will be made in risk assessment as measurements of toxin concentrations, an understanding of the factors that affect their development, their effects on stock and humans and the quick identification of toxic strains of algae become available.³⁴⁶

341 Australian Water Resources Council *Freshwater Algal Blooms* Occasional paper prepared by Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.7.

342 Engineering and Water Supply Department, South Australia, Submission No. 49, Appendix VIII, p.3.

343 Johnstone, Evidence, 27 July 1993, p.398.

344 Australian Water Resources Council *Freshwater Algal Blooms* Occasional Paper prepared by Water Resources Management Committee of the Australia Water Resources Council, November 1991, p.11.

345 Johnstone P, (1993) *Establishing Priorities for National Algal Bloom Research*, April 1993, p.18.

346 Engineering and Water Supply Department, South Australia, Submission No. 49, Appendix VI, p.3.

Risk analysis is also hindered by inadequate knowledge of the ecology of many of Australia's waterways.

Cost of Algal Blooms

3.50 The cost of algal blooms in Australia in 1992/93 was estimated to be about \$10 million and in most states was comparable to the previous year.³⁴⁷ These costs relate to the treatment and prevention of blooms but the difficulties in determining the costs for health, agriculture, tourism and the environment meant that these are not usually included in estimates.³⁴⁸

3.51 A comprehensive cost benefit analysis is urgently needed to provide an indication of the type of data required on the social, environmental and economic costs of algal blooms. Very little reliable information is available about their true costs to governments, individuals, communities, and research organisations, and this information is essential before a reliable cost benefit analysis can be carried out.

3.52 During the November 1991 algal bloom in the Darling system, the Australian Embassy in Japan had inquiries about whether it was safe to eat Australian beef, and inquiries were made in Germany in relation to the safety of tourists wishing to visit Australia.³⁴⁹ Professor Cullen warned of the possible catastrophic effect of such fears on our primary industries in a competitive agricultural export market,³⁵⁰ and these types of costs should be factored into the equation.

3.53 Increased cost can be incurred through the additional water treatment; filter clogging, pH changes and interference with the coagulation process; the use and construction of additional water supplies; upgrading of sewerage works; more intensive monitoring programs; implementing appropriate farm management practices;

347 *National Algal Scoreboard 1992/93*. Agriculture and Resource Management Council of Australia and New Zealand, p.4.

348 *National Algal Scoreboard 1992/93*. Agriculture and Resource Management Council of Australia and New Zealand, p.4.

349 Cullen, Evidence, 27 August 1993, p.856-7.

350 Cullen, Evidence, 27 August 1993, p.857.

measures taken to reduce soil erosion; construction projects, such as the Dawesville Channel (Peel Harvey Inlet); stock deaths and loss of condition; provision of an alternative water supply for stock; human health problems; losses for industries which require acceptable water quality such as fishing; losses to export and domestic trade in produce; adverse effects on industrial investments; loss of real estate values; loss of tourist income and subsequent unemployment; social costs including disruption to water supplies and recreational use; off setting opportunity costs of local government funds which could have addressed other community needs; environmental costs, including loss of biodiversity and loss of ecosystems; and loss of wildlife and native flora.

3.54 Progressively figures are becoming available on known costs. The bloom in the Darling River cost the New South Wales Government \$1.3 million, but the expense to the community was much higher and concerns were expressed by the tourist industry and meat export market.³⁵¹ New South Wales lost an estimated \$10 million in tourist revenue in 1991 as a result of the algal blooms.³⁵² At Mungindi the cost during the 1991 algal bloom was about \$70 000.³⁵³

3.55 The Committee was also given some examples such as the dairy industry in the Lake Albert area in South Australia which was worth \$7.5 million annually, and the fishing industry in the same area which was worth up to \$4 million; these industries were under threat of severe losses resulting from algal blooms.³⁵⁴ An estimated \$6.5 million was lost in tourist revenue in the Gippsland Lakes area in 1990.³⁵⁵ At Edenhope in Victoria (population 1000), \$70 000 was required for a drilling program and water cartage due to a blue-green algal bloom in Lake Wallace; as well there was a negative impact on tourism.³⁵⁶ It would cost \$40 000 a day to use activated carbon at the Happy Valley

351 New South Wales Blue-Green Algae Task Force, Submission No.53, p.8.

352 Verhoeven, Evidence, 11 September 1992, p.134.

353 Davison, Evidence, 5 August 1993, p.703.

354 Meningie Progress Association, Submission No.22, p.5.

355 Department of Primary Industries and Energy, Submission No.91, p.4.

356 Hall, Submission No.14, p.1.

filtration plant in South Australia.³⁵⁷ To flush an algal bloom in the Hawkesbury-Nepean River, the retail value of the drinking water released was \$45 million, with an additional potential cost of \$5.8 million to replace this water.³⁵⁸ At Cessnock dam there was an additional cost of \$20 000 to pump from alternative supplies for six weeks as a result of an algal bloom.³⁵⁹

3.56 Some towns, such as Moree, have alternative water supplies and there is less concern in these situations.³⁶⁰ Also, there was some social cost but big costs arise when there is no alternative water supply and water needs to be trucked in.³⁶¹ The Committee was told that some households at Narran had no rain water and had to move out if water was unavailable as it was too expensive and too far to cart it in.³⁶²

3.57 To date the costs of algal blooms have been substantial. Some of these costs will decrease as more is known about how to manage and control algal blooms. It is essential that adequate funds be available to enable research to continue into areas of concern which enable improved management of our waterways.

Control of Algal Blooms

Contingency Plans

3.58 Contingency plans for dealing with algal blooms are now being developed which define the powers, roles, objectives and actions of all participants. These now clarify the responsibility of authorities/agencies for monitoring, reporting and control in relation to total catchment management practices. These plans define lines of responsibility for actions and funding between different levels of government, the community and industry, although these may differ in each location.

357 Bursill, Evidence, 12 August 1993, p.764.

358 New South Wales Blue-Green Algae Task Force, Submission No.53, p.8.

359 Clewitt, Evidence, 4 August 1993, p.689.

360 O'Reilly, Evidence, 5 August 1993, p.703.

361 Clewitt, Evidence, 4 August 1993, p.689.

362 Treweeke, Evidence, 4 August 1993, p.669.

3.59 Contingency plans must be realistic and affordable. Any contingency plan implemented should be closely monitored and have an automatic feedback mechanism on its success and effectiveness in catchment management at the State/Territory level and to the national network. The effectiveness of various monitoring techniques and the success of community participation approaches should be assessed against performance indicators. Research organisations should have an input into the monitoring programs.

3.60 Plans should be reviewed as new information becomes available, and there should be a comparative assessment of alternative strategies being used in the regional areas. It is important that all potential contributors be given the opportunity to participate in the development of local policy and be kept informed. There has been an increase in the number of training programs and the dissemination of information through schools, colleges and Landcare groups and the release of public information which is designed to ensure appropriate information is available for the local communities and agencies involved in water resource management.

3.61 An integral part of contingency planning is risk assessment based on dose-response data of humans at probable exposure levels. Acceptable daily intake is not known for algal toxins and is dependent on the uses which will determine the potential for human exposure.³⁶³ The results of recent research into the effects of toxins on humans could be distributed to the water managers when positive results are found in laboratory tests. This would ensure that the water managers and local health authorities had the relevant information on which to base their risk assessment decisions.

Biological Control Mechanisms

3.62 The revegetation of river banks to reduce erosion and increased numbers of water plants will reduce the levels of nutrients in the waterways. The European Union requires that 15 per cent of farm land be set aside to accommodate buffer strips, woodlands and native pasture

363 *Health Effects of Toxic Cyanobacteria (Blue-green algae). Report to the Environmental Health Standing Committee on the National Health and Medical Research Council.* University of Adelaide and South Australian Health Commission. June 1993, pp.57-63.

areas.³⁶⁴ This approach may not be appropriate in many Australia ecosystems, and programs such as the National Corridors of Green are designed to address this situation.

3.63 Little is known about the survival of toxic algae in the dormant stages of their life cycle,³⁶⁵ and there may be a possibility of a control mechanism at this stage. Research is currently being conducted in the Water Studies Centre, Monash University.³⁶⁶

3.64 In sufficient numbers, bacteria can control blue-green algae.³⁶⁷ Dried bacterial cultures have the potential to be used as a low cost alternative treatment for algal blooms in closed water systems. However, these are most effective under aerobic conditions and require temperatures between 25 and 30 degrees celsius and it may take 28 days to reach the environmental balance.³⁶⁸ Work is being done at Melbourne University on bacteria which will ingest the toxins.³⁶⁹ The use of viruses that infect blue-green algae is another possibility.³⁷⁰

Barley Straw

3.65 It has been suggested that the use of barley straw may produce substances that inhibit the development of algal blooms and also provide a habitat for zooplankton which feed on the algae,³⁷¹ but further research is needed into its potential use on a larger scale. The

364 Hindmarsh, Submission No.95, p.3.

365 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.8.

366 van Dok W (1993) *The Importance of Resting Cells in Seeding Algal Blooms*. Water Studies Centre. Monash University. Doctorate Research 1992-95.

367 May V, (1972) 'Blue green algal blooms at Braidwood, NSW (Australia)'. *Science Bulletin* No.82. NSW Department of Agriculture; Fraleigh P and Burnham J (1988) 'Myxococcal predation on cyanobacterial populations: nutrient effects'. *Limnology and Oceanography* 33(3):476-483.

368 Organic Waste Recyclers (Australia) Pty Ltd, Submission No.20, p.4.

369 'What can be done about blue green algal blooms'. *Ecos* (Winter 1992) 72:14-19, p.18.

370 CSIRO, Submission No.72, p.12.

371 Hindmarsh, Submission No.95(b), p.3.

Committee was told that about one tonne of barley straw has the potential to clear 100 megalitres of water.³⁷² The Committee was also told that the use of barley straw had the potential to enable the interim treatment of algal blooms without severe environmental damage,³⁷³ and it was suggested that the existing weirs could be used for barley straw treatments.³⁷⁴

3.66 The New South Wales Department of Water Resources is conducting trials with barley straw at Penrith,³⁷⁵ and other trials are being conducted in Victoria and at Murdoch University.³⁷⁶ The trials in Victoria have, however, shown varied results, and there is concern about the additional organic material in waterways which could increase the levels of trihalomethanes, which are potential carcinogens.³⁷⁷ Further research is needed into the conditions under which the use of barley straw is effective,³⁷⁸ and into the environmental safety of the use of this approach.³⁷⁹

3.67 Competition by predators and other organisms may inhibit the development of algal blooms if these organisms are present in sufficiently large numbers; alternatively, the presence of synergistic organisms may enhance the development of blooms.³⁸⁰ Insufficient

372 Hindmarsh, Evidence, 3 August 1993, p.618.

373 Hindmarsh, Evidence, 3 August 1993, p.619.

374 Austin, Evidence, 3 August 1993, p.629.

375 Hindmarsh, Evidence, 3 August 1993, p.618.

376 Government of Victoria Department of Conservation and Natural Resources, Victoria, Supplementary Submission No. 81(a), Attachment 6, p.1.

377 Government of Victoria Department of Conservation and Natural Resources, Victoria, Supplementary Submission No. 81(a), Attachment 6, p.1.

378 Jelbart J and Abbott G (1993) *An Investigation of the Effect of Rotting Barley Straw on the Cyanobacterium Microcystis aeruginosa*. Paper presented to the 56th Water Industry Engineers and Operators Conference, Ballarat, September 1993.

379 Jelbert, J (1993) 'Effect of Rotting Barley Straw on Cyanobacteria. A Laboratory Investigation'. *Water*. October 1993: 31-32, p.32.

380 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.5.

information is available in relation to Australian ecosystems to enable this to be a feasible alternative at this stage.

3.68 Zooplankton which feed on the blue-green algae may also survive in the bottom strata where oxygen levels are lower and not suitable for predatory fish. Herbivorous zooplankton have been used in Danish lakes during the recovery period after a bloom.³⁸¹ Blue-green algae can benefit from the grazing pressure on other more palatable algae species.³⁸² Some algal toxins can kill predatory zooplankton and may inhibit competitors.³⁸³ Small zooplankton may also be unable to graze on large filaments or colonies of blue-green algae.³⁸⁴ Therefore the introduction of zooplankton may favour the large species of blue-green at the expense of other phytoplankton and create a further imbalance. Further, healthy zooplankton populations were found during the algal bloom in the Darling River,³⁸⁵ casting doubt on the effectiveness of this method of control.

Wetlands

3.69 The Committee has been told that wetlands can substantially reduce the levels of phosphorus entering the waterways. For example, at Lake Apopka in Florida, USA, there is a proposal to recycle water from the lake through wetlands to reduce nutrient levels.³⁸⁶ Wetlands also provide a refuge for zooplankton which feed on the algae. In 1991 a workshop was held on wetland conservation and management which considered the conservation policies and programs, the threats to and

381 Australian National Industries Ltd, Submission No.39, p.11.

382 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.22.

383 Carmichael, W (1981) *The water environment: algal toxins and human health*. Plenum Press, New York.

384 Lynch M and Shapiro J (1981) 'Predation enrichment and phytoplankton community structure.' *Limnology and Oceanography* 26(1):86-102; Edmonson W and Litt A (1982) 'Daphnia in Lake Washington.' *Limnology and Oceanography* 27(2):272-293.

385 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.55.

386 Higgins, Evidence, 2 August 1993, p.483.

the wise use of wetlands.³⁸⁷ There is no comprehensive survey of Australian wetlands despite their importance in flood control, ground water recharge, erosion control and water purification.³⁸⁸

3.70 It has been pointed out, however, that blue-green algae living in wetlands provide a seed source to the main waterway, and in South Australia trials are being conducted into the use of booms to prevent the algae from entering the waterways.³⁸⁹

European Carp

3.71 The role of the carp is not clearly understood,³⁹⁰ but, there is a common perception that the European carp (*Cyprinus carpio*) plays a significant role in the development of algal blooms.³⁹¹ If this is the case then the regulation of fish populations has the potential to be used to keep algal growth under control. Carp may increase nutrient levels in water by disturbing the sediments, thus increasing turbidity levels as well as well as having an impact on the food chain.³⁹² Carp can feed on the water fleas which graze on the blue-green algae, and it was suggested to the Committee that the removal of carp from the Murray-Darling would reduce of algal blooms.³⁹³

3.72 The effectiveness of this approach will depend on an appropriate method of eradicating this species. The Victorian Government declared the carp a noxious animal, but the Victorian Fisheries and Wildlife

387 Australian National Parks and Wildlife Service, *Educating and Managing for Wetland Conservation*. Proceedings of the Wetlands Conservation and Management Workshop. University of Newcastle and the Wetlands Centre, Shortland. Edited by P Donohue and B Phillips. 11-15 February 1991.

