LAKE MACQUARIE ESTUARY MANAGEMENT STUDY

VOLUME 2 - LAKE MANAGEMENT ISSUES

Prepared for:	Lake Macquarie City Council
Prepared by:	WBM Oceanics Australia 99 Leichhardt Street SPRING HILL QLD 4004
Telephone: Fax:	(07) 3831 6744 (07) 3832 3627
Document:	9487.R5.4

DOCUMENT CONTROL SHEET

WBM Oceanics Australia
99 Leichhardt Street
SPRING HILL QLD 4004
AUSTRALIA

TELEPHONE: 07 3831 6744
International: +617 3831 6744
FAX: 07 3832 3627
International: +617 3832 3627

Document No:	9487.R5.4
Archive Document No:	00016787
Original Date of Issue:	6/12/96
Project Manager:	Bill Syme

Title:	Lake Macquarie Estuary Management Study Volume 2- Report on Lake Management Issues
Author:	Dr Rick Morton, Bill Syme, Jenny Pocock, Tony McAlister, Cassandra Rose,
Client:	Lake Macquarie City Council
Client Contact:	Neale Farmer
Client Reference:	

Synopsis:

WBM Oceanics Australia has been commissioned by the Lake Macquarie City Council to undertake an Estuary Management Study and prepare an Estuary Management Plan for Lake Macquarie. This report forms Volume 2 of the Estuary Management Study and deals specifically with management issues associated with the Lake. Consideration is given primarily to the water quality and ecological, fisheries and public amenity attributes of the Lake. Options for management of these issues and their advantages/disadvantages are presented. Extensive community consultation has been undertaken as part of the Study in order to scope issues and consider options.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE	CHECKED BY		ISSUED BY	
0	06/12/96	A McAlister		R Morton	
1	20/12/96	A. McAlister		R Morton	
2	4/2/97	A. McAlister		R Morton	
3	10/6/97	J Pocock		W Syme	
4	11/7/97	J Pocock		W Syme	

DISTRIBUTION

DESTINATION										
	0	1	2	3	4	5	6	7	8	9
Lake Macquarie City Council	6	30	60	2	100					
WBM Newcastle	1	1	1	-	1					
WBM Library	1	1	1	1	1					
Whitehead & Associates			1	-	1					

FOREWORD

The State Government's Estuary Management Manual is directed towards better management of estuaries. Estuaries are recognised to vary widely in their natural attributes, degree of development and the administrative/legal mechanisms whereby they are controlled. Better Estuary Management is needed not only to halt on-going degradation, but also to rectify past damage, with the overall objective of achieving an integrated, balanced, responsible and ecologically sustainable use of these resources in the future. The stages of estuary management are detailed in the Estuary Management Manual and these stages are detailed below:

Stages of the Estuary Management Process

Stage	Description
1. Form an Estuary Management Committee	A committee, to be chaired by a local council, should include representation from various stakeholders, including relevant authorities, local community groups and users of the estuary.
2. Assemble existing data	Provides a basis for assessing data deficiencies and future assessments of the estuary
3. Estuary Process Study	Involves the definition of the 'baseline' conditions of the various estuarine processes and the interactions between them.
4. Estuary Management Study	Utilises information from the Estuary Process Study, together with other studies, to define management objectives, options and impacts.
5. Draft Estuary Management Plan	Consists of a scheduled sequence of recommended activities that need to be undertaken to achieve the estuary management objectives.
6. Review Estuary Management Plan	Public display and review of the Draft Estuary Management Plan to assess and comment on the recommended actions.
7. Adopt and Implement Estuary Management Plan	Council and Government (either collectively or separately) adopt and implement recommended actions in the Estuary Management Plan.
8. Monitor and Review the management process	Monitoring studies are needed to ensure management actions and controls have the desired effects on estuarine habitat quality and amenity.

This study by WBM Oceanics Australia represents stages 4 to 6 of the estuary management process. The Estuary Management Study has been separated into two volumes. Volume 1 (Entrance Issues) details issues relating to the physical processes of the entrance channel of Lake Macquarie. Volume 2 (Lake Issues) deals specifically with issues associated with the main body of the Lake, tidal tributaries, and waterbodies connected to the entrance channel. More specifically, Volume 2 addresses issues associated with Lake management, water quality, ecology, fisheries foreshore erosion and public amenity. This document details Volume 2 of the Estuary Management Study (Lake Issues).

Volumes 1 and 2 of the Estuary Management Study are important resource documents in considering the Estuary Management Plan (presently being prepared).

EXECUTIVE SUMMARY

WBM Oceanics Australia has been commissioned by Lake Macquarie City Council to undertake an Estuary Management Study and prepare a Management Plan for Lake Macquarie. The Lake is a valuable natural resource to the region providing a variety of commercial and recreation uses to the community. If not managed effectively, such usage of the Lake and surrounding catchment can lead to conflicts and changes to the natural environment.

This Management Study is designed to identify the essential characteristics and values of the Lake, as well as management issues arising from its behaviour and usage. Management options to deal with these issues are presented in this Study, outlining the advantages disadvantages, costs and the level of community acceptance for each management option. Each management option can then be considered and this deliberation will assist in formulating preferred strategies. The ranking and selection of preferred strategies for the Lake will then be undertaken during the next stage, ie. the development of the Management Plan.

This Estuary Management Study report deals specifically with management issues associated with the main body of the Lake, tidal tributaries and waterbodies connected to the entrance channel, such as Black Neds Bay. Issues specifically relating to the Entrance Channel of the Lake have been identified in an earlier report (WBM Oceanics Australia, 1996). The Council and Estuary Management Committee resolved that the Entrance Channel issues were required to be addressed as a matter of priority. Therefore, the Management Study has been separated into two volumes. However, the final Estuary Management Plan will cover all issues and management options for both the entrance channel and the Lake.