388 Australian Conservation Foundation, Supplementary Submission No.75(a), p.20.

389 Suter, Evidence, 12 August 1993, p.782.

390 Bowmer, Submission No.63, p.2.

391 Arnott, Evidence, 5 August 1993, p.707.

392 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.52.

393 Hindmarsh, Evidence, 3 August 1993, p.615.

Department were unsuccessful in their attempt to eradicate the species.³⁹⁴ Research is currently being done in Victoria with a carp virus called *spring viraemia*, which appears to have no deleterious effect on native fish species.³⁹⁵

3.73 There are divided opinions as to the extent to which carp cause irreparable damage.³⁹⁶ The encouragement of native species and the reduction of carp numbers³⁹⁷ may be desirable for a number of environmental reasons, but the complexity of the ecosystem makes the prediction of the outcome difficult. These methods of control are not usually attractive to regulatory bodies because they are difficult to control.³⁹⁸

Chemical Control Mechanisms

3.74 Reliance on water treatment to remove algal toxins is not wise due to the difficulties in detection of toxins present and the possibility of mechanical failure during the treatment process, or inefficiencies in the equipment due to the clogging of filters by the algal biomass, or changes in water properties due to the presence of algae. For example, photosynthesis increases the pH of the water and this may alter the necessary treatment.³⁹⁹

3.75 Further research is needed into the effects of various water treatments on the full range of algal toxins, such as the use of

394 Williams, Evidence, 12 August 1993, p.809.

395 Hindmarsh, Evidence, 3 August 1993, p.617.

396 Williams, Evidence, 12 August 1993, p.809.

397 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.15.

398 Bowmer K (1981) 'Nutrient Enrichment Eutrophication: Cause of problem plant growth possibilities for regulation'. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs) New South Wales Department of Water Resources pp.491-501, p.494.

399 Australian Water Resources Council, *Freshwater Algal Blooms*. Occasional paper prepared by the Water Resources Management Committee of the Australian Water Resources Council. November 1991, p.2.

chlorination for the treatment of hepatotoxins.⁴⁰⁰ It has been found that hepatotoxins can be degraded by low dose rates of chlorine, which provides a low cost practical treatment for water to be used by stock.⁴⁰¹ However, the chlorination of water containing blue-green algae can lead to the formation of trihalomethanes and other undesirable organic compounds⁴⁰² and therefore may have adverse health implications.⁴⁰³

3.76 Algicides are not usually biospecific and the adverse effects on other organisms are not always known. Copper-based algicides are the only ones registered in Australia for use in water supplies.⁴⁰⁴ The Committee was told that the use of this algicide can cause greater environmental degradation than an untreated algal bloom⁴⁰⁵ and the degree of success depends on the chemistry of the water.⁴⁰⁶ As well, the residual copper may remain in the water supply for some time, and the use of copper sulfate releases the algal toxins into the water supply.⁴⁰⁷ Copper sulfate also kills water fleas that feed on the algae.⁴⁰⁸ Lower copper toxicity has been reported for siderophore producing species of blue-green algae.⁴⁰⁹

400 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.15.

401 Bursill, Evidence, 12 August 1993, p.753-4.

402 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.78.

403 Australian Water Resources Council *Freshwater Algal Blooms Occasional Paper* prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.5.

404 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.14.

405 Water Studies Centre, Submission No.30, p.1.

406 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.14.

407 Burns, Submission No.31, p.3.

408 Hindmarsh, Evidence, 3 August 1993, p.619.

409 Clarke S, Stuart J and Saunders-Loehr J (1987) 'Induction of siderophore activity in *Anabaena* spp. and its moderation of copper toxicity'. *Applied and Environmental Microbiology* 53(5):917-922.

3.77 On Palm Island, over 140 people were hospitalised after the water supply was treated with copper sulfate releasing the toxins into the drinking water.⁴¹⁰ The use of copper sulfate should be restricted to situations where there are low cell counts.⁴¹¹ Mass algae kills with algicides also result in the deoxygenation of the water during the decay of large masses of plant material which release nutrients which can be used by subsequent algal blooms. Further research is needed into the degradation rates of toxins released during the decay of the cells for Australian algal species, as some may take two weeks to break down.⁴¹²

3.78 The Committee was told that copper sulfate was being used by managers who felt under political pressure to be seen to be doing something.⁴¹³ As the water supply needs to be closed down after treatment with copper sulfate, it may be better to leave the bloom untreated.⁴¹⁴ Research is needed into alternative compounds in relation to their potential (possibly latent) effects on humans and biota. Research is also currently being done into the possible use of chelated forms of copper.⁴¹⁵

3.79 The other chemical approach is to reduce the nutrient levels in the water to retard the development of algal blooms. The mineral zeolite can be used to remove nutrients from water as it absorbs up to 5 kilograms of phosphate per tonne of zeolite and has the advantage that it can be re-used as a slow release fertiliser.⁴¹⁶ The Committee was told that there is a concern that zeolite-based products may release heavy metals into the environment, but so does the conventional sludge

410 Falconer, Evidence, 12 August 1993, p.789.

411 Falconer, Evidence, 12 August 1993, p.793.

412 National Project Manager, Algal Bloom Research ARMCANZ, Submission No.33, p.15; CSIRO, Submission No.72, p.6.

413 van Dok, Evidence, 27 July 1993, p.409.

414 van Dok, Evidence, 27 July 1993, p.409.

415 Engineering and Water Supply Department, South Australia, Submission No.49, Appendix VI, p.1.

416 Zeolite Applications Group Pty Ltd, Submission No.40, p.1.

which is currently being used for agriculture.⁴¹⁷ The Murray-Darling Basin Commission Technical Advisory Group on Domestic Use of Polyphosphates stated that zeolites were considered to be the most viable alternative to phosphates in detergents in Australia.⁴¹⁸

3.80 Chemicals such as alum and gypsum may also be used for phosphate removal in farm dams⁴¹⁹ but may introduce other unacceptable impurities.⁴²⁰ These chemicals precipitate phosphorus out and therefore inhibit the development of blooms but they do not remove it from the system and the Committee was told that this may create potential problems in 10-15 years.⁴²¹

Herbicides

3.81 Herbicides may reduce the development of algal blooms. There is no regular monitoring program for agricultural products such as herbicides on a long-term basis⁴²² and work is needed to establish ambient levels in waterways and their role in the inhibition of algal bloom development. A reduction of herbicide levels in drainage channels may permit weed growth and therefore reduce nutrients reaching the water bodies.

Pesticides

3.82 Pesticides from domestic and agricultural land may adversely affect the zooplankton which feed on toxic blue-green algae, but the actual effect on algal blooms is not known. Millipore Australia Pty Ltd,

417 Cullen, Evidence, 27 August 1993, p.860.

418 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.41.

419 May V and Baker H (1978) *Reduction of Toxic Algae in Farm Dams by Ferric Alum*. Technical Bulletin 19 January 1978. Department of Agriculture NSW.

420 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.117.

421 Muntisov, Evidence, 25 September 1992, p.253.

422 Cullen, Submission No.42, p.6.

CSIRO and the Australian Government Analytical Laboratories are developing test kits to detect pesticides under field conditions.⁴²³

Physical Control Mechanisms

3.83 The use of flow rates to control algal blooms has been discussed in Chapter 2. There are, however, a number of other physical mechanisms that can be used in appropriate circumstances.

3.84 Artificial aeration of reservoirs may inhibit algal bloom development by increasing turbulence and preventing stratification, and reducing the release of nutrients from the sediments which promote the growth of toxic algae.⁴²⁴ The Committee was told that intermittent aeration techniques are now available which are automatically controlled by the conditions in the water body and provide an effective low cost phosphorus control mechanism.⁴²⁵ Aeration techniques have been applied in Japan, England and Germany and have been shown to be effective if used in conjunction with other phosphorus removal techniques.⁴²⁶ Destratification by mixing can also stimulate increased chlorophyll formation in deeper water because of the lower light levels, and hence increase the levels of geosmin.⁴²⁷ Aeration is being considered as a short term solution at Chaffey Dam, which can be severely stratified⁴²⁸ and has high phosphorus levels in the sediments.⁴²⁹

3.85 A number of other physical controls may be appropriate in some circumstances. For example, the monitoring of algal cells at different levels may enable selective pumping of water. The New South Wales Department of Water Resources is trialing the use of harvesters and

423 Minister for Industry, Technology and Regional Development, Submission No.89, p.11.

424 Burns, Submission No.31, p.2.

425 Burns, Supplementary Submission No.31(a), p.2.

426 Ibid, p.3-4.

427 'What can be done about toxic algal blooms?' *Ecos* (Winter 1992) 72:14-19, p.18.

428 Sinclair, Evidence, 5 August 1993, p.737.

429 Garrard, Evidence, 5 August 1993, p.737-8.

floating booms.⁴³⁰ Explosives have been used in the United States but this does not remove nutrients or toxins.⁴³¹ The practical and environmental implications of dredging the sediments prohibits this approach in some situations, but it may be useful in some lakes or reservoirs. Experimental work is being conducted on the use of calcium salts to prevent the transport of phosphorus from the sediments.⁴³²

Economic Instruments

3.86 A user pays system for water could cover the costs of the supply, distribution and disposal, including the consequences of the disposal method. The effects of user pays on consumers and the effect on environmental allocations, sustainable management of resources and adequate economic models must be considered.⁴³³ The Minister for Primary Industries and Energy, the Hon Simon Crean, has supported the introduction of market based measures subject to consultation with those affected, but only if these economic measures contribute to a solution.⁴³⁴

3.87 With the move to a user pays system there must be an appropriate pricing structure. Water users can be persuaded to accept price increases if there is an associated improvement in service.⁴³⁵ The issue of water pricing must be based on a need for social responsibility with the necessary adaptation and adjustment processes.⁴³⁶ Problems arising in respect of low income consumers must be addressed.

430 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.117.

431 Humphries, Evidence, 22 October 1992, p.343.

432 Bursill, Evidence, 12 August 1993, p.756.

433 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.1.

434 Minister for Primary Industries. Address to the AWRC and ANZECC National Conference on Water Quality Management and Ecologically Sustainable Development. Delivering the Opportunities. Adelaide 3-4 December 1992, p.4.

435 Wardle, Evidence, 2 August 1993, p.513.

436 Alexandra, Evidence, 27 July 1993, p.440.

3.88 The introduction of user pays requires efficient management of water as consumers cannot be expected to pay for inefficient practices by authorities. In determining the price of water consideration should be given to addressing the inappropriate use of potable water and to encouraging reuse of water.⁴³⁷

3.89 The use of water for the purpose which provides the highest financial return cannot always be justified and must be balanced against any social and environmental benefits.⁴³⁸ The impact of pricing on industry development or maintenance must also be considered. The landholders make commercial decisions based on their allocation of water; if the rules are changed then it should be subject to appeal.⁴³⁹ The Dumaresq-Barwon Border Rivers Commission believes that start up flows should be allocated on a merit basis.⁴⁴⁰

3.90 The question also arises whether the community is expected to pay for major capital works, and what sort of consultation processes are necessary. There was a concern that with the introduction of a user pays system the farming community would need to find a substantial amount of money in a short period. If the beneficiary should pay, the question arises whether that means all Australians because of the wider benefits of irrigation to the country.⁴⁴¹ The user pays system would be unfair in situations in which there was a critical need to upgrade an asset. The price of irrigation water would need to increase 5-10 fold to cover the full costs of building, repairing and operating irrigation infrastructure, and would nearly equal the profit per megalitre for dairy and rice growers.⁴⁴²

437 Nature Conservation Council of New South Wales (1993). Submission to the Joint Select Committee upon the Water Board, 2 August 1993, p.32.

438 Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), Submission No.54, p.5.

439 Hutton, Evidence, 27 August 1993, p.920.

440 Hutton, Evidence, 27 August 1993, p.921.

441 Roberts, Evidence, 11 September 1992, p.22-23.

442 Australian Conservation Foundation, Supplementary Submission No.75(a), p.37.

3.91 The Committee was told that it would be fairer to upgrade the asset and then account for depreciation in charging policies.⁴⁴³ The point was also made that in some situations the upgrade was necessary because of poor planning by government agencies.⁴⁴⁴ The potential impact of the privatisation of irrigation infrastructure may be substantial if water users are required to pay the full costs of building, repairing and operating. These issues all need further consideration.

3.92 The baseline is to determine how much people are prepared to pay for a safe water supply, and an analysis of the risks involved. The estimated cost of improvement to the Darling River sewage treatment works to remove nutrients is \$200 million plus the increased operational costs.⁴⁴⁵ The Sydney Water Board will spend \$600 million reducing nutrient discharge into the Nepean Hawkesbury River System.⁴⁴⁶ Money for updating of sewage treatment works may be needed as grants or long term loans to upgrade plants in small communities.⁴⁴⁷ Subsidies may be considered in some situations.⁴⁴⁸ In particular, communities with low rate bases should have sufficient information on alternatives available, although many communities could benefit from this information.

3.93 The low interest rates which are available in some States provide incentives for the implementation of improved farming techniques.⁴⁴⁹ The use of modern technologies such as recirculation systems, off-river storage and laser grading have significantly improved the efficiency of water use.⁴⁵⁰ The rice industry, for example, has a target for reducing

443 Donovan, Evidence, 2 August 1993, p.475.

444 Donovan, Evidence, 2 August 1993, p.475.

445 New South Wales Blue-Green Algae Task Force, Submission No.53, p.8.

446 Industry Commission, *Water Resources and Waste Water Disposal*, Report No.26, 17 July 1992, p.153.

447 Murray River Management Board and the Murray Irrigation Area and Districts Management Board, Submission No.52, p.1.

448 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.5.

449 Australian Irrigation Council, Submission No.58, p.11.

450 Australian Irrigation Council, Submission No.58, p.15.

the water used by one megalitre per hectare per year, and for the most part has been able to achieve this.⁴⁵¹

3.94 There needs to be a move away from the assumption that water has an opportunity cost of zero, and there needs to be an appreciation of the environmental value of water as well as its industrial and urban uses.⁴⁵² The environment and water resources are not free goods because there is a significant maintenance cost,⁴⁵³ and it may be useful to evaluate the environment in terms of its replacement cost.⁴⁵⁴ Major industries and regional communities are based on subsidised water.⁴⁵⁵

3.95 If there are to be reductions in the allocation of water for irrigation, the New South Wales Irrigators' Council expressed the concern that there should be a balance between the community's economic needs and environmental considerations. Values in terms of lost productivity can often exceed the costs of sustaining the environment, and other benefits are bonuses.⁴⁵⁶ For example, the Committee was told that a bale of cotton required a megalitre of water to produce and had a value of \$400.⁴⁵⁷ Riparian flows should be considered in terms of the value of the water to farmers. The cost to farmers/irrigators if reallocation of water was introduced may require compensation.⁴⁵⁸

451 Wardle, Evidence, 2 August 1993, p.509.

452 Culgoa-Balonne Minor Distributary System Water Users' Association, Submission No.37, p.11.

453 Humphries, Evidence, 22 October 1993, p.331.

454 Humphries, Evidence, 22 October 1992, p.330

455 Australian Conservation Foundation, Supplementary Submission No.75(a), p.36.

456 Humphries, Evidence, 22 October 1992, p.331-32.

457 Arnott, Evidence, 5 August 1993, p.706.

458 Environmental Protection Authority, Western Australia, Submission No.85, p.5.

3.96 The major cost of water is currently that of fuel or electricity to pump the water,⁴⁵⁹ and this does not reflect the true value of a scarce resource. Increased charges for water would have an immediate effect on irrigators and other rural users and this may result in dislocation of local communities. Increased water costs will encourage recycling of water on land and this may reduce input into the streams.⁴⁶⁰ The New South Wales Irrigators' Council told the Committee that there had always been economic imperatives to use water efficiently, particularly in times of low water availability.⁴⁶¹ The Council of Australian Governments found that reforms are taking place in all jurisdictions but the speed and direction of reforms differ.⁴⁶²

3.97 Some other suggestions have been made to reduce excessive water use. These include tax incentives for the installation of efficient irrigation systems,⁴⁶³ and increased prices for irrigation water for those who are not using modern efficient farming methods.⁴⁶⁴ The New South Wales Department of Water Resources in its monitoring program receives a levy from the irrigators on a per megalitre basis.⁴⁶⁵ There is a concern that any government charges in relation to water use should be used for water services and not as a general revenue source.

3.98 There is a gradual move to user pays, with the increased prices providing a signal to the community.⁴⁶⁶ As the price of water increases, serious consideration may need to be given to the reuse of

459 Blainey, Evidence, 2 August 1993, p.476.

460 Industry Commission (1992) *Water Resources and Waste Water Disposal* Report No.26, 17 July 1992, p.159.

461 Donovan, Evidence, 2 August 1993, p.475.

462 Environment, Sport and Territories Portfolio, Supplementary Submission No.92(b), p.3.

463 Lower Darling-Murray Water Users Association, Submission No.26, p.4; Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), Submission No.54, p.6.

464 Campaspe Region Water Authority, Submission No.32, p.6.

465 Corish, Evidence, 5 August 1993, p.730-31.

466 Cauchi, Evidence, 3 August 1993, p.558.

water. Domestic sewage is suitable to treat and recycle if it can be kept separate from industrial effluent and hazardous substances. The possible introduction of 'grey water' for watering gardens and flushing toilets must be seriously considered⁴⁶⁷ as discussed in Chapter 2. Only 25 per cent of household water may need to be potable.⁴⁶⁸

3.99 Melbourne and Sydney are investigating the use of grey water and dual supplies in new land developments.⁴⁶⁹ Land developments in outer Sydney, such as Rouse Hill, will have dual reticulation systems for the use of grey water.⁴⁷⁰ The Nursery Industry Association of New South Wales has discussed the possible use of grey water with the Sydney Water Board as a means of keeping costs down.⁴⁷¹ People could be allowed to install tanks instead of this water going down the storm water drain.⁴⁷²

Transferable Water Entitlements

3.100 The use of transferable water entitlements is an effective way of improving efficiency levels and therefore moving closer to a sustainable water resource.⁴⁷³ The Committee was told that tradeable water entitlements would be taken up by the most efficient user, thus lowering the overall demand for water, making more available for the environment.⁴⁷⁴ Industrial and urban water users may have a greater ability to pay than rural users and may result in the dislocation of rural

467 Australian Construction Services Aboriginal Projects Group, Submission No.78, p.2.

468 Williams, Evidence, 24 September 1992, p.172.

469 Cullen, Evidence, 27 August 1993, p.878.

470 Cauchi, Evidence, 3 August 1993, p.558.

471 Peters, Evidence, 2 August 1993, p.459.

472 Cauchi, Evidence, 3 August 1993, p.558.

473 Department of Primary Industries and Energy, Submission No.91, p.8.

474 Wardle, Evidence, 2 August 1993, p.503.

economies.⁴⁷⁵ If marginal irrigation enterprises were charged on a full cost recovery basis they would be uneconomic.⁴⁷⁶

3.101 This system would, however, enable the Government and environmental groups to purchase water for environmental flows⁴⁷⁷ and would also enable the sale of unwanted water.⁴⁷⁸ The introduction of tradeable water rights would also enable compensation to be paid.⁴⁷⁹ The Minister for Natural Resources and the Treasurer of Victoria have announced a task force to develop a framework for the introduction of tradeable water entitlements.⁴⁸⁰

3.102 The trading of water entitlements may also help put a market value on the worth of water⁴⁸¹ and enforce a disciplined approach to assigning environmental values. There is, however, some uncertainty in respect to environmental outcomes of a market based approach.⁴⁸² It was stressed that the environmental allocation should be purchased and water not used for the environment could be traded back to the irrigators for the end of season top up.⁴⁸³ It was pointed out that the cotton industry would pay a substantial amount for the last application at the end of the season.⁴⁸⁴

475 Australian Conservation Foundation, Supplementary Submission No. 75(a), p.34.

476 Australian Conservation Foundation, Supplementary Submission No. 75(a), p.37.

477 Murray River Management Board and Murray Irrigation Area and Districts Management Board, Submission No.52, p.1.

478 Industry Commission, *Water Resources and Waste Water Disposal*, Report No.26, 17 July 1992, p.160.

479 Donovan, Evidence, 2 August 1993, p.472.

480 Minister for Natural Resources and the Treasurer. News Release, 18 October 1993. *Water Reforms to Improve Service and Performance*.

481 Heeps, Evidence, 25 September 1992, p.206.

482 Department of Primary Industries and Energy, Submission No.91, p.8.

483 Wardle, Evidence, 2 August 1993, p.505.

484 Wardle, Evidence, 2 August 1993, p.505.

3.103 The introduction of tradeable water rights assumes that water is available and this may not be the case in situations where water is already over-allocated. Most States/Territories are moving towards transferable water entitlements, but these will only work if there is security of supply.⁴⁸⁵ Selling allocations to downstream irrigators may be inefficient because of transmission losses, and this aspect may need further consideration.⁴⁸⁶ The Committee was told that the introduction of transferable allocations on the River Murray has led to some implementation problems rather than problems with the concept.⁴⁸⁷

Pollution Measures

3.104 The introduction of tradeable pollution rights enables polluters to buy more permits rather than treating their waste,⁴⁸⁸ but assumes that there is something to trade. When pollution levels are too high then trading will exacerbate the situation.⁴⁸⁹ The use of tradeable rights to discharge nutrients into the waterways is still under investigation.⁴⁹⁰ Any such scheme should reflect the quantity and potential impact of discharge.

3.105 The Committee was told that in principle the tax level should reflect the damage caused,⁴⁹¹ which will reflect the assimilatory capacity of the particular environment, rather than the level of pollution discharged. Pollution taxes for non-point sources may be

485 Australian Irrigation Council, Submission No.58, p.12-13.

486 Turner, Evidence, 5 August 1993, p.729

487 Barratt, Evidence, 12 August 1993, p.830.

488 Industry Commission, *Water Resources and Waste Water Disposal*, Report No.26, 17 July 1992, p.162.

489 Humphries, Evidence, 22 October 1992, p.329.

490 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.129.

491 Industry Commission *Water Resources and Waste Water Disposal* Report No.26, 17 July 1992, p.164.

impossible to implement.⁴⁹² These will affect the practical application of this mechanism.

3.106 The implementation of a polluter pays system will be difficult because of the politics of the issue and its social unacceptability,⁴⁹³ and could be costly and difficult to monitor and enforce. Enforcement is essential in this type of system. The implementation of a pollution tax would ideally need to be able to determine which phosphorus compounds are present and their varying solubility,⁴⁹⁴ and may need a permit for each type of pollution. Imposing a pollution tax does not necessarily reduce the amount of pollution, and money may be better spent on reducing levels by other means. If pollution taxes are to be imposed, there is a need to consider the ability of the industry, agriculture or community to pay.

3.107 Another suggestion was a levy on detergents.⁴⁹⁵ The Horticultural Research Development Corporation, which is a major source of research funding in the industry, derives funds from a nursery pot levy which provides about \$600,000 per year.⁴⁹⁶ If levies are imposed, they should be used for a specific purpose and should not be seen as an additional general revenue measure.

Comments

3.108 The issues of who pays and who determines the apportionment of costs across agencies and the community need to be clarified.⁴⁹⁷ The costs must be equitably distributed to consumers, urban communities, land owners and industrial users. Further research is needed into the effects of water pricing policies on the welfare of consumers because of the difficulties in quantifying these outcomes. The

492 Australian Irrigation Council, Submission No.58, p.10.

493 Humphries, Evidence, 22 October 1992, p.319.

494 CSIRO, Submission No.72, p.12.

495 Lambert, Evidence, 27 August 1993, p.892.

496 Peters, Evidence, 2 August 1993, p.456.

497 Anderson, Evidence, 25 September 1992, p.201.

rural community is already in recession and there has been an increased demand for welfare assistance.⁴⁹⁸

3.109 Corporatisation of water supply authorities should address conflict of interests between commercial and other objectives.⁴⁹⁹ For example, the financial constraints on corporations may prevent authorities carrying out fringe activities that are more beneficial to other agencies.⁵⁰⁰

3.110 If a user pays system is to be introduced, there needs to be a system of accountability to ensure that the most efficient services are provided and that inefficient management practices do not financially penalise the local community. This may also mean that governments may in some situations need to assist with larger projects, and may provide funds with low interest rates or tied grants. There is an 'interesting public policy issue on rationing of a scarce resource made available from a public investment ... providing water for one use does introduce [the question of] the opportunity cost from the alternative uses of water'.⁵⁰¹

3.111 The benefits of implementing strategies to control algal blooms must outweigh any environmental, social and economic costs of leaving them untreated.⁵⁰² The most economic solutions are not always best, as it is cheapest for industry to discharge into rivers,⁵⁰³ and there is a need to look at the ethics and legality of the issue. Despite the economics, it comes down to a matter of what the community is prepared to put up with. Now that blue-green algae have focussed attention on water quality, the community may be prepared to pay more.

498 Government of Victoria, Submission No.81, p.9.

499 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.5.

500 Robinson, Evidence, 22 October 1992, p.368.

501 Cullen, Submission No.42, p.6.

502 New South Wales Blue-Green Algae Task Force, Submission No.53, Letter p.1.

503 Humphries, Evidence, 22 October 1992, p.346.

3.112 Encouragement of Best Management Practices and Codes of Practice may well be used with a mix of regulatory and market based approaches.⁵⁰⁴ A market based approach would need to reflect the value of sustainable land use practices, recognising that current productivity may not be indicative of future yields.⁵⁰⁵

3.113 Management strategies should be cost effective, and they need to cost various control options. The New South Wales State Algal Coordinating Committee is preparing a report on the options available for water supply treatment and the costs.⁵⁰⁶ Strategies should address both the long and short term situation. While some of these strategies may primarily reduce the frequency or severity of algal blooms, there are also substantial other social and environmental benefits in having healthy waterways and in the reduction of soil degradation, which should be entered into the cost equation.

3.114 There needs to be a balance between the costs of monitoring, control and research against the agricultural, tourism and ecological and other values of the catchment. It is not merely a balance between the cost of treatment for algal blooms and improved catchment management, but must consider the general health of the water bodies and their environs. Inadequate information is available on the impact of toxic algae on the ecosystem and its resilience, to enable costing to be applied. For a cost benefit analysis some of the benefits include a reliable water supply, healthy waterways, savings on water treatments and improved agricultural industry.⁵⁰⁷ There is also a need to estimate the costs of rehabilitation of degraded lands and production losses.

504 CSIRO, Submission No.72, p.12.

505 Mues C and Collins D, (1993) A review of Commonwealth landcare initiatives - promoting sustainable farming systems. *Outlook 93*, Canberra, 2-4 February 1993, p.5.

506 New South Wales State Algal Coordinating Committee, Supplementary Submission 53(a), p.6.

507 New South Wales Blue-Green Algae Task Force, Submission No.53, p.9.

CHAPTER 4

A NATIONAL APPROACH

Role of State and Territory Governments

4.1 The States/Territories are moving towards integrated catchment management involving the community, industry and all levels of government.⁵⁰⁸ The benefits of this approach include:

- . the coordination of agencies allowing for better informed decision making;
- . streamlining of organisation procedures;
- . definition of responsibilities, powers and roles of agencies;
- . definition of boundaries;
- . the setting of environmental targets;
- . focus on community involvement and the use of their resources, energy and views on land use; and
- . coordination of community activities.

4.2 The States/Territories which have had significant problems with blue-green algal blooms have formed blue-green algal task forces, and have State/Territory contingency plans and regional bodies to develop local contingency plans. This focus has enabled better communications, assessment of priorities, research coordination, data collection and the implementation of more streamlined arrangements for algal identification, cell counts and toxicity testing.

4.3 The Regional catchment groups are sufficiently large to deal with problems of the magnitude of toxic algae, and they can be self monitoring. The role of the regional committees is to provide community advice and develop and implement management strategies ensuring safe water supplies, while coordinating committees utilise technical and professional regional officers and central specialists to support the regional committees. The New South Wales State Algal Coordinating Committee has members representing Queensland, Victoria and South Australia, and there is an interchange system facilitating information flow.