The overall approach to the Study has been to:

- identify the essential characteristics of the Lake;
- identify key management issues;
- develop general management aims; and
- identify and assess various options for management of the issues.

The Study has included considerable community consultation to ensure all important issues are identified and to achieve broad community acceptance of the Study. The community consultation program has comprised a wide range of activities including:

- the preparation of a 24 hour telephone and fax comment line;
- receipt, collation and analysis of responses to questionnaires;
- interactive community workshops; and
- a parallel schools program with mailing of information to schools in the region.

The essential ecological features and physical processes of the estuary have been determined by reviewing past studies, carrying out further investigations and through the community consultation program.

This work has shown that the Lake has been subject to considerable change and is continuing to change, particularly in relation to catchment development (and associated population growth). Population growth/development of the Lake's catchment results in commensurate increases in both the rates of pollutant input to the Lake (due to sewage overflows and stormwater runoff from developing and developed catchments) and the pressures applied to the ecological resources of the Lake (by both deteriorating water quality conditions and more people fishing on the Lake).

The key issues associated with Lake management relate to :

(a) Water Quality

- degraded Lake water quality;
- excessive sedimentation;
- poor community attitudes to Lake water quality;
- inputs of selenium to the Lake.

(b) Ecology

- decline in area of seagrass;
- wetland conservation;
- thermal discharges.

(c) Fisheries

- reduced individual angler catches;
- haul netting;
- selenium and heavy metal contaminants in biota.

(d) Foreshore Erosion and Public Amenity

- foreshore erosion;
- excessive sedimentation;
- seagrass and algae removal from foreshore recreational areas;
- accumulation of seagrass/algae on beaches;
- nuisance algal and weed growth in some areas;
- litter/pet faeces.

Unless appropriate management strategies are adopted, these issues are likely to become of greater community concern as population growth continues.

Management strategy options have been identified for each of the above issues. Implementation of strategies for improving Lake water quality will have direct benefits to the Lake's ecology and fisheries (ie. water quality works would address more than one issue). Options are presented for conserving the Lake's seagrasses and wetlands. Issues relating to fisheries are primarily associated with declining angler

catch rates (a phenomenon common to many NSW estuaries). This had lead to conflict between commercial and recreational fishers. This issue needs to receive urgent attention. Management options are presented in this report recognising that management (hence implementation of a selected option) of the Lake's fisheries is the responsibility of NSW Fisheries.

Implementation of many of the management options described in this report may be difficult due to overlapping jurisdiction and responsibilities of Government Departments and Local Authorities. In this regard, the benefits of various options for managing the process of maintaining and improving the Lake's environmental, fisheries and recreational values have also been considered.

All issues identified are important by their nature and need to be addressed. The options presented here will be considered further in determining strategies, priorities and directions for the Estuary Management Plan.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AHD	Australian Height Datum
ANZECC	Australian & New Zealand Environmental and Conservation Council
ARI	Annual Recurrence Interval
ASAP	As Soon As Possible
Biol.	Biological
C	Celsius
CAG	Concerned Anglers Group
CSIRO	Commonwealth Science & Industrial Research Organisation
DCP	Development Control Plan
Dept	Department
DLWC	Department of Land and Water Conservation
DUAP	Department of Urban Affairs and Planning
EPA	NSW Environmental Protection Authority
et al	*et alia;* and others
Fisheries	NSW Fisheries
GPT	gross pollutant trap
g	gram
H_s	(metres) *Significant* wave height; the average height of the highest 33% of waves.
ha	hectare
HPHU	Hunter Public Health Unit
HWC	Hunter Water Corporation
Is	Island
ie.	*id est;* that is
Int.	International
J.	Journal
kg	kilogram
km	kilometre
L	litre
LCU	Lake and Catchment Unit
LMCC	Lake Macquarie City Council
LMCMC	Lake Macquarie Catchment Management Committee
LMECMC	Lake Macquarie Estuary & Coastal Management Committee
m	metres
Min	Minimal
mg	milligram
mg-P/L	milligrams of phosphorus per litre
mg-N/L	milligrams of nitrogen per litre
MHL	Manly Hydraulics Laboratory
mL	millilitre
MSB	Maritime Service Board
m^3	cubic metres
Mod	Moderate
MoU	Memorandum of Understanding
Mw	Megawatt
NHMRC	National Health & Medical Research Council
NSW	New South Wales
NW	north-west
No	Number
PWD	Public Works Department
pH	a measure of acidity or alkalinity
p.a.	*per annum;* each year
pers. comm.	personal communication
pp	pages
ppm	parts per million
ppt	parts per thousand
SEPP	State Environment Protection Policy
SPCC	State Pollution Control Commission
Soc.	Society
s, sec.	seconds
spp.	species
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
t	tonne
URGE	United Residents Group for the Environment of Lake Macquarie
Vol.	Volume
Waterways	NSW Waterways Authority
WSC	Wyong Shire Council
WSUD	Water Sensitive Urban Design
WWTW	Waste Water Treatment Works
µg	microgram
Vhigh	Very High
yr	year

ACKNOWLEDGMENTS

The Study Team would like to thank Lake Macquarie City Council, the Lake Macquarie Estuary and Coastal Management Committee, the various Government representatives and the community for their contributions to this Estuary Management Study. Much was gained from their local knowledge and experience. We would also like to thank Joe Whitehead for running the community consultation program.

1 INTRODUCTION

1.1 Background

Lake Macquarie is the largest coastal lake in eastern Australia, covering an area of about 110km^2. It is situated between Sydney and Newcastle (see Figure 1.1) and is surrounded by extensive residential and industrial development. The Lake is a valuable natural resource to the region providing a variety of commercial and recreation uses to the community. If not managed effectively, such usage of the Lake and surrounding catchment can lead to conflicts and changes to the natural environment.