508 Ray L Wallis and Sally J Robinson, 'Integrated Catchment Management: the Western Australian Experience', *Environment*, 33(10) December 1991, pp.31-33.

4.4 Under the Constitution, the States have the primary responsibility for environmental issues. State instrumentalities therefore need to consider all potential users of the river system⁵⁰⁹ and need to balance community expectations against the management of environmental and water resources. Trade-offs between environmental and community needs will require community involvement in establishing acceptability of various options. An effective system will vary from State to State depending on the existing government organisation, but will only succeed with the support and involvement of both rural and urban communities.

4.5 The Committee was told that lack of communication between some departments was causing confusion⁵¹⁰ and that agency culture can be a problem.⁵¹¹ For example, problems were experienced at Edenhope because of the lack of a clear definition of responsibility.⁵¹² Also the Moree Plains Shire Council planned to establish a wetland at Mungindi and were able to acquire a funding grant and the support of the Departments of Water Resources and Public Works. However, the New South Wales Environment Protection Authority expressed concerns relating to the project late in the planning process. These situations can only be overcome if there is a clear definition of institutional responsibilities and accountabilities, where responsibility is shared, and there is timely communication and consultation.

4.6 The integrated catchment management approach will facilitate the expeditious resolution of disagreements in relation to interstate water sharing. A problem has arisen in relation to the reliance on significant inflow from Queensland to New South Wales,⁵¹³ and this matter can be expected to get worse as Queensland develops its own irrigation industry with the effect of further reducing flow. This matter will fall within the jurisdiction of the Dumaresq-Barwon Border Rivers Commission and under the umbrella of the Murray-Darling Basin Commission and will be considered in the ICM approach.

509 Treweeke, Evidence, 4 August 1993, p.659.

510 Jones, Evidence, 5 August 1993, p.701.

511 Robinson, Evidence, 22 October 1992, p.370.

512 Hall, Submission No.14, p.2.

513 Arnott, Evidence, 5 August 1993, p.711.

4.7 One of the major roles of State/Territory governments is to provide the regulatory framework which sets standards to be achieved by upstream communities. Single issues managed by separate government authorities have led to a plethora of regulations. Governments are now working at overcoming this type of regulatory fragmentation, and any new legislation should link natural resource industries and the environment.

Recommendation 30

The Committee recommends that the development of new legislation or other regulatory measures be required to demonstrate that due consideration has been given to the link between the natural resource industries and the environment.

4.8 The regulatory mechanisms need to clarify the responsibilities and roles of various government agencies. The Committee was told that even when there were acts of parliament which specified the responsibilities of particular government agencies, there was scope for them to deny that issues and responsibilities fell within their charter.⁵¹⁴

Recommendation 31

The Committee recommends that as part of the National Water Quality Management Strategy, regulatory mechanisms be reviewed to ensure that the respective responsibilities and roles of various government agencies are clearly defined.

4.9 The Committee was told that the introduction of legislation to ensure maintenance of adequate environmental flows should be considered.⁵¹⁵ The agricultural industry should be subject to the same regulations and planning controls, in relation to matters such as

514 Cauchi, Evidence, 3 August 1993, p.539.

515 Culgoa-Balonne Minor Distributary System Water Users' Association, Submission No.37, p.10.

location and effluent discharge, as other industries.⁵¹⁶ This approach would require that farmers' land rights also need to be recognised in determining future strategies and should be clarified at the State/Territory level.

4.10 The counter view was that incentives would be more effective in improving agricultural techniques than a regulatory approach.⁵¹⁷ The view was also given that regulations on one side of the river should be applicable to the other side even if it is across a State/Territory border.

Recommendation 32

The Committee recommends that as part of the National Water Quality Management Strategy, consideration be given to the effectiveness of incentive schemes for improving agricultural techniques in relation to maintaining water quality.

4.11 When State/Territory and local authorities are responsible for the allocation of water rights, these bodies need to clarify the rights to compensation when water rights are not met due to an over-allocation upstream. The Committee was told that there was a need for more control of water extraction in terms of monitoring quantity and rate of removal.⁵¹⁸

4.12 Different States/Territories have approached these matters in different ways. For example, Western Australia has developed Environmental Protection Policies and Statements of Planning Policy to ensure implementation of environmental management targets for the catchments and the development of industry codes of practice. In Western Australia, the focus on environmental protection may mean increasing restraints on agricultural developments.⁵¹⁹ Western Australia has moved to a regional allocation approach which integrates

516 Cullen, Submission No. 42, p.7.

517 Murray River Management Board and Murray Irrigation Area and District Management Board, Submission No.52, p.3.

518 Arnott, Evidence, 5 August 1993, p.710.

519 Office of Premier, Western Australia, Submission No.47, p.6-7.

a conservation strategy with other environmental needs.⁵²⁰ In 1990, the Office of Catchment Management was established as the focus for integrated catchment management.

4.13 The trend towards 'corporate agriculture' has made large irrigation projects economically viable without government financial support⁵²¹ and governments have less influence over these projects than State/Territory supported projects. For example, Cubbie Station is an integrated water conservation and management project near Dirranbandi in Queensland which aims to achieve efficient use of water by deep storage reservoirs to reduce evaporation, no runoff and the use of floodplains in a manner which enables the continued passage of flood water.⁵²²

4.14 Research has shown that the farmers' main source of information on irrigation is the people selling irrigation equipment or the media.⁵²³ There needs to be infrastructure that enables the community to get information on water quality and the efficient use of irrigation water quickly. The Committee was told that there was room for improvement in the development of clear lines of communication between those in the field and those required to make the decisions. The role of the government is the dissemination of information to the community, who can then develop and implement their own programs.⁵²⁴

4.15 The Committee was told that the provision of manuals to show people how to do things was preferable to a regulatory approach.⁵²⁵ States/Territories are preparing information sheets and booklets aimed at increasing public awareness. For example, New South Wales Department of Water Resources has produced a set of guidelines under the interim plan for unregulated flow management. Under these

520 Office of Premier, Western Australia, Submission No.47, p.6.

521 Culgoa-Balonne Minor Distributary System Water Users' Association, Submission No.37, p.3.

522 Cubbie Station, Submission No.36, p.1.

523 Day, Evidence, 12 August 1993, p.818-9.

524 Day, Evidence, 12 August 1993, p.812.

525 Blainey, Evidence, 2 August 1993, p.470.

guidelines, farm storage dams are used to supplement reduced licence allocations with unregulated flows.⁵²⁶

Role of Local Governments

4.16 Local authorities have a primary role in the implementation of environmental policies in their areas of jurisdiction and therefore in the development of policies or contingency plans in relation to blue-green algal blooms. Under the total catchment management concept, the State/Territory and local governments have the opportunity to work together to develop long term strategies to ensure the financial viability of schemes and select the most cost effective alternative to meet predetermined objectives set by the community.⁵²⁷ Local governments provide the formal link between the community and State/Territory governments and can develop the community's appreciation of bureaucratic processes of State/Territory and Federal governments.

4.17 Local authorities often control water supply, sewage disposal and planning of developments. There are other cases, however, when local authorities do not have control over the total management of the catchment area, and a number of agencies may be responsible for water and waste water services, storm water and rural drainage. For example, the Campaspe Region Water Authority does not have control over the management of the catchment area.⁵²⁸ The Shepparton Water Board is responsible for water and waste water services but not for storm water and rural drainage.⁵²⁹ In Victoria, the Rural Water Corporation has responsibility for the management of the river and catchment areas.⁵³⁰

4.18 These situations emphasise the need for a coordinated and cooperative approach. A common set of standards will help address interregional inequities, and the policing of standards is important to

526 Browne, Evidence, 5 August 1993, p.715

527 The Response of the Queensland Government to the Industry Commission's draft Report on Water Resources and Waste Water Disposal. May 1992 p. 4.

528 Campaspe Region Water Authority, Submission No.32, p.2.

529 Shepparton Water Board, Submission No.97, p.7.

530 Shepparton Water Board, Submission No.97, p.12.

prevent illegal water diversion and pollution.⁵³¹ The Committee sees the step to reduce the number of water authorities in Victoria from 120 to about 30 as a positive step in pooling financial and human resources and coordinating tasks.

4.19 The Moree Plains Shire Council has established a development committee which aims not only to improve water availability, quality and effluent use but also:

to conduct suitable forums to ensure that the overall community is aware of the benefits, issues, surveys and investigations that have been undertaken in regards to water quality and quantity; and finally, to lead the community in any joint venture approach to water development.⁵³²

The Condamine-Balonne Water Committee has prepared a set of training notes for water quality monitoring.⁵³³ As the integrated catchment management concept develops, it is expected that other local government bodies will expand their role in it.

4.20 There needs to be some sort of public accountability mechanisms which require reporting to the community, for example, groups managing integrated catchment management systems could provide annual reports to enable an audit of their activities, and provide information for the community. There should be an independent body which can make public the failure of the water suppliers to meet standards, the results of monitoring programs and instances of downgrading of quality of the water provided because of financial constraints.⁵³⁴

4.21 In the past, accountability requirements have led to a reluctance to implement strategies because the increased public scrutiny has

531 Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), Submission No.54, p.4.

532 Jones, Evidence, 5 August 1993, p.699.

533 Rayment G and Popawski W (1992) *Training Notes on Sampling for Water Quality Monitoring*, Condamine-Balonne Water Committee, May 1992.

534 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.15.

caused everyone to wait for the perfect solution. In some situations it may be necessary to take the best available option rather than do nothing: although there may be some mistakes, there will be progress overall. Problems in this area may be minimised if strategies are devised on the basis of community preferences for water quality standards, in consultation with technical managers making decisions on the communities' behalf.

Role of the Community

4.22 Subsequent to the 1991 algal bloom in the Murray-Darling Basin, there has been a great deal of publicity given to the blue-green algae problem. The public is now more aware of its extent. The drop in the employment levels during the drought has also given an insight into possible future social problems associated with inadequate water availability.⁵³⁵ This has heightened the community awareness of these issues.

4.23 Community involvement is an expensive and slow process, and the community must be well informed to be an active participant in the process. It is the community who pays the increased cost of improved treatments and the willingness to pay determines the water quality. This may create a difficulty in that everyone is involved but the authorities are still responsible, and majority decisions are not always correct in relation to technical and efficiency considerations.

4.24 Substantial progress has been made in communicating the concept of ecologically sustainable water resources in some jurisdictions where successful initiatives have been based on individual approaches to each member of the community. The New South Wales State Algal Coordinating Committee reports that the State Algal Contingency Plan is operating successfully and that the communities are now in a much better position to deal with algal blooms.⁵³⁶

4.25 There must be a balance between providing sufficient information to enable national and State/Territory wide consistency, and the importance of avoiding a bureaucratic takeover of the community

535 Browne, Evidence, 5 August 1993, p.714.

536 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), pp.1-2.

process. It should be a process of the government assisting the local community to manage its own affairs while ensuring a clear decision making process which outlines the ground rules, and clear responsibility and authority for decisions. If government views are imposed on the community, then participation will cease when the funds are no longer forthcoming. If authorities do not have a genuine commitment to take on board community views then the community will become disinterested. Integrated catchment groups should be a partnership which has equal say for all parties.

4.26 It is not clear to what extent the current groups are representative of the community as a whole. It is important that all potential contributors be given the opportunity to participate in the development of local policy and be kept informed. Total catchment management groups must not alienate sections of the local community, including Aboriginal communities, and should be accountable for their performance. All residents within the area covered by an integrated catchment management body should be eligible for and vote for election to these bodies.⁵³⁷

4.27 Community education in relation to algal blooms has largely involved the symptoms and causes but now the emphasis is shifting to management strategies and action plans and is becoming achievement oriented. The Committee was told that the bottom up approach to changes in land management will facilitate the coordination of the social and economic features in developing a strategic plan.⁵³⁸

4.28 There should be more publicity given to successful models so that others can build on successes of those groups. The Committee was told that in some areas community education was still needed as to what the real issues were.⁵³⁹ The extent to which the community now understands the true situation and the necessary measures is uncertain in many areas, and even the level of community concern is not known. Little information is available on the extent of the community's awareness and knowledge, and this information would be beneficial in developing new policy approaches. It is necessary that this be assessed to enable adequate planning of future educational programs.

537 Alexandra, Private Briefing, 26 November 1993, p.33.

538 Smith, Evidence, 12 August 1993, p.833.

539 Austin, Evidence, 3 August 1993, p.630.

Recommendation 33

The Committee recommends that as part the National Water Quality Management Strategy, the state of community awareness in relation to algal blooms be assessed so that specific problem areas can be identified.

4.29 The Chaffey Dam Advisory Committee was held up as an effective model for dealing with environmental problems because it involved landholders, government agencies and members of the total catchment management committee.⁵⁴⁰ The Committee was also given the example of the Nepean Hawkesbury Catchment Management Committee which has members representing 11 councils and 10 government agencies as well as the community.⁵⁴¹

4.30 In contrast, the South Australian River Murray Wetlands Management Committee does not have community members and sees its role as coordinating agency groups and technical agents.⁵⁴² It did invite members of the community with particular expertise to their first workshop on flow management strategy. It will seek community membership once it has determined the options for flow management on a ten year plan.⁵⁴³

4.31 The resources needed to take a regulatory approach are also expensive in order to measure, monitor and report. The resources would be better spent in getting the communities to understand the issues and make the changes.⁵⁴⁴

4.32 Many communities will be slow to develop a collective ownership of the toxic algae problem because of the spatial and temporal separation of cause and effect. Those members of the community who have had algal blooms in farm dams, had to provide alternative water

540 Sinclair, Evidence, 5 August 1993, p.735.

541 Cauchi, Evidence, 3 August 1993, p.543.

542 Jensen, Evidence, 12 August 1993, p.775.

543 Jensen, Evidence, 12 August 1993, p.775-6.

544 Blackmore, Evidence, 27 August 1993, p.908.

supplies for stock, had to truck in water or been subjected to water restrictions when urban water supplies have been affected or have been denied access to recreational areas will have a greater appreciation of the problem.

4.33 In some areas there is still an issue of how to motivate communities that are not interested in addressing the problem. The community must be provided with a clear statement of the purpose of and need for their involvement in the development of the strategy. A system of networking with community leaders can be very effective in stimulating community involvement. The Committee was told that community involvement may be enhanced if the process is driven by a 'champion' who is closely associated with the catchment.⁵⁴⁵

4.34 The media can play an important role in stimulating community involvement. Community support will be greater in areas where information is available in an easily understood form and in manageable quantities, and could be incorporated at all levels in the education system.

4.35 The Committee was told that the word educate implies that 'someone knows and someone else does not and that you are doing them a favour', and so the extension principle which involves the sharing of information and knowledge and working with the community is a better approach.⁵⁴⁶ Getting technical information across to the community groups means building trust and working through issues, not just sending them published information.⁵⁴⁷ It is not sufficient simply to write to community groups and interested parties as a form of consultation.

4.36 Information can be provided by the agricultural extension officers, as they are the people with the communication networks in the agricultural industries.⁵⁴⁸ The Soil Conservation Council in South

545 Hart, Evidence, 27 July 1993, p.421.

546 Sledge, Evidence, 3 August 1993, p.595.

547 Cullen, Evidence, 27 August 1993, p.872.

548 Cullen, Evidence, 27 August 1993, p.873.

Australia has developed a manual and is establishing demonstration sites for field days to show land management techniques.⁵⁴⁹

4.37 Another avenue for providing information for the community is in the preparation of the guidelines provided by the National Water Quality Management Strategy to explain the costs and mechanisms to achieve the water quality levels.⁵⁵⁰ The National Strategy also includes a number of educational seminars around the country, which are also providing information to the regional areas.⁵⁵¹

4.38 Other areas still need attention. For example, with regard to educating the community through schools and universities, Professor Williams pointed out that most textbooks in biology at the first year level are American.⁵⁵² The Murray-Darling Basin Commission is preparing a kit of curriculum materials through the Teachers Released from Industry Program which is suitable for primary and secondary schools.⁵⁵³

4.39 The Committee was told of a number of successful models of total catchment management committees that involve communities. For example, the South Australian Water Resources Council, which advises the Minister of Public Infrastructure, has a majority of community members, representing local government, commerce, industry, farmers, unions, environmental groups and domestic water users, and also includes the chief executives of the four relevant departments.⁵⁵⁴

Landcare

4.40 The Commonwealth National Landcare Program community grants are available to enable the Landcare groups to undertake

549 Butler, Evidence, 12 August 1993, p.837.

550 Lambert, Evidence, 27 August 1993, p.888.

551 Lambert, Evidence, 27 August 1993, p.893.

552 Williams, Evidence, 12 August 1993, p.807.

553 Murray-Darling Basin Ministerial Council, Algal Management Strategy for the Murray-Darling Basin, Draft August 1993, p.19.

554 Barratt, Evidence, 12 August 1993, p.822.

projects.⁵⁵⁵ The Commonwealth Natural Resource Management Strategy program provides \$13 million to support community projects.⁵⁵⁶ Proposals for funding are considered by the relevant total catchment management committees, which consist of community and agency representatives.⁵⁵⁷

4.41 The National Landcare program has had a significant impact in local areas.⁵⁵⁸ Twenty-five per cent of rural landholders are participating in these types of activities and another 25 per cent get this type of information from other sources.⁵⁵⁹ The National Landcare movement is different from the others as it involves hobby farmers, full-time farmers and urban people working together⁵⁶⁰ and provides the opportunity to integrate catchment management on a regional basis. The Landcare movement originally had a focus on land-based, soil-based activities, but there has been a gradual move away from that towards a water-related focus.⁵⁶¹ The Landcare program has been very successful, but there is also a need to reach those members of the community who are not involved with it.

Waterwatch

4.42 The Commonwealth Waterwatch program aims to facilitate a set of standard monitoring processes for community groups. This program is based on the Ribbons of Blue program established in Western Australia. It targets the local community through schools and is designed to reach some members of the community who are not involved with Landcare.⁵⁶² Further, this program helps overcome the

555 Reville Evidence, 27 August 1993, p.893.

556 Blackmore, Evidence, 27 August 1993, p.905.

557 Blackmore, Evidence, 27 August 1993, p.906.

558 Smith, Evidence, 12 August 1993, p.834.

559 Johnson, Evidence, 12 August 1993, p.841.

560 Crawford, Evidence, 12 August 1993, p.842.

561 McDonald, Private Briefing, 26 November 1993, p.32.

562 Phillips, Evidence, 27 August 1993, p.893.

'pass the buck upstream' syndrome.⁵⁶³ This provides information on marked changes within the waterways which can be further tested by the relevant authorities. The Commonwealth will provide \$2-9 million to establish the program which will link with and support State/Territory based programs.⁵⁶⁴

4.43 Streamwatch is a similar program in Sydney, and other groups are operating in South Australia, Queensland and Tasmania.⁵⁶⁵ In Western Australia, some government monitoring has been able to be cut back in areas where the community is gathering data.⁵⁶⁶ State/Territory programs are guided by steering committees which involve the relevant agencies, and the Commonwealth Government will provide \$700,000 to facilitate the process.⁵⁶⁷

4.44 Despite the success of these programs and others, there are still areas where it is difficult to motivate the local communities. Existing government policies may indirectly encourage local communities to wait until a problem becomes critical so that State/Territory and Federal governments will assist. For example, the provision of funds for sewerage systems as discussed in Chapter 2.

Recommendation 34

The Committee recommends that as part of the National Water Quality Management Strategy, a review be conducted of government policies to establish whether there is potential to provide incentives for members of the community to undertake preventative actions in relation to maintaining water quality.

4.45 Local communities may not see the effects of their actions, positive or negative, as the impact may be visible a considerable

563 Phillips, Evidence, 27 August 1993, p.894.

564 Keating, P (1992) Statement on the Environment. Australia's Environment: a natural asset. 21 December 1992 Adelaide, p.14.

565 Phillips, Evidence, 27 August 1993, p.895.

566 Phillips, Evidence, 27 August 1993, p.896.

567 Phillips, Evidence, 27 August 1993, p.896.

distance downstream. Those who experience the effects may not have control over the causes. This can be overcome to some extent by having communities work on a catchment basis. Again, however, there are difficulties when the catchment is extremely large and many members are remote from the area experiencing difficulties. The community may be divided when it comes down to the question of who pays, and ICM committees must have the correct processes for dealing with resource management conflicts.

4.46 It is difficult to measure the extent to which the integrated catchment management concept has been successful in convincing the community to accept the toxic algae problem and be prepared to participate in measures to reduce the frequency and intensity of blooms. It was suggested that providing a water quality update on the weather report would provide feedback to the community on their success or further problems.

Role of the Commonwealth

4.47 Under the Constitution, the Commonwealth Government does not have jurisdiction over environmental issues. The Commonwealth does, however, have a role in Australia's economic wellbeing and hence a concern in relation to the sustainability of water resources to meet urban, rural and industrial needs. The Commonwealth's role is one of leadership and its water policy relates to the efficient, sustainable and equitable utilisation and development of the nation's water resources.⁵⁶⁸ The Commonwealth is actively involved in national forums to promote this policy, and is participating in the development of a comprehensive strategic approach to the water resources issue.

4.48 The Commonwealth's participation is through: the Agriculture and Resource Management Council; the Murray-Darling Basin Initiative; the Federal Water Resources Assistance Program; and other financial assistance programs, such as the Land and Water Resources Research and Development Corporation. The Commonwealth seeks to foster cooperation from the community, industry and governments and

568 Department of Primary Industries and Energy, Submission No.91, p.4.

where possible to provide institutional arrangements and resolve conflicts enabling sustainable use of Australia's water resources.⁵⁶⁹

4.49 The Commonwealth can facilitate the implementation of a national water management program through resource use changes, and has considered aspects such as access rights, market and regulatory approaches, conflict resolution mechanisms and information exchange.⁵⁷⁰

4.50 The Commonwealth is also involved in a number of other related activities. The Government is required to demonstrate the adequacy of their management of Commonwealth land and land use policies in relation to sound resource management.⁵⁷¹ The Commonwealth Environment Protection Agency is looking at methods of keeping Australian industries up to date on available technologies for reducing pollution levels.⁵⁷² In 1992, the Industry Commission finalised its inquiry into *Water Resources and Waste Water Disposal*.

4.51 The National Landcare Program links a number of programs in the Environment portfolio and Primary Industries and Energy portfolio such as Landcare, the National Soil Conservation Program, Federal Water Resources Assistance Program, the One Billion Trees Program and other programs relating to forestry, water resources and soil conservation.⁵⁷³ The funding of the National Landcare Program for community groups will enable joint projects, reduce administrative costs and provide coordination of programs.

569 Department of Primary Industries and Energy, Submission No.91, p.5; Commonwealth Environment Protection Agency, Submission No.93, p.10.

570 The National Landcare Program. Discussion Paper. *Sustainable Natural Resource Management - Integration of Primary Industries and Energy Programs*. Department of Primary Industries and Energy, April 1992, p.8.

571 The National Landcare Program. Discussion Paper. *Sustainable Natural Resource Management - Integration of Primary Industries and Energy Programs*. Department of Primary Industries and Energy, April 1992, p.8.

572 Commonwealth Environment Protection Agency, Submission No.93, p.10.

573 The National Landcare Program. Discussion paper: *Sustainable Natural Resource management Integration of Primary Industries and Energy Programs*, Department of Primary Industries and Energy April 1992.

4.52 The Commonwealth supports the integrated approach now being taken to water resource issues, which brings together agricultural, industry and community groups to develop strategies which will provide economic benefits as well as sustaining the environment. As part of the Commonwealth's commitment to an integrated approach, the *Natural Resources Management (Financial Assistance) Act 1992*⁵⁷⁴ establishes a National Landcare Advisory Committee and enables funding for integrated resource management. The Federal Government may also exercise some control over agricultural industries through powers over external affairs, trade and commerce, corporations, taxation, customs and excise, and the fiscal powers under section 96 of the Constitution in relation to providing financial assistance to the States.

4.53 The provision of substantial amounts of funding is to stimulate action to address water resources and other landcare issues through partnership arrangements with the States/Territories. Some taxation incentives are also available under Sections 51(1) and 75(b) and (d) of the *Income Tax Assessment Act 1936* to assist primary producers with soil and water conservation management, as well as the 150 per cent tax deductions for relevant research and development projects, such as the Zootech research into zooplankton culture in sewage stabilisation ponds.⁵⁷⁵ Tax incentives are less effective in times of recession, and grants and rebates for money spent on conservation or efficient water use may be more appropriate. The South Australian Soil Conservation Council considered that more incentive monies should be made available for items such as riparian zone protection.⁵⁷⁶

4.54 The Commonwealth also has a role in funding research. The Commonwealth Environment Protection Agency commissions research into environmental resources: CEPA commissioned a report on Seeking Solutions Towards Healthy Rivers, and has instigated the Monitoring of River Health Initiative. The CSIRO has provided \$3 million to research the effects of changes in water flows, toxicology, biological options and conceptual modelling. The Land and Water Resources Research and Development Corporation also coordinates and funds research projects, and has a \$10.5 million budget. The Land and Water

574 *Natural Resources Management (Financial Assistance) Act 1992*, No.242 of 1992.

575 Zootech, Submission No.68, p.8.

576 Smith, Evidence, 12 August 1993, p. 837-8

Resources Research and Development Corporation has given river research a priority in its strategic plan, identifying issues such as flow requirements and development of indicators in river health both in stream and flood plains.⁵⁷⁷ Further, a Cooperative Research Centre for Freshwater Ecology has been established at the University of Canberra. The Department of Environment, Sport and Territories has established a program on the Investigation of Environmental Flow Requirements.⁵⁷⁸

4.55 The Commonwealth also has a role in increasing public awareness, in community, landholders' and farmers' education, and in information distribution.

A National Approach

4.56 During the inquiry the Committee was impressed with the extent to which cooperation between and within the three levels of government and the community was improving. The Committee was told that there had been a 200 per cent improvement in coordination over the previous three years, and there was improved communication.⁵⁷⁹

4.57 The Inter-governmental Agreement on the Environment facilitates a national approach and the proposed National Environment Protection Authority will be able to provide the national oversight.⁵⁸⁰ Under this arrangement the States/Territories will vote on national action,⁵⁸¹ and the ministerial council will determine the national environmental protection measures for water.⁵⁸² The Inter-governmental Agreement on the Environment also provides a greater opportunity for local governments to play a more prominent role.

577 Murray-Darling Basin Ministerial Council, *Algal Management Strategy for the Murray-Darling Basin*, Draft August 1993, p.7.

578 Murray-Darling Basin Ministerial Council, *Algal Management Strategy for the Murray-Darling Basin Draft*, August 1993, p.7.

579 Wardle, Evidence, 2 August 1993, p.514-5.

580 Lambert, Evidence, 27 August 1993, p.886.

581 Lambert, Evidence, 27 August 1993, p.899.

582 Lambert, Evidence, 27 August 1993, p.886.

4.58 The Agriculture and Resource Management Council of Australia and New Zealand, formerly the Australian Water Resources Council (AWRC), includes agriculture, soil and water State/Territories and Federal ministers and provides a whole systems approach. The ARMCANZ is developing a shared policy framework on issues of national concern, and has formed an Algal Blooms Task Force which is preparing a national strategy. A national algal data base is one example of the items on the ARMCANZ agenda.

4.59 The Murray-Darling Basin Commission involves New South Wales, Victoria, South Australia, Queensland and the Commonwealth Governments and is developing an algal management strategy which addresses five key approaches:

- . improved flow regimes and flow management;
- . reduced nutrient concentrations in the streams and storages of the basin;
- . heightened community awareness;
- . improved scientific knowledge; and
- . progressive refinement of the strategy.⁵⁸³

The strategy outlines the roles of the community, local, State/Territory and Commonwealth governments as well as the Commission, research institutions and industry.⁵⁸⁴

National Water Quality Management Strategy

4.60 The National Water Quality Management Strategy aims to integrate environment and resource interests. Both the Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand are involved in its formulation and implementation.⁵⁸⁵ The strategy must

583 Murray-Darling Basin Ministerial Council, *Algal Management Strategy for the Murray-Darling Basin*, Draft, August 1993, p.23.

584 Murray-Darling Basin Ministerial Council. *Algal Management Strategy for the Murray-Darling Basins*. Draft, August 1993, pp.29-30.