In recognition of this situation, the Lake Macquarie City Council commissioned WBM Oceanics Australia to undertake an Estuary Management Study for Lake Macquarie. This Study is designed to identify recreational, industrial and environmental issues relating to the estuary and present options for their management. These findings are to form the basis for the preparation of a Management Plan for Lake Macquarie.

The Estuary Management process is being coordinated through the Lake Macquarie Estuary and Coastal Management Committee with assistance from the State Government's Estuary Management Program. An outline of the Estuary Management process is contained in Section 1.2 below. Through this process, a number of key concerns in the Lake have been identified as having a high priority to be addressed. These concerns relate primarily to water quality and ecological issues. By proper management of these issues, most of the significant attributes of the Lake (for example, recreation and aesthetic values as identified through community consultation) should be able to be protected or enhanced.

1.2 Estuary Management Framework

It is well recognised that estuaries are of considerable environmental, social and economic value. Because of their attractiveness and value, estuaries are used for a wide variety of purposes by different groups of people. Often these uses are in conflict. In addition, inappropriate use and over-use of estuaries and surrounding catchments can, and has, degraded their natural values.

There is growing recognition that to better protect the varied uses and attributes of an estuary, a coordinated planning approach is required. This approach needs to allow proposals for development, nature conservation and remedial works to be assessed and proceed on an integrated and objective basis. The preparation of an Estuary Management Plan provides such a coordinated planning base.

Figure 1.1 Locality Plan

For a Management Plan to be effective, it needs to :

- reflect the considered and objective views of all regulatory authorities and interested parties;
- be formally adopted as planning policy by local council(s) and other major stakeholders; and
- be implemented by council(s), government authorities, interest groups and the community in general.

The NSW Government has formulated an Estuary Management Policy in accordance with the above to foster the better management of estuaries. An Estuary Management Manual (NSW Government, 1992) has also been produced providing guidelines to help develop and implement soundly based Estuary Management Plans. The Lake Macquarie Estuary Management Study and Estuary Management Plan are being carried out in basic accordance with these guidelines. The components of estuary management as documented in the Manual are illustrated in Figure 1.2 and described briefly below.

- *Form Estuary Management Committee* - Estuary Management Plans are prepared under the guidance of an Estuary Management Committee, in this instance, the Lake Macquarie Estuary and Coastal Management Committee. The Committee is made up of representatives from the local Council, relevant Government Departments, relevant authorities and community groups.
- *Assemble Existing Data* - All available existing data from various Government, industry and community agencies is generally assembled to form a basis for further investigations.
- *Carry Out Estuary Processes Study* - This Study defines the 'baseline' conditions of the various estuarine processes and the interactions between them. The Lake Macquarie Estuary Processes Study has been carried out as documented by AWACS (1995).
- *Carry Out Estuary Management Study* - The Estuary Management Study uses information from the Estuary Processes Study, together with additional studies and community consultation to define and assess management objectives, options and impacts. This present report forms part of this component which is described in more detail in Section 1.3 below.
- *Prepare Draft Estuary Management Plan* - From the management options identified in the Estuary Management Study, a scheduled sequence of recommended activities that need to be undertaken to achieve the estuary management objectives is formulated into a draft Estuary Management Plan.
- *Review Estuary Management Plan* - The draft Estuary Management Plan is subject to public display and review providing all interested or affected parties with the opportunity to assess what is proposed and register any objections or suggestions. These comments are taken into consideration in finalising the Estuary Management Plan.

- *Adopt and Implement Estuary Management Plan* - Once finalised, the Estuary Management Plan is formally adopted and implemented using a range of planning and regulatory controls as well as physical works and other measures as appropriate.
- *Monitor and Review Management Process* - An Estuary Management Plan is not a static instrument. It needs to be reviewed on a regular basis and updated where necessary to cater for the changing needs and desires of society. Monitoring studies should be undertaken to ensure that management activities and controls are having the desired effects.

1.3 Estuary Management Study

As discussed above, the main objective of the Estuary Management Study is to use information from the Estuary Processes Study (AWACS, 1995), together with additional studies and community consultation, to define management objectives, options and impacts. In broad terms, the Estuary Management Study seeks to :

- identify the significance of the estuary in terms of regional and broader coastal planning issues;
- identify 'essential features' of the estuary, be they physical, chemical, biological, aesthetic, social, or economic;
- document 'current uses' and conflicts of use in the estuary; eg. industry, commercial and recreational fishing, water sport, tourism, habitat protection etc;
- identify possible future land-uses and assess their impact on the 'essential features';
- assess the need for nature conservation and remedial measures;
- identify and assess management objectives; and
- assess planning controls, works and other strategies to achieve these objectives.

Through the Estuary Management process to date, a number of management issues for Lake Macquarie have been identified. For these, together with other issues identified through further investigation and community consultation, the Estuary Management Study is to formulate appropriate management objectives and identify and evaluate strategies to achieve these objectives. In evaluating options, consideration is to be given to tangible and intangible advantages and disadvantages in terms of environmental effects, social factors and the associated costs, to provide a balanced view.

The Estuary Management Plan will then consider each identified management strategy further and develop strategies, priorities and directions for management of Lake Macquarie Estuary.