585 Lambert, Evidence, 27 August 1993, p. 887.

be supported by and enforced in the States/Territories to be effectively implemented.⁵⁸⁶

4.61 It is important that the national guidelines on water quality be sufficiently flexible to be able to be applied to specific locations, and should have an ecological quality requirement rather than a purely physio-chemical basis. Water quality criteria should depend on use (including environmental) and may need to be reviewed as more information becomes available.

Recommendation 35

The Committee recommends that the guidelines for the National Water Quality Management Strategy be based on environmental criteria as well as physio-chemical factors.

Recommendation 36

The Committee recommends that the guidelines for the National Water Quality Management Strategy be sufficiently flexible to accommodate the natural variability in Australian freshwater ecosystems.

4.62 There is also a need to develop performance indicators to measure the effectiveness of outcomes of the proposed strategies in relation to water quality. The determination of performance targets should involve community, industry and regulatory authorities and the relevant government agencies. There need to be clearly defined roles for local, State/Territory and Federal agencies and governments to address catchment specific requirements in relation to water quality.

586 Australian Conservation Foundation, Supplementary Submission No.75(a), p.1.

Recommendation 37

The Committee recommends that the development of performance indicators to measure the effectiveness of outcomes of proposed strategies in relation to water quality be an integral part of integrated catchment management.

Coordinated Control of Major Catchments

4.63 Across Australia there has been a strong move towards integrated catchment management involving the community, industry and all levels of government. The ICM movement has enormous potential to address the environmental problems involved in the management of our waterways, but there are still some matters to be resolved.

4.64 It is essential that adequate resources are supplied to assist with the enormous tasks expected of these groups. The question is what proportion of the total spending on resource management is allocated and controlled by the ICM groups responsible for the catchment.

Recommendation 38

The Committee recommends that adequate funding of integrated catchment management bodies be ensured, possibly as a proportion of the total expenditure on resource management.

4.65 The Committee was told that there was still some duplication in situations where government instrumentalities did not talk to each other.⁵⁸⁷ Coordination of government agencies is essential to provide support and resources for enthusiastic community groups as well as situations where communities are difficult to motivate. There were examples where problems were still being sorted out.

4.66 Another example is the establishment of a coordinating and managing body, the Hawkesbury Nepean Catchment Management Trust, to bring together the multitude of agencies working within that

587 Cauchi, Evidence, 3 August 1993, p.546.

catchment. The Committee notes, however, that this will not include the New South Wales Department of Water Resources or the Department of Public Works and will only involve the lower part of the catchment.⁵⁸⁸ The Trust will rely on existing rights and various mechanisms to require agencies to provide their test results and research information.⁵⁸⁹

4.67 Little is known about the extent to which total catchment management committees and other bodies actually represent the community as a whole. The predominance of rural or urban members in any one area may not always reflect the views of the community as a whole. Insufficient is known of the awareness and support of the community as a whole even in areas where there are very active catchment management committees.

Recommendation 39

The Committee recommends that community representatives be elected by their communities to positions on integrated catchment management committees.

4.68 The Committee found that there was very little support for the formation of an additional national body to oversight the algal situation. Any additional functions or powers should be given to one of the existing bodies, or to the National Environment Protection Authority when it is formed with an appropriate resource allocation. The solution to the algae problem must be addressed on many fronts and this will be difficult through a single authority.⁵⁹⁰

4.69 On the other hand, a plethora of agencies can hinder the process of effective management if everyone is involved but no one is ultimately responsible.⁵⁹¹ There is a need for an effective delineation of roles and responsibilities, and clear definition and separation of powers in all

588 Rozzoli, Evidence, 3 August 1993, p.567.

589 Rozzoli, Evidence, 3 August 1993, p.566.

590 Cauchi, Evidence, 3 August 1993, p.540.

591 Alexandra, Evidence, 27 July 1993, p.428.

spheres of government.⁵⁹² This must be balanced with the need to have flexible methods to address catchment specific requirements. The Western Australian Water Resources Council was able to identify some gaps in responsibility for the coordinated management of rivers, and these have been addressed with an integrated catchment management approach.⁵⁹³ Professor Burton has pointed out that integrated catchment management is not about amalgamating existing bodies but about increasing the extent of cooperation and coordination between groups and agencies and developing a realistic view.⁵⁹⁴

4.70 The Committee is concerned at the number of bodies involved in the management of the waterways where this type of coordination is not inherent in the system. For example, there is no formal link between the Murray-Darling Basin Commission and the Dumaresq-Barwon Border Rivers Commission; however, one of the Commissioners is on both bodies.⁵⁹⁵

4.71 The Committee was told that there should be a great deal of caution before attempting a major upheaval of the current administrative arrangements because of the complex network of interrelationships which are involved.⁵⁹⁶ For example, in the Murray-Darling Basin Commission, the Ministers represent land, water and the environment. Decisions taken at that level assist the coordination that occurs within government agencies.⁵⁹⁷

4.72 Although there has been an improvement in the cooperation between the three levels of government and the community, there could be greater acknowledgment and encouragement of the role played by local government and communities, which in some areas has been substantial. There is a delicate balance between providing enough information to ensure a national and statewide approach and the

592 Alexandra, Evidence, 27 July 1993, p.429.

593 Office of Premier, Western Australia, Submission No.47, p.3.

594 Burton, J (1993) 'The Big Picture' *Water*, October 1993, p.3.

595 Hutton, Evidence, 27 August 1993, p.918.

596 Blainey, Evidence, 2 August 1993, p.481.

597 Blackmore, Evidence, 27 August 1993, p.904.

bottom up approach needed for communities to feel ownership of the problem.

4.73 There needs to be greater consideration of the impact of individual government policies on other policies. It was suggested that there should be a more multi-objective approach to the management of resources. The example was given that the pumping of water to cool a power station could be done in such a way as to destratify water supply reservoirs.⁵⁹⁸ Consideration of further applications for water allocation should require proof that they would not adversely affect environmental flows.⁵⁹⁹ Another example was the construction of drains to control the excess surface water which had the undesirable effect of fast-tracking nutrients to waterways and wetlands. Reviews of the framework within the States/Territories which determines water allocation need to identify commonalities and areas which require a flexible approach. The consideration of all future policy initiatives must take an integrated approach.

Recommendation 40

The Committee recommends that the relevant government agencies be required to demonstrate that due consideration has been given to the impact of individual policies on other government or community programs in accordance with a multi-objective approach to management of resources.

4.74 There needs to be a systematic long term survey to assess the national status of Australia's waterways, and the long term productive capacity of the nation's water resources. In many catchments there is an urgent need to look at the cumulative environmental impacts of the loss of native vegetation, different agricultural pursuits and industrial and urban uses. Strategic approaches require long and short term measures as well as research and monitoring, and may involve all relevant agencies and the community for the entire catchment.

4.75 Municipal planning schemes should also include consideration of catchment sensitivities and dynamics. Before strategies are

598 Higgins, Evidence, 2 August 1993, p.484.

599 Cullen, Submission No.42, p.10.

implemented, there is a need to balance the potential amount to be spent on the environment against the perceived benefits of other uses.⁶⁰⁰

4.76 The implementation of economic and regulatory measures must also have an integrated catchment focus. Where market forces operate, such as in a system of tradeable water entitlements, governments should monitor these to ensure that the public interest is served.⁶⁰¹ There may need to be a mix of regulatory and market strategies. If a regulatory system is developed, it must be responsive to local situations and be sufficiently flexible to provide adequate volumes of water for all needs in a timely manner. The advantages of a regulatory approach include the direct impact and predictable outcome.⁶⁰² Although incentives will encourage people to improve their management practices, there is still a need for disincentives for misuse.⁶⁰³

Recommendation 41

The Committee recommends that the relevant government agencies be required to demonstrate that due consideration has been given to the integrated catchment management approach in the implementation of economic and regulatory measures.

4.77 The Committee was told that traditionally matters of water quantity were considered to be most important and the decision making process was dominated by engineers.⁶⁰⁴ With the change in emphasis to water quality there should be more influence given to biologists, microbiologists, chemists and limnologists to give resource management greater prominence relative to issues of accountability and economic

600 Arnott, Evidence, 5 August 1993, p.706.

601 The National Landcare Program Discussion Paper: *Sustainable Natural Resource Management -Integration of Primary Industries and Energy Programs*. Department of Primary Industries and Energy. April 1992, p.7.

602 Department of Primary Industries and Energy, Submission No.91, p.8.

603 Wardle, Evidence, 2 August 1993, p.512.

604 Williams, Evidence, 12 August 1993, p.800.

management which have dominated the decision making processes.⁶⁰⁵ There is a concern that guidelines should be developed by the expertise within industries rather than within the regulatory bodies to ensure a practical approach.⁶⁰⁶ This approach must now be broadened to include communities within the catchment.

Legislation

4.78 There is a need for a review of the regulation/legislation pertaining to water resource issues. Any such revision needs to acknowledge the integration of natural resource issues and the environment. State/Territory differences in regulatory control are largely being addressed through the national approach, but there needs to be a flexible approach in considering the capacity of competing users to adjust to limitations on use.

4.79 There are 16 New South Wales government agencies and 32 Acts of Parliament associated with the management of the waterways, which makes the policing of these acts and regulations difficult.⁶⁰⁷ Regulations will only be effective if they are adequately policed. The Committee was told that developers can get away with a lot because they know that councils have limited resources and when caught can avoid penalties on a point of law.⁶⁰⁸ The Committee was told that the prosecution of cotton growers was an incentive for improved management practices.⁶⁰⁹

4.80 In some situations, there is still a need to clarify who has the burden of proof, for example in instances such as fish kills.⁶¹⁰ There is also a need to clarify the legal position in a number of other circumstances. If the responsible authority does not provide adequate warning or restrictions on the use of waterways what is the liability for negligence? Is the erection of warning signs sufficient or is there a

605 Williams, Evidence, 12 August 1993, p.800.

606 Baker, Evidence, 2 August 1993, p.494.

607 Simmons, Evidence, 3 August 1993, p.571.

608 Cauchi, Evidence, 3 August 1993, p.552.

609 Baker, Evidence, 2 August 1993, p.495.

610 Cullen, Submission No.42, p.6.

need to check their effectiveness? The Committee was told that when the New South Wales Department of Water Resources wanted to erect warning signs on the Hawkesbury River this was stopped by the local council who felt that the presence of signs would imply that the other areas were safe.⁶¹¹ Water supply managers may close water supplies as a precautionary measure to avoid any risk of liability. There is also still a need in some situations to clarify who has responsibility for particular water bodies.

4.81 In situations where corporations or individuals have contributed excessive levels of nutrients to the waterways but have subsequently left the business or improved their operating practices to meet current standards and have always met any standards current at the time, what is the potential liability? It may be that nutrients have built up historically, and relatively small contributions by current companies/individuals are sufficient to exceed the threshold level sufficient to promote the development of algal blooms. The legal position of all of these situations will need to be clarified.

Development of Research Priorities/Guidelines for Action

4.82 The Water Resources Management Committee of the former AWRC developed a mechanism to focus research effort into and dissemination of information on algal bloom management. The Committee's National Projects Manager for Algal Bloom Research prepared a register of current research and interests to enable areas of duplication and gaps to be identified and research priorities set for more efficient funding arrangements. This will form a register of research activities, such as those being carried out in universities.

4.83 In 1982 the Australian Water Resources Council stated:

Australia's current water research effort is inadequate, fragmented and poorly balanced, and has substantial gaps. Immediate national needs are sound management, leadership and substantially increased funding.⁶¹²

611 Johnstone, Evidence, 27 July 1993, p.403.

612 Australian Water Resources Council (1982) *Water Research in Australia: New Directions*. Report of the Working Group on Water Research Policy. Australian Water Resources Council. Water Management Series No.1.

This is finally being addressed in the development of the Algal Bloom Research Framework.⁶¹³ The workshop conducted by the Algal Research Board produced a list of priority research areas, looked at the current funding arrangements and considered areas where research was inadequate.⁶¹⁴

4.84 The Murray-Darling Basin Commission is currently investing \$21 million per year in information generation and community action, and some of this will assist the algal problem.⁶¹⁵ There was \$10.5 million being spent on algal research, and much is being done in relation to the general water quality improvement which is of benefit to the study of algae.⁶¹⁶

4.85 The Committee was told that there were still substantial deficiencies in the knowledge of effective farm management techniques which required further research funding,⁶¹⁷ particularly regarding irrigation methods⁶¹⁸ and the encouragement of the principles embodied in the Best Management Practices for farming communities.⁶¹⁹ The irrigation industry also provided substantial funds for research. The South Australian Farmers Federation cited the example of research being done by commodity groups which might be useful to other groups.⁶²⁰

4.86 The Australian Irrigators' Council had taken this a step further and required researchers to explain the adoption process for the

Department of National Development and Energy. Canberra.

613 Johnstone P (1993) *Establishing Priorities for National Algal Bloom Research*. April 1993. AWRC National Project Manager.

614 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, pp.1-17.

615 Blackmore, Evidence, 27 August 1993, p.902.

616 Johnstone, Evidence, 27 July 1993, p.396.

617 Australian Irrigation Council, Submission No.58, p.7.

618 Cullen, Submission No.42, p.7.

619 National Water Quality Management Strategy *Water Quality Management in the Rural Environment*. Discussion Paper August 1992, p.3.

620 Day, Evidence, 12 August 1993, p.818.

implementation of the results before it funded projects.⁶²¹ The environmental audit of the cotton industry commented on the well developed research and development system, and the strong link between growers and researchers.⁶²² The cotton industry also had extension personnel who worked alongside farmers to implement measures.⁶²³

4.87 The objectives of the National Algal Bloom Research Program included ensuring effective communication between researchers and other parties, identification of information needs and provision of advice on funding and management of research.⁶²⁴ This would enable the establishment of a mechanism for the identification and funding of future research needs, and ensure a coordinated, cost-effective approach, eliminating duplication of effort. This could partially address the need for more coordination of State/Territory-based research programs to complement national programs and address the specific needs of the States/Territories.⁶²⁵

4.88 In his keynote speech to the Water Allocation for the Environment Seminar, in November 1991, Professor Williams suggested that there should be a balance between 'excessive and sensible bureaucracy' and between 'intrusive and enlightened control'.⁶²⁶ The Agriculture and Resource Management Council of Australia and New Zealand is also in a prime position to determine research priorities and prepare guidelines and information dissemination. The Council is currently looking at the reallocation of resources within research fields

621 Wardle, Evidence, 2 August 1993, p.511.

622 Gibb Environmental Sciences and Arbour International. *An Environmental Audit of the Australian Cotton Industry*. Executive Summary. October 1991, p.15.

623 Wardle, Evidence, 2 August 1993, p.511.

624 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.4.

625 New South Wales Blue-Green Algae Task Force. Final Report. *Blue Green Algae*, August 1992, p.xix.

626 Williams W (1991) *Water for sustainable resource management within a semi-arid continent*. Seminar and workshop on Water Allocation for the Environment, November 1991. p.14.

and the opportunity to direct research funds into areas where needed.⁶²⁷

4.89 Governments must provide a consistent approach to funding to enable long term research and investigations underpinning effective management. The Murray Valley League pointed out that the funding of short term research projects provided short term answers, and possibly discouraged the dissemination of information to maintain a short term funding advantage.⁶²⁸ It is important to use successful outcomes to justify more resources from the government, and there is a need to reduce the amount of red tape for research projects.

4.90 Professor Williams considered that one of the major constraints in the management of Australia's water resources was a lack of 'stable and consistent attitudes from governments towards funding, implementation of aquatic research and investigations underpinning effective management'.⁶²⁹ For example, the previous core funding of the 13 research centres provided by the Australian Water Research Advisory Council was discontinued by the Land and Water Resources Research and Development Corporation.⁶³⁰

4.91 It is the view of the Committee that a balance must be struck between rushing into doing something merely to be seen to be doing something and the tendency to continue research ad infinitum to justify a preconceived view or to delay making hard decisions. There must, however, be sufficient research to define the efforts which will have the greatest impact.

4.92 Much of the research conducted into overcoming the blue-green algae problem has a larger application to the health of waterways generally.

627 Johnstone, Evidence, 27 July 1993, p.397.

628 Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), Submission No.54, p.7.

629 Williams, W.D. *Water for sustainable Resource Management Within a Semi-arid Continent*. Keynote Address for seminar and workshop on Water Allocation for the Environment, November 1991, p.13.

630 Water Studies Centre, Submission No.61, p.3.

Recommendation 42

The Committee recommends that the current level of Commonwealth Government funding for research be maintained if not increased, and that consideration be given to long term funding security for approved research projects.

Market Approach to Water Use

4.93 The Federal Government has the power to allocate funds, introduce taxes and provide tied grants.⁶³¹ There are a number of reviews currently being conducted of water charges as incentives to improve efficiency of irrigation practices. It was suggested that a 'license and charge strategy' may be more effective than prohibiting activities.⁶³² A system of transferable water entitlements is being trialled in some areas, which will allow inefficient consumers to leave the market.⁶³³

4.94 In addressing the causes of blue-green algal blooms and other water resource issues, there may be a need for a mix of regulatory and market strategies. Regulatory systems must be responsive to local situations and be sufficiently flexible to provide adequate volumes of water for all needs in a timely manner. Regulatory approaches may have a more direct impact and a more predictable outcome than other approaches. The introduction of a pollution levy to charge farmers for the consequences of their pollutants downstream would not affect well managed irrigation farms and would only affect those that were causing degradation.⁶³⁴

Early Warning System

4.95 As part of the development of a nationally coordinated early warning system, there needs to be a clear definition of the algal levels at which warnings should be given. Warning limits should depend on

631 Greenpeace Australia, Submission No.2, p.5

632 Cullen, Submission No.42, p.9.

633 Cullen, Submission No. 42, p.8.

634 Cullen, Submission No.42, p.9.

toxicity levels, but until these can be adequately quantified it may be necessary to rely on the type and density of algae present (hence the potential threat). Warnings against inappropriate use may avoid the closure of water storage supplies. Consumers may complain of odours and taste at what is technically a safe level for consumption and may need to be advised accordingly.

4.96 It is essential that sufficient quality information is available in a timely manner to justify to health authorities the need to provide adequate warnings to the public and in some areas to close the water bodies. Water authorities usually prefer to close water supplies rather than risk possible liability. Many of the early warning systems relate to the lack of agreement on what constitutes a problem and at what stage is it worthwhile taking action. The lack of monitoring in recreational areas may also mean that there is no warning system in place.

4.97 The Committee was told of many examples of situations where blooms were detected in the early stages of development and were treated successfully. The Committee was concerned, however, that although developing blooms could be detected in water supplies during routine monitoring, serious blooms in recreational waters may not be detected because of the lack of monitoring, or not reported because of the potential impact on the local tourist industry. This type of information was not forthcoming during the inquiry but may pose a problem in some areas.

4.98 Once a problem has been acknowledged, in most situations mechanisms are in place to treat the bloom or implement satisfactory avoidance procedures. It is very important to advise the public when the waterway has returned to normal and can be used. The impact on the tourist industry can be devastating, and restrictions on the use of water bodies should be seriously considered before implementation.

4.99 One way of informing the public is to provide information as part of the weather report in the same manner as ski reports. This could provide information on any problems, the removal of those problems and provide feedback to integrated catchment management participants on successes within the catchment and areas needing further work.

CHAPTER 5

SUMMARY OF ISSUES

5.1 The degradation of water quality resulting in toxic algae blooms has brought into focus the environmental and social values of the water resource. Water is a finite resource and considerable effort has been put into developing sufficient infrastructure and knowledge to enable an integrated approach to be implemented to replace the rhetoric which has previously been widely used as a substitute for action. Problems are being prioritised to enable work on them to go forward systematically in what is hopefully a realistic timeframe.

5.2 Strategic approaches require long and short term measures as well as research and monitoring, and should involve all relevant agencies and the community for the entire catchment. Short term strategies may be only bandaiding the situation but can go part of the way to resolving long term problems. Targets must be set so that strategies can be developed and communities have goals to work towards.

5.3 Decisions must be made as to the acceptable levels of nutrients and the intensity and frequency of algal blooms that can be tolerated and managed. There must be an assessment of risks, and there is a need to consider for what percentage of the time water bodies need to be potable, and acceptable limits for water quality. To put the toxic algae problem into perspective, the question needs to be considered: to what extent should there be improvement in water quality irrespective of the blue-green algae?

5.4 Progress has been made towards long term solutions to this problem through a cooperative effort between the community, industrial consumers, landholders, government and local authorities within the catchment in consultation at the policy formulation stage. Long term strategies can be developed and refined as a much better understanding of the causes, extent and implications of the situation is gained.

5.5 No one set of measures will solve a problem of the complexity of the sustainability of Australia's water resources. Economic instruments such as pollution taxes, water entitlements, increased costs of water, strategies to reduce pollution sources and the possible reallocation of water licences will only partly address the problem and may only be

appropriate in certain circumstances. Levies collected from irrigators, farmers and other water users should be spent on water resources.

5.6 There is a challenge to researchers to provide the urgently needed information on causes and cost effective treatment of algal blooms, toxicology, the role of nutrients, riverine ecology and the effects of flow rates, the environmental value of water and the realistic appraisal of the impact of algal blooms. There is also a challenge to the community, industry and governments to provide adequate funding and to use this information.

5.7 Accessible data bases for information are being developed which will assist researchers as well as inform the communities. There should not be research for its own sake. There may be a tendency to keep researching in order to obtain the desired answers, rather than accepting obvious, though unpalatable results. The emphasis must be on finding solutions, not apportioning blame, and communities may need to take hard decisions in the light of research findings.

5.8 These decisions need to be made by the local stakeholders negotiating the most acceptable tradeoffs to ensure their rapid implementation. The Committee was told that official inquiries resulted in reports, rhetoric, the appointment of more bureaucrats and recommendations that were only implemented if they cost little money.⁶³⁵ There needs to be firm targets and timetables against which performance indicators can be developed.

5.9 Although not all of the answers are known and there are still a number of areas which need to be addressed, basically the problems and the solutions are known; most States/Territories now have the mechanisms in place, and only the political will is needed to provide the funding to carry them out. The only reason for hesitation should be the importance of directing funding priorities to give the most impact to the problem. Plans and strategies are only the first step and their effective implementation will depend on the extent of government and community support.⁶³⁶

635 Williams, Evidence, 12 August 1993, p.800-1.

636 Australian Conservation Foundation, Supplementary Submission No.75(a), p.4.

5.10 Implementation of strategies should not be strangled by bureaucratic red tape. The implementation of community education should focus on involvement and the provision of information, as the community can supply the political will. Communities will need clear policy directions which are logical, coordinated, well resourced and have realistic expectations.⁶³⁷

5.11 There needs to be coordination and clarification of roles between the many natural resource management and economic development programs currently in place. Confusion stems from the conflicting objectives, different administration channels and timeframes of these programs.⁶³⁸ The Committee is concerned that the proliferation of small programs may result in insufficient funds being available for each to be effective.

5.12 There was little support for the formation of a new national agency to coordinate a national program, and it was suggested that it would be preferable to extend the role of existing or proposed bodies such as the National Environment Protection Authority (NEPA), the Murray-Darling Basin Commission or ARMCANZ. Resources may be better spent strengthening the existing system than in creating a new body. The tendency to create a new agency every time there is a new problem has contributed to the existing lack of coordination in some areas.

5.13 The Committee is concerned at the lack of coordination of the current monitoring programs. As a matter of priority, monitoring programs should be implemented which are adequate to provide an early warning of the development of algal blooms and to provide information on the factors favouring their development.

5.14 There should be a balance between the need for consistent State/Territory-wide and national policies and the social, economic and environmental factors in each catchment. This may vary depending on the social structure and financial constraints of each community. For example, if an algal bloom develops in a community that relies heavily on tourism there may be a tendency not to report it to the authorities to avoid the adverse publicity. There will not be evidence of the problem if it is not looked for. This is particularly important in

637 Barratt, Evidence, 12 August 1993, p.822.

638 Barratt, Evidence, 12 August 1993, p.825.

recreation areas, as water supplies undergo regular routine testing. These situations can be particularly important in areas where algal blooms produce hepatotoxins which have cumulative effects.

5.15 The Committee was told that there was already a plethora of legislation and regulations, but there was still some confusion as to who was responsible for various activities and even for some of the water bodies. It is also important that the rules do not keep changing. Water users make commercial decisions on the basis of their water allocations and the rules at the time. Additional allocations should not be made until more is known about the water available to meet existing allocations plus sufficient for environmental flows.

5.16 The Commonwealth Government has provided funding for healthy rivers, but there is a need to know if it is to be ongoing funding to continue projects already started under these initiatives.⁶³⁹ Commitment is needed to longer term funding to enable longer term projects. The Murray-Darling Freshwater Research Centre was cited as an example of the lack of a stable funding base.

5.17 There is a need for an environmentally safe method of treating algal blooms until long term strategies for prevention can be implemented and become effective. Treatment of algae requires further research into the safer alternatives to copper sulfate, the early detection of blooms, use of increased flow and the use of booms to prevent the seeding of the main water channels from wetlands and small tributaries, the possible use of harvesters and biological controls. There is a need to determine safe levels to ensure that the available information is provided to the water managers.

5.18 The areas needing attention are the identification of sources of nutrients/pollutants, the critical levels for algal bloom development, what factors influence the potential to form toxins, and the priorities for reduction of levels of fertilisers, intensive animal production, detergents, sewage effluent, riparian strip maintenance, stormwater, and septic tanks. The community must be convinced that there is a problem in order to develop a sense of collective ownership, particularly in small to medium sized communities.

639 McCutcheon, Evidence, 4 August 1993, p.692.

5.19 In many areas there may be a need to balance the needs of economic farming and blue-green algae treatment. Information on costs will enable priorities to be determined and can also determine the balance for the levels of the treatment. There is also the issue of getting people upstream to spend money for the benefit of the people downstream.

5.20 There is a need for information on the cost of algal blooms in order to develop priorities. The economic impact of blue-green algae is an order of magnitude less significant than the problem of rising watertables, which is currently the primary focus of the Murray-Darling Basin Commission's activities.⁶⁴⁰ The Western Australian Waterways Commission is currently looking at dinoflagellates, which have potentially devastating effects on estuaries. The factors which favour the bloom of these species are similar to those where algal blooms occur. Much of the research done on algal blooms will assist in addressing these other situations.

5.21 The integrated catchment management concept serves as a focus and must be adequately resourced and supported by government agencies to maximise the potential benefit to be derived from enthusiastic communities. The ICM movement cannot be expected to solve problems of this dimension without adequate resources, and support in the form of acknowledgment of their effort and technical advice when needed.