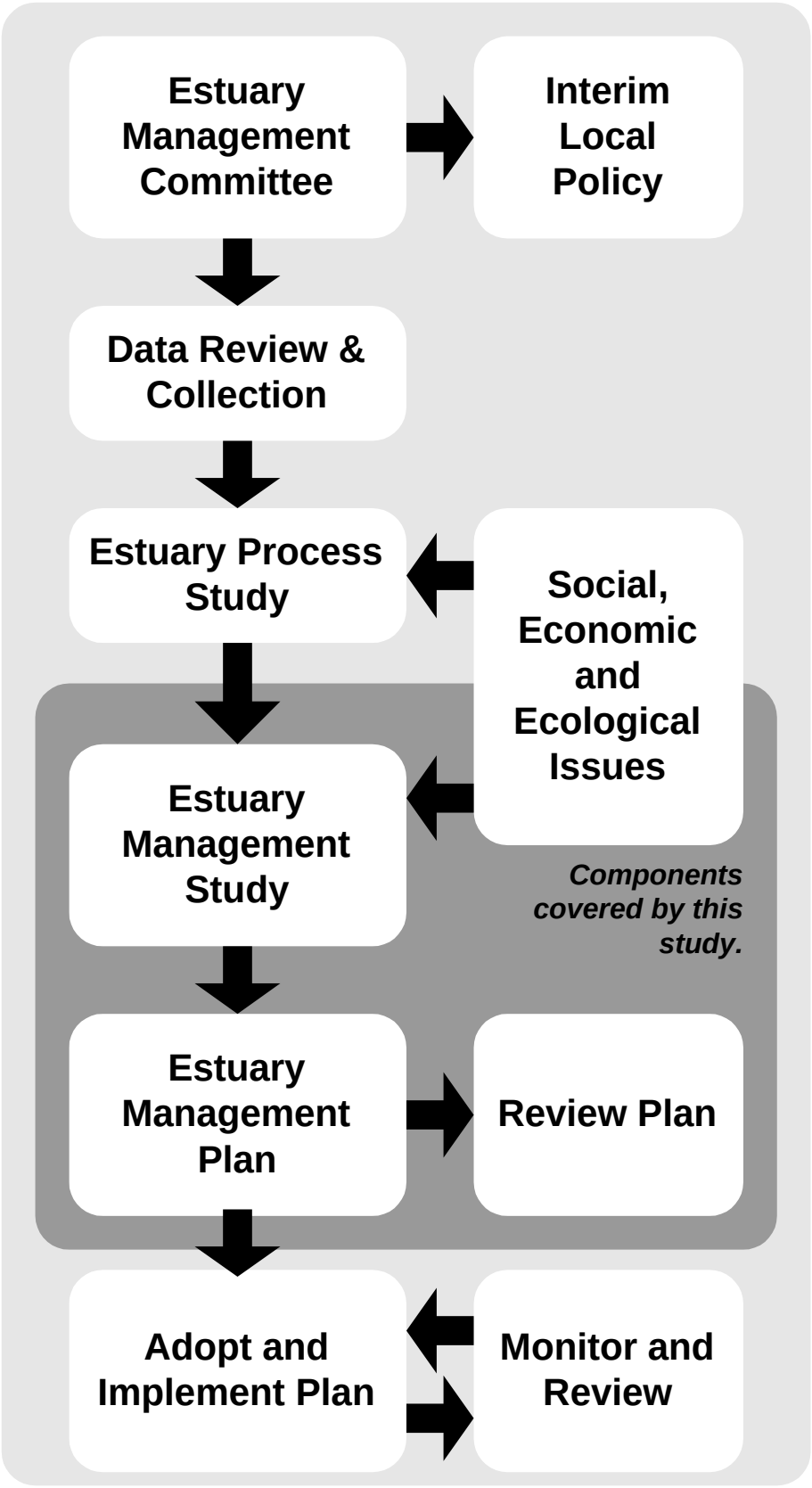

Figure 1.2 Estuary Management Framework

1.4 Scope of this Report

This volume of the Estuary Management Study Report deals specifically with issues and management options relevant to Lake Macquarie proper. A separate volume has been prepared previously which deals specifically with issues relating to the entrance channel of the Lake (WBM Oceanics Australia, 1997).

The key matters identified as part of the Estuary Management process to date involve the need for the maintenance and possible improvement of the existing recreational, water quality, ecological and fisheries attributes of the Lake. In a similar manner to many estuaries elsewhere in Australia and around the world, high levels of water quality, ecological health and productivity are principal attributes related to the viability and community perception of an estuary, and this is particularly the case for Lake Macquarie. Specific issues that this Study addresses in this regard are as follows:

- perceived degradation in water quality levels in the Lake in recent years;
- reported degradation of the Lake's ecological attributes;
- conflicts between commercial and recreational fishers of the Lake.
- perceived reductions in recreational fish catches from the Lake in recent years;
- concerns with respect to excessive levels of sedimentation in the Lake with progressive urbanisation of the Lake's catchment; and
- recreational and functional amenity of beaches and other foreshore areas.

This report outlines the following matters as they apply to the management of these issues in Lake Macquarie:

- the various study components and general approach;
- management issues identified;
- the key characteristics of Lake Macquarie in relation to the identified issues;
- assessment of management options and strategies; and
- key conclusions.

The objectives and management options for the Lake presented here will be eventually integrated with those for the entrance channel in preparing recommended management actions for the final Lake Macquarie Estuary Management Plan. As the entrance study components detailed in Volume 1 of the Estuary Management Study (WBM Oceanics Australia, 1997) are considerably advanced, comprehensive considerations are presented here with respect to the influences of entrance channel works on Lake water quality and ecological characteristics.

2 STUDY COMPONENTS AND GENERAL METHODOLOGY

2.1 General Approach

The Estuary Management Study has involved a multi-disciplinary approach to ensure that viable and sustainable implementation strategies are produced for the management issues identified. An extensive community consultation program is also being carried out to ensure broad community acceptance of the Study. Details of this program as it applies to the Lake are outlined in Section 2.2 below.

The primary goal of the Study is to produce a set of non-conflicting short and long term management strategies which enhance, preserve and minimise impacts on Lake Macquarie's environmental values and are basically understood and accepted by government, communities, business and industry. To achieve this goal, the overall Study is following a structured and integrated sequence of tasks with input from various technical disciplines. In broad terms, the stages of the Study are as follows:

- collect and review data;
- establish baseline conditions and management issues; and
- identify and assess management options.

The general methodology adopted for these stages with respect to the Lake is outlined in Sections 2.3 to 2.5 below.

2.2 Community Consultation Activities

The Community Consultation program undertaken as part of the Study relating to the Lake has comprised a wide range of activities including:

- the preparation and distribution of a minimum of 4,000 copies each of one introductory and two Lake specific information brochures;
- the placement of newspaper advertisements inviting members of the community to two interactive community workshops;
- the distribution of media releases to a wide range of television and radio stations and newspapers;
- a large number of radio interviews and newspaper articles;
- the maintenance of a 24 hour telephone and fax comment line throughout the period of the Study;
- the receipt, collation, analysis and incorporation into the Study of in excess of 250 responses to questionnaires received by post, fax or phone to the comment line;
- the facilitation of two interactive community workshops, one on Lake management issues and the other on Lake management options, and the incorporation of the discussion and findings of these workshops into the Study; and

- the conducting of a schools program throughout the period of the Study with mailings to all Primary and High Schools in Lake Macquarie and response to individual requests from schools for additional materials as required.

By the above means, a large number and a wide cross section of the community have taken the opportunity to become involved in, and contribute to, the Estuary Management Study.

A wide range of issues has been raised by the community, as follows:

- degraded Lake water quality;
- increased levels of Lake pollution;
- pressure on fish stocks;
- reduced catches by recreational fishers;
- the effect of perceived reduced entrance flushing efficiency;
- siltation around the Lake;
- navigability of the Lake;
- increased foreshore erosion;
- wetland degradation;
- reduced recreational amenity;
- declaration of Lake Macquarie as a Marine Reserve; and
- tourism.

These issues were taken into consideration as part of the technical aspects of the Study. Possible management options were presented and discussed at the second interactive community workshop.

The level of community concern was determined by the summation of all responses which related to a particular concern. Each concern was ranked using depending on the number of responses and the level of concern stated in each response. Where a concern, raised by the community, related to more than one issue specifically, the response was included under all the relevant issues. For example, concern regarding chemical pollutants was included in the ranking of degraded water quality (Issue A), selenium inputs to the Lake (Issue D) and selenium/heavy metal contamination of aquatic flora and fauna (Issue J). The number of public submissions to the draft Estuary Management Study relating to each issue were also considered in determining a level of community concern.

Full details of the community consultation program for the Lake are contained in the report prepared by Whitehead and Associates, which is included as Appendix A.

2.3 Data Collection and Review

Significant data and reports, including the Estuary Process Study (AWACS, 1995), already exist from previous investigations of Lake Macquarie. This information has been collated and reviewed for input into this Study.

For the purposes of this Study, additional water quality investigations were performed to assist in the recommendations that the Study will be required to make. These investigations involved the measurement of sediment nutrient release rates at six locations in the Lake and the development of a preliminary Lake water quality model. The results from the sediment nutrient release experiment were used in the water quality model development, and details of these studies are documented in Appendix B.

2.4 Establish Baseline Conditions and Management Issues

An understanding of baseline conditions is essential for identifying management issues and options to address those issues. These baseline conditions relate to specific environmental features such as:

- physical processes;
- water quality; and
- ecology.

as well as broader planning, aesthetic, social and economic considerations.

This report deals primarily with the water quality, fisheries, ecological and some public amenity issues in the Lake (as these were key issues identified in community consultation), with reference to other related matters, where appropriate. Recreational issues have been addressed where they affect the water quality, ecology or public amenity of the Lake. Information has been gathered from:

- a review of existing process related reports including the Estuary Process Study (AWACS, 1995);
- a review of available data including flora/fauna reports, fisheries statistics, water quality records and historical photographs and maps. These reports and records are included in the reference list (Section 8);
- additional data collection on the nutrient release characteristics of sediments contained within Lake Macquarie (see Appendix B);
- additional modelling of key water quality processes in the Lake (see Appendix B); and
- community consultation and discussion with long term residents regarding the Lake and perceived historical changes that they can recall.

In addition to the above, planning, recreation and visual amenity considerations for the Lake have been considered, as documented in Appendices C to E.

This information has been used to identify the key management issues, to understand how they have evolved and to examine the interactions between them.

2.5 Identify and Assess Management Options

This stage of the Study has involved the identification of management options and strategies for their implementation. Consideration has been given to management options and their associated advantages and disadvantages for each of the water quality, ecological and public amenity issues.

This process has involved preliminary water quality modelling of some options to ascertain their potential impacts. The modelling allowed a better understanding of the Lake's processes to be developed, with details of the modelling being provided in Appendix B. In addition, valuable community input was also obtained from the Interactive Community Workshops which reviewed various options.

The feasibility and sustainability of options have been considered in terms of potential impacts, conflicts and costs as well as the level of community concern. Community concern was determined by a summation of all responses during the community consultation phases, submissions from various organisations and government departments and responses to public exhibition draft documents. These allowed the level of community concern to be broadly categorised between very high and low. This then allowed the options to be ranked for further consideration in identifying preferred strategies for the Lake Macquarie Management Plan, to be prepared subsequent to this Study.

3 LAKE MANAGEMENT ISSUES

The scope of this report covers key management issues related to the long term viability of the Lake. The issues which require management in Lake Macquarie are outlined in Table 3.1 to Table 3.4 below. Each table includes a brief general discussion on the likely causes of these issues and the relevant level of community concern.

The level of community concern was determined by the summation of all responses which related to a particular concern. Each concern was ranked using depending on the number of responses and the level of concern stated in each response. Where a concern, raised by the community, related to more than one issue specifically, the response was included under all the relevant issues. For example, concern regarding chemical pollutants was included in the ranking of degraded water quality (Issue A), selenium inputs to the Lake (Issue D) and selenium/heavy metal contamination of aquatic flora and fauna (Issue J). The number of public submissions to the draft Estuary Management Study relating to each issue were also considered in determining a level of community concern.