640 Blackmore, Evidence, 27 August 1993, p.914.

Appendix 1

List of Submissions

1. Messrs A Rose, M Southwell and R Sledge, NSW
2. Greenpeace Australia Ltd, NSW
3. District Council of Meningie, SA
4. National Herbarium of New South Wales
5. Dumaresq-Barwon Border Rivers Commission, QLD and NSW
6. Mrs J Kimbley, SA
7. Dr E Heidecker, QLD
8. Mr B Milson, VIC
9. Mr Q Bowers, VIC
10. Aspley Special School Recycling Station, QLD
11. Professor P Jones, QLD
12. Medi Herb Pty Ltd, QLD
13. Mr A Rafferty, NSW
14. Mr B Hall, VIC
15. Professor W Williams, SA
16. Professor I Falconer, SA
17. NSW Irrigators' Council, NSW
18. Gutteridge Haskins & Davey Pty Ltd, VIC
19. River Murray Action Group, VIC
20. Organic Waste Recyclers Pty Ltd, QLD
21. Associate Professor J Weir, NSW
22. Meningie Progress Association, SA
23. Mr A Faggion, NSW
24. Queensland Herbarium, QLD
25. Chaffey Dam Catchment Management Advisory Committee, NSW
26. Lower Darling Murray Water Users Association, NSW
27. Minister for Transport & Works, NT
28. The Hon J Doohan, NSW
29. Clivus, QLD
30. Water Studies Centre Monash Centre, VIC
31. Mr F Burns, VIC
32. Campaspe Region Water Authority, VIC
33. National Project Manager, Algal Bloom Research, Agriculture and Resource Management Council of Australia and New Zealand (formerly AWRC) National Project Manager for Algal Bloom Research, VIC
34. Condamine-Balonne Water Committee, QLD
35. North West Total Catchment Management Committee, NSW

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36. Cubbie Station, QLD
 37. Culgoa-Balonne Minor Distributory System Water Users' Association, QLD
 38. Mr P Wright, VIC
 39. Australian National Industries Ltd, NSW, I Kruger Consult AS, Denmark, National Environmental Research Institute, Denmark
 40. Zeolite Applications Group Pty Ltd, WA
 41. Lower Murray-Darling & Western Catchment Management Committees, NSW
 42. Professor P Cullen, ACT
 43. Environmental Protection Authority, WA
 44. Ballarat Water Board and West Moorabool Water Board, VIC
 45. Dr G Hallegraeff, TAS
 46. Bureau of Meteorology
 47. Office of the Premier, WA
 48. Coalition of Hawkesbury & Nepean Groups for the Environment, (CHANGE), NSW
 49. Engineering & Water Supply Department, SA
 50. Goulburn-Broken Catchment Salinity Program Advisory Council, NSW
 51. South Australian River Murray Wetlands Management Committee, SA
 52. Murray River Management Board and Murray Irrigation Area and Districts Management Board, NSW
 53. New South Wales Blue-Green Algae Task Force, NSW
 54. Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), SA
 55. South Australian Water Resources Council, SA
 56. Waterways Commission, WA
 57. Launceston Environment Centre, TAS
 58. Australian Irrigation Council, NSW
 59. Snowy River Improvement Trust, VIC
 60. Professor R Bayly, VIC
 61. Professor B Hart, VIC
 62. United Farmers & Stockowners of South Australia Inc, SA
 63. Dr K Bowmer, NSW
 64. National Fishing Industry Council, ACT
 65. Macquarie Valley Irrigators Association, NSW
 66. Australian Cotton Foundation Ltd, NSW
 67. Nepean Hawkesbury Catchment Management Council, NSW
 68. Zootech (Australia), TAS

69. Murray Darling Basin Commission, ACT
70. Australian Meat Holdings Pty Ltd, QLD
71. Mr P Higgins, NSW
72. CSIRO, ACT
73. Gwydir Water Users Council, NSW
74. Nursery Industry Association of Australia Ltd, NSW
75. Australian Conservation Foundation, VIC
76. Hawkesbury City Council, Community Environment Committee, NSW
77. Gwydir Valley Cotton Growers' Association, NSW
78. Australian Construction Services Aboriginal Projects Group, NSW
79. P Hunter, QLD
80. National Parks and Wildlife Service Kosciusko District, NSW
81. Government of Victoria
82. Australian Nature Conservation Agency (formerly Australian National Parks and Wildlife Service), ACT
83. Soil Conservation Council, SA
84. Office of Catchment Management, WA
85. Environmental Protection Authority Western Australia, WA
86. Dalgety & District Community Association, NSW
87. R Condon, NSW
88. Southern Riverina Irrigation Districts' Council, NSW
89. Department of Industry, Technology and Regional Development (formerly Industry, Technology and Commerce), ACT
90. Government of Tasmania
91. Department of Primary Industries and Energy, ACT
92. Department of Environment, Sport & Territories (formerly Department of the Arts, Sport, the Environment and Territories), ACT
93. Commonwealth Environment Protection Agency, ACT
94. Department of Conservation & Environment, Orbest Region, VIC
95. Dr M Hindmarsh, VIC
96. MacIntyre Valley Cotton Growers Association Inc, NSW
97. Shepparton Water Board, VIC
98. Murray-Darling Freshwater Research Centre, NSW
99. Greening Australia, ACT
100. Moree Plains Shire Council, NSW
101. Gunnedah Shire Council, NSW
102. Mr P Cornish, NSW

- 103. Australian Fertilizer Manufacturers' Committee Inc, ACT
- 104. Cups Landowners Association Incorporated, VIC
- 105. Mr T B Green, VIC
- 106. Mr R W Betts, QLD
- 107. Dr M Clarke, NSW
- 108. Ms Kate Boyd, NSW

Appendix 2

List of Public Hearings and Witnesses

**Friday, 11 September 1992: Committee Room 2S2
Parliament House
CANBERRA ACT 2601**

Mr T Roberts, Assistant Secretary, Water Branch, Land Resources Division, Commonwealth Department of Primary Industries and Energy

Dr N McDonald, Director, Water Branch, Land Resources Division, Commonwealth Department of Primary Industries and Energy

Mr J Morris, Manager, Environment Industries, Department of Industry, Technology and Commerce

Dr K Bowmer, Assistant Chief, Division of Water Resources, Commonwealth Scientific and Industrial Research Organisation

Dr J Davis, Senior Principal Research Scientist, Division of Water Resources, Commonwealth Scientific and Industrial Research Organisation

Mr TJ Verhoeven, Chairman, New South Wales Blue Green Algae Task Force, Department of Water Resources

**Thursday, 24 September 1992: City Council Chambers
SHEPPARTON VIC 3630**

Councillor J Gaylard, Chairman, Salinity Program Advisory Council

Mr W O'Kane, Executive Officer, Salinity Program Advisory Council

Mr W Trehwella, Departmental Support Officer, Salinity Program Advisory Council

Mr P Williams, Chairman, Campaspe Region Water Authority

Mr L Gleeson, General Manager, Shepparton Water Board

Dr R Oliver, Senior Research Scientist, Murray Darling Freshwater Research Centre

Friday, 25 September 1992: **Legislative Council
Parliament of Victoria
MELBOURNE VIC 3000**

Mr M Anderson, Director, Water Industry Management Division,
Department of Water Resources

Mr D Heeps, Director, Water Resources Management, Department of
Water Resources and Chairman, Victorian Project Team on Blue-Green
Algae

Mr W Wealands, Manager, Technical Branch, Department of Water
Resources and Member, Victorian Project Team on Blue-Green Algae

Mr B Stewart, Superintendent Hydrology, Bureau of Meteorology

Ms M Voice, Supervising Meteorologist, Climate Analysis Section,
National Climate Centre, Bureau of Meteorology

Mr M Muntisov, Senior Engineer, Gutteridge Haskins & Davey Pty Ltd

Mr F Burns, Consulting Engineer, Frank L Burns Consulting Engineers

Thursday, 22 October 1992: Board Room,
John Tonkin Water Centre
629 Newcastle Street
LEEDERVILLE WA 6007

Mr G Mauger, Supervising Engineer, Catchment Management Planning and Policy Section, Surface Water Branch, Water Resources Directorate, Water Authority of Western Australia

Mr P George, Supervising Engineer, Flood Plain Management and Strategic Drainage Planning, Water Authority of Western Australia

Mr J Kite, Supervising Engineer, Environmental Management, Ground Water and Environment Branch, Water Authority of Western Australia

Mr P George, Program Leader, Division of Regional Operations, Department of Agriculture

Dr R Humphries, Executive Officer, Western Australian Water Resources Council

Mr G Bott, Environmental Officer, Land Use Development Branch, Environmental Protection Authority Western Australia

Mr R Atkins, Director, Environmental Investigations and Assessments, Waterways Commission

Prof A McComb, Head of Environmental Science, Murdoch University

Ms S Robinson, Acting Director, Office of Catchment Management

Dr R Wallis, Director, Office of Catchment Management

Tuesday, 27 July 1993:

**Legislative Council Committee Room
Parliament of Victoria
MELBOURNE VIC 3000**

Dr P Johnstone, National Project Manager, Algal Bloom Research, Agriculture and Resource Management Council of Australia and New Zealand

Professor B Hart, Director, Water Studies Centre, Monash University

Ms W Van Dok, Doctorate Student, Water Studies Centre, Monash University

Mr J Alexandra, Sustainable Landuse Coordinator, Australian Conservation Foundation

Monday, 2 August 1993:

**Conference Room
11th Floor
70 Phillip Street
SYDNEY NSW 2000**

Mr T Scott, Director, Nursery Industry Association of New South Wales and Director, Nursery Industry Association of Australia Ltd

Mr K Peters, General Manager, Nursery Industry Association of New South Wales

Mr J Blainey, Former Executive Director, New South Wales Irrigators Council

Mr G Donovan, Director, New South Wales Irrigators Council

Mr P Higgins, Noraville, NSW

Mr H Baker, Environmental Director, Australian Cotton Foundation Limited

Mr A Wardle, Executive Director, Australian Irrigation Council

Mr J Towns, Chief Executive, ANI-Kruger Pty Ltd

Mr H Regnersgaard, National Technical Manager, ANI-Kruger Pty Ltd

Mr R Bailey, Trainee Architect, Australian Construction Services

Tuesday, 3 August 1993:

**Councillors Room
Hawkesbury City Council
George Street
WINDSOR NSW**

Mr J Cauchi, Resource Management Officer, Nepean Hawkesbury
Catchment Management Council

The Hon K Rozzoli, MLA for Hawkesbury

Mr B Simmons, Community Representative, Community Environmental
Committee, Hawkesbury City Council

Mr J Murphy, Vice President, Coalition of Hawkesbury and Nepean
Groups for the Environment

Mr R Sledge, Private Citizen, Windsor, NSW

Mr J Fitzgibbon, Technical Officer, Wilberforce Reach Landcare Group

Tuesday, 3 August 1993:

**Dubbo City Council
DUBBO NSW**

Mr R McCutcheon, Chairman, Macquarie Valley Irrigators Association

Dr M Hindmarsh, Veterinary Research Officer, Department of

Agriculture, New South Wales Agricultural Research and Veterinary Centre

Tuesday, 3 August 1993:

Walgett Shire Council
WALGETT NSW

Mr J Austin, Member, North West Total Catchment Management Committee and Shire Engineer, Walgett Shire Council

Wednesday, 4 August 1993:

Cubbie Station
DIRRANBANDI QLD

Mr J Grabbe, Manager, Cubbie Station

Ms L Bouilly, Secretary, Culgoa-Balonne Water Users Association

Mr T Treweeke, Chairman, Culgoa Balonne Water Users Association

Wednesday, 4 August 1993:

Public Meeting Room
Dalby Shire Council
DALBY QLD

Mr M Clewitt, Member, Condamine-Balonne Water Committee and Executive Engineer, Planning and Administration, Toowoomba City Council

Mr S Kenway, Project Officer, Water Quality Monitoring, Condamine-Balonne Water Committee

Mr I McClement, Member, Condamine-Balonne Water Committee

Mr W McCutcheon, Executive Member, Condamine-Balonne Water

Committee

Thursday, 5 August 1993: **Council Chamber**
 Civic Centre
 Balo Street
 Moree Plains Shire Council
 MOREE, NSW

Mr G Jones, Mayor, Moree Plains Shire Council

O'Reilly, M J, Acting General Manager, Moree Plains Shire Council

Mr W Davison, Shire Engineer, Moree Plains Shire Council

Mr K Arnott, Chairman, Gwydir Water Users Association

Mr L Smith, Vice-Chairman, Gwydir Water Users Council

Mrs A Scott, Vice-President, Gwydir Valley Cotton Growers Association

Mr S Mulligan, Committee Member, Gwydir Valley Cotton Growers Association

Mr R Browne, Committee Member, Gwydir Valley Cotton Growers Association

Mr P Corish, Chairman, MacIntyre Valley Cotton Growers Association

Mr R Keeley, Vice-Chairman, MacIntyre Valley Cotton Growers Association

Mr D Turner, Vice-Chairman, MacIntyre Valley Cotton Growers Association

**Thursday, 5 August 1993: Council Chamber
Tamworth City Council
TAMWORTH NSW**

Mr A Sinclair, Member, Water Subcommittee, North West Catchment Management Committee; Chairman, Chaffey Dam Catchment Management Advisory Committee; and Member, State Blue-Green Algal Coordinating Committee

Mr W Garrard, Executive Officer, North West Catchment Management Committee

**Thursday, 12 August 1993: First Floor Conference Room
Legislative Council
Parliament House
ADELAIDE SA**

Mr D Bursill, Group Manager, Scientific Services, Engineering and Water Supply Department and Director, Australian Centre for Water Quality Research, Engineering and Water Supply Department

Mr M Burch, Research Biologist, Engineering and Water Supply Department and the Australian Centre for Water Quality Research, State Water Laboratory

Dr D Steffensen, Senior Biologist, Engineering and Water Supply Department and the Australian Centre for Water Quality Research

Mrs A Jensen, Chairperson, South Australian River Murray Wetlands Management Committee and Manager, Wetlands and Murray-Darling Basin, Department of Environment and Land Management

Dr P Suter, Freshwater Biologist, Engineering and Water Supply Department, State Water Laboratory

Professor I R Falconer, Deputy Vice-Chancellor (Academic), University

of Adelaide

Professor W D Williams, SA

Mr P Day, Executive Officer, Natural Resources Division, South Australian Farmers Federation

Mr J Barratt, Executive Officer, South Australian Water Resources Council

Mr N Smith, Chairperson, Soil Conservation Council, Department of Primary Industries

Mr G Butler, Member of Council, Soil Conservation Council, Department of Primary Industries

Ms M Crawford, Member of Council, Soil Conservation Council, Department of Primary Industries

Mr A Johnson, Leader, Soil Conservation Services Section, Department of Primary Industries

Mr L Broster, General Manager, Murray Darling Association Incorporated

Friday, 27 August 1993:

Senate Committee Room 2S1
Parliament House
CANBERRA ACT

Professor P Cullen, Director, Cooperative Research Centre for Freshwater Ecology, University of Canberra

Mr A Copp, Officer, Natural Resources Management Branch, Department of the Environment, Sport and Territories

Dr I Lambert, Director, Standards and Industry Guidelines, Commonwealth Environment Protection Agency, Department of the Environment, Sport and Territories

Mr D Habel, Assistant Director, Pollution Avoidance Section, Commonwealth Environment Protection Agency, Department of the Environment, Sport and Territories

Dr B Reville, Executive Director, Conservation Management, Australian Nature Conservation Agency, Department of the Environment Sport and Territories

Dr B Phillips, Director, Landscape Conservation Unit, Australian Nature Conservation Agency, Department of the Environment, Sport and Territories

Mr D Blackmore, Chief Executive, Murray-Darling Basin Commission

Dr R Banens, Principal Water Quality Scientist, Murray-Darling Basin Commission

Mr W Hutton, Secretary, Dumaresq-Barwon Border Rivers Commission

Appendix 3

List of Inspections

24 September 1992

Murray Darling Freshwater Research Centre, Albury
Goulburn River and Lake Mokoan
Shepparton including Sewerage Treatment Works

22 October 1992

Mandogalup vegetable areas
Mundijong sheep assembly areas
Pinjarra
Peel Harvey Inlet
Dawesville Channel

4 August 1993

Cubbie Station, Dirranbandi