The level of community concern regarding the issue of reduced angler catches and haul netting also took into consideration other community consultation forums, additional submissions to WBM Oceanics Australia by fisheries groups and government liaison. This was because the interactive workshop did not examine these particular issues in detail, although they have been raised by several groups in other forums and are recognised to have a high level of community concern.

4 LAKE MACQUARIE BASELINE CONDITIONS

Having identified the items of Community and Government concern with respect to Lake Macquarie, a review of available data was undertaken to determine the availability, adequacy and reliability of data to assess these management issues. This assessment is presented below.

4.1 Water Quality

The water quality of a lake is heavily influenced by the quality and quantity of water which enters the lake. The inflows to Lake Macquarie include catchment runoff, tidal exchange and point source discharges into the Lake. Where the quality of inflows to the Lake are poor, accumulation of pollutants may occur in both Lake waters and sediments, resulting in water quality degradation. This water quality degradation can in turn affect the lake's ecology, in addition to recreational and visual values. The interactions between sediments and water quality can be complex, but under certain conditions, sediments can contribute stored nutrients to the water column and cause water quality degradation, particularly in shallow embayments.

Water quality levels in Lake Macquarie have been measured from 1983 to the present by a comprehensive monitoring program conducted on behalf of the Hunter Water Corporation (HWC). The results of this monitoring program have been analysed by AWACS (1995), and are summarised below.

4.1.1 Temperature

Annual water temperatures of Lake Macquarie are typical of those of a temperate estuary. The temperatures of embayments receiving discharges from the major power stations at the southern periphery of Lake Macquarie have been shown to be higher than elsewhere in the Lake by of the order of 0.5-1.0ºC.

4.1.2 Salinity

Mean annual salinities of the Lake (32-34 g/L) are typically at, or slightly below, salinity levels associated with ocean waters, indicating the relatively efficient nature of exchange of waters between the Lake and the ocean. In particularly wet years, mean annual salinities (28-30 g/L) are depressed to values slightly less than oceanic concentrations.

4.1.3 pH

Mean annual pH levels in Lake Macquarie are also typical of temperate estuarine water bodies, ranging between 8.1 and 8.4 pH units.

4.1.4 Dissolved Oxygen

Dissolved oxygen levels in most of the main body of Lake Macquarie are typically at, or near, fully saturated conditions, which meets the ANZECC dissolved oxygen for the protection of aquatic ecosystems. Oxygen levels are typically less in wetter years than in drier years. The upper reaches of some of the tributaries of the Lake have also been observed to contain lower dissolved oxygen levels, indicative of the entry of various point and non-point sources of

pollutants to these waterways. Some of the dissolved oxygen concentrations in these tributaries are less than the ANZECC criterion for dissolved oxygen. Data collected over the last 10 years does not seem to indicate significant changes in oxygen levels in the Lake.

4.1.5 Ammonia Nitrogen

Annual mean ammonia concentrations for the bulk of the main body of Lake Macquarie are relatively low, being less than the detection limit of 0.1 mg/L. Exceptions to this case are once again some of the tributaries of the Lake, which have experienced significant discharges of sewage effluent. Once again, wet years appear to coincide with elevated ammonia levels in the Lake due to increased runoff.

The ANZECC criterion for ammonia (of 0.005mg/L) is commonly exceeded in most NSW Estuaries (AWACS, 1995) and is frequently below the detection limit of laboratory ammonia tests. Therefore, the ANZECC ammonia criterion is not considered an appropriate criterion level for Lake Macquarie and its tributaries. An appropriate and well accepted criterion for ammonia has not yet been developed for areas such as the Lake Macquarie Estuary.

4.1.6 Organic Nitrogen

Annual mean organic nitrogen levels for Lake Macquarie vary between 0.2 and 0.6 mg/L for the period of time that water quality data were collected by Hunter Water Corporation. Similarly to the case for ammonia nitrogen, elevated levels of organic nitrogen were observed in areas receiving sewage effluent discharges.

4.1.7 Oxidised Nitrogen

Annual mean oxidised nitrogen levels in the Lake vary between 0.005 and 0.018 mg/L for the period of time that water quality data were collected by Hunter Water Corporation. No trend of increase in oxidised nitrogen levels for this period of time was apparent, with the exception of wet years exhibiting higher levels than dry years. Similarly to the case for ammonia nitrogen, elevated levels of oxidised nitrogen were observed in areas receiving sewage effluent discharges.

4.1.8 Total Nitrogen

Annual mean values of total nitrogen in the Lake ranged from 0.34 to 0.70 mg/L for the period of time that water quality data were collected by Hunter Water Corporation. No apparent trend was observed in the annual mean value data, except that the values rose in wet years, and fell in dry years. Similarly to the case for ammonia nitrogen, elevated total nitrogen levels were observed in areas receiving sewage effluent discharges.

4.1.9 Orthophosphate

The data collected by Hunter Water Corporation for orthophosphate levels in Lake Macquarie indicated that mean ortho-P levels rose from around 0.017 mg/L in 1983/84 to 0.028 mg/L in 1988/89, after which it trended downwards. It is important to realise that from 1988/89, substantial progressive improvements have been made to the Hunter Water Corporation sewerage system, commencing with chemical phosphorus removal from the Toronto plant in

1988/89. Subsequent activities have resulted in the progressive removal of all effluent discharges from the Lake.

Orthophosphate levels were heavily influenced by relative locations in the Lake. The tributaries of Lake Macquarie that were receiving sewage discharges exhibited considerably higher levels of ortho-P than elsewhere in the Lake.

4.1.10 Total Phosphorus

Total phosphorus levels in Lake Macquarie exhibited similar temporal trends to ortho-P, obviously being affected by the treatment practices of the Hunter Water Corporation sewage plants and catchment runoff. Total P levels rose from 0.04 mg/L in 1983/84 to 0.07 mg/L in 1988/89, and subsequently reduced to a level of 0.043 mg/L in 1993/94.

Total P levels were also heavily influenced by relative locations in the Lake. The tributaries of Lake Macquarie that were receiving sewage discharges exhibited considerably higher levels of total P than elsewhere in the Lake. Foreshore areas also exhibited higher levels of total P, than the open water areas of the Lake.

4.1.11 Water Clarity

Hunter Water Corporation recorded water clarity via a number of methods, including the following:

- percentage transmission of light through water;
- total suspended solids concentrations;
- total volatile suspended solids concentrations;
- Secchi depth; and
- turbidity.

All of these measures indicated a relationship between water clarity and the relative amount of rain experienced in any year, with this relationship being stronger for sites in foreshore areas of the Lake, or within major tributaries. Wetter years had lower levels of water clarity. No apparent deterioration in water clarity over time was obvious from the data.

4.1.12 Chlorophyll a

Annual mean values of chlorophyll *a* in Lake Macquarie ranged between 2.06 and 4.97 µg/L for the period of the Hunter Water Corporation data record. High values occurred during relatively wet years, and lower values occurred during relatively dry years. No apparent increase in chlorophyll *a* levels over time was obvious from the data.

Chlorophyll *a* concentrations in the tributaries of Lake Macquarie were considerably higher than the concentrations recorded in the Lake. The concentrations ranged between 0.11 and 697µg/L, with a mean of 44µg/L.

4.1.13 Faecal Coliforms

Faecal coliform bacteria levels in the main body of Lake Macquarie were very low during dry weather. In wet weather, bacterial concentrations rose at some nearshore stations in the Lake to several thousands of organisms per 100 mL. No apparent increase in faecal coliform levels over time was obvious from the data.

4.1.14 Selenium

The power stations at Vales Point (Delta Electricity) and Eraring (Pacific Power) produce quantities of ash as a waste/by-product of electricity generation. This ash is disposed of to two dams constructed over wetlands. At Vales Point power station, Mannering Bay/Hole was dammed off from the main body of the Lake and has been progressively filled by ash-slurry. At Eraring power station, both a freshwater and a brackish wetland was used.

These dams, together with tradewaste discharged to Cockle Creek from the Pasminco operation, other industrial discharges and catchment runoff are the sources of selenium entry to the Lake. Possible remobilisation of selenium from the sediments may also be a source of selenium to the Lake.

Ambient water monitoring by the Environment Protection Authority (EPA) has found localised concentrations of selenium in streams and lagoons where ash dam discharges have been focussed. Delta Electricity and Pacific Power have since initiated strategies to decrease selenium loads to the Lake. Ash dam capacities have been increased and recycling of ash dam waters introduced. The AWACS (1995) study reported that EPA estimates on selenium inputs from both power stations was approximately 400kg/year. Recent communication with the power stations suggests this input is now less than 120kg/year for each power station.

The AWACS (1995) study also reported that during large rainfall events the ash dams at Vales Point overflows and spills ash and associated selenium into Wyee Bay. In a comment by Pacific Power provided to Council in response to the AWACS study, it was refuted that such ash spills occur. Pacific Power indicated that the major civil works to increase dam capacities have been undertaken at the ash dams to ensure that fly ash and associated selenium does not routinely escape to the Lake. Overflows still occur during large rainfall events, although some dilution by catchment runoff will occur.

4.1.15 Historical Trends

As an adjunct to the data presented in AWACS (1995), earlier sources of water quality data for Lake Macquarie were investigated to see if there were any apparent longer term water quality trends not present in the Hunter Water Corporation data.

SPCC (1983) presented the results of various earlier water quality monitoring in the Lake. Of particular relevance to this Study are the data presented for sites LM2 and LM4 for the SPCC study, which compare sites 6 and 11 of the Hunter Water Corporation data set. By comparing the data records for these sites, a greater insight into possible long term deterioration of water quality in the Lake could be gained. This comparison is presented in Table 4.1 below, together with a summary of relevant National Water Quality Criteria.

Table 4.1 Historical Water Quality Summary

Water Quality Parameter	Units	SPCC (1983) Data for 1953-1957	SPCC (1983) Data for 1973-1983	Mean of HWC Data (1983 - 1995)		AWACS (1995)	ANZECC (1992) Standards
				Lake	Tributaries		
Temperature	^{o}C			20.4	-	21	< 2 ^{o}C Increase
Salinity	g/L			33.2	24.4	35	
pH	-			8.3	7.7	8.1	< 0.2 Change
Dissolved Oxygen - surface - bottom	 mg/L mg/L	5.5±0.7	7.2±1.0	 7.6 5.6	 6.8 5.5	 95 % Sat	>6 (>80-90% Sat)
Ammonia-N	mg/L			0.074	0.608	<0.1	<0.005
Organic-N	mg/L			0.36	1.03	0.4	
Oxidised-N	mg/L	0.013±0.021	0.010±0.015			0.01	0.01-0.1
Total-N	mg/L			0.44	1.65	0.5	
Ortho-P	mg/L	0.005±0.004	0.015±0.013	0.020	0.515	0.015	0.005-0.015
Total-P	mg/L			0.056	0.74	0.035	
Secchi Depth	m		3.3-3.8	3.3	0.8	3.3	< 10% change in euphotic depth
Chlorophyll *a*	µg/L			2.98	44.0		1-10
Faecal Coliforms	org/ 100mL		< 100	66	575		<150

4.1.16 Summary of Baseline Water Quality Data

Based upon perusal of the water quality data set described in Section 4.1, the following summary comments can be made.

- there appears to have been an increase in nutrient concentrations in the Lake since the early 1950's, corresponding in time and location with progressive urbanisation of the catchment. The recent sewage effluent diversion activities of the Hunter Water Corporation appear to have stabilised nutrient levels in the Lake, though unmanaged future urbanisation will continue to increase these levels;
- there may have been a decrease in the clarity of the water, probably caused by a combination of increase algal growth and possibly also by greater amounts of sediment input and resuspension within the Lake though the data supporting this observation are not extensive. Present water clarity levels in the main body of the Lake are very high;
- algal levels in the Lake appear to have increased in association with the increased nutrient concentrations, though there are little rigorous data upon which to support this judgement; and
- nutrient levels in Lake Macquarie are approaching the acceptable limits recommended by Australian water quality criteria, and if exceeded, possible increases in algal and aquatic weed populations in the Lake are likely to continue to increase.

4.1.17 Water Quality Modelling

In order to better understand the interactions which influence the water quality in Lake Macquarie, a conceptual water quality model was developed. Details of the modelling performed are included in Appendix B. The model allowed a higher understanding of the interactions between the processes which influence water quality to be developed. In particular, the major sources of nutrients to Lake Macquarie and the major paths which remove nutrients from the Lake could be identified. Other pollutants were not able to be modelled (such as heavy metals or selenium), as the environmental chemistry of these pollutants is extremely complex and is not well understood. The assumptions required to simulate their interactions in the environment would therefore be subject to large uncertainties, thus limiting their usefulness as a management tool. Nutrients typically control algal growth and excessive algal growth in the Lake could cause adverse ecological, recreational and visual consequences.

In addition to understanding the existing water quality interactions, the model was used as a predictive tool (refer Section 6.2.1 and Appendix B). Various management strategies where simulated using the conceptual model.

Salient points from the modelling assessments include:

- the rate of nutrient release from the sediment was measured in six locations around Lake Macquarie, as part of this Study. These measurements were then used in the water quality modelling, and in every year simulated by the model the sediment nutrient release was the largest (or equal largest) source of nutrients to the Lake;
- urban runoff was the second (or equal first) largest source of nutrients to the Lake. Urban runoff also contributes to the sediment nutrient release rate, as urban runoff typically contains high loads of oxygen demanding material in addition to nutrients. This oxygen demanding material can result in deoxygenated (anoxic) sediments. Sediments which typically store nutrients can release these stored nutrients back into the water column under anoxic conditions. Therefore, the pollutants from urban runoff were demonstrated to be the primary influence on Lake water quality. Urban areas contribute more than 80% of the nutrients in stormwater in an average rainfall year, but comprise approximately 35% of the total catchment area;
- the nutrient status of the Lake is presently approaching critical levels and unmanaged urbanisation of the catchment has the capacity to alter the nutrient status to above critical levels;
- treatment of urban runoff has the potential to provide significant water quality benefits to the Lake, particularly reducing the time for good water quality conditions to be restored, following large rainfall events;
- seagrasses play a very important role in nutrient uptake, and reduction in seagrass areas could cause an increase in nutrient levels in the Lake; and
- tidal exchange in the Lake does play a role in flushing nutrients from the Lake, however entrance works (such as dredging) have only a limited potential to improve water quality.

4.1.18 Summary of Water Quality Issues

There is a strong relationship between catchment management and the health of the estuary. Urban runoff is considered to be the largest influence on the water quality of the Lake as it not only directly contributes a major proportion of the nutrients to the Lake, but also contributes to the sediment nutrient release rate (which is typically the largest source of nutrients to the Lake). Developing urban areas (particularly construction sites) also contribute large sediment loads, causing siltation and decreased water clarity in the Lake. Other sources of pollution to Lake Macquarie include sewage, point source discharges, powerboat engines and sediments which erode from foreshore areas and waterways. Most sewage discharges from treatment plants have been halted in the Lake. The few remaining discharges will also be ceased in the near future. However, the Lake still receives sewage from sewer overflows, poorly managed septic systems in unsewered areas and boat wastes. No data is available to quantify these sources, although they are not likely to be major (at present).

Powerboat engines, particularly two stroke outboard motors, may "pass fully 25 percent of their total hydrocarbon intake, fuel and lubricating oil, out the tail pipe and into the environment" (Mele, 1993). There are several areas in the Lake which have the potential to become contaminated due to hydrocarbons/boat engine discharges, however as boat usage increases in the Lake this issue may become more extensive. Some aquatic organisms have the potential to bioaccumulate pollutants (such as mussels) and there is some research which indicates that the genetic composition of some aquatic species can be altered by exposure to heavy metals and organo pollutants (which are typically derived from industrial and boating activities).

Foreshore and waterway erosion contributes sediment to the Lake. As nutrients can be bound onto sediment particles, erosion can also contribute nutrients to the Lake and cause degraded water quality, particularly in localised areas. Stabilisation of foreshores (with vegetation or engineering works) will also assist in the prevention of localised water quality degradation. Refer to Section 4.4 for a further discussion of foreshore erosion and excessive siltation.

Excessive nutrient levels in the Lake may result in algal blooms and other undesirable effects of eutrophication. Algal blooms not only reduce the visual amenity of the Lake, but also decompose into a black ooze which releases a sulphurous odour and reduces dissolved oxygen levels in the sediments. Low oxygen levels in sediments can alter sediment chemistry, causing nutrients bound in the sediments to be re-released into the water column. This can lead to increased algal growth, which further worsens the problem. Excessive algal levels and subsequent deoxygenation overnight and in sediments can also have ecological impacts, such as fish kills and the death of benthic organisms. Some algae species release toxins into the water, which can also adversely effect the ecology of the system.

4.2 Ecology

Lake Macquarie supports abundant and diverse flora/fauna communities, many of which are of significant ecological, conservation, fisheries and educational value. Community consultation indicated issues of key concern relating to the ecology of Lake Macquarie involve declines in

(and impacts on) seagrass communities, the absence of lake-specific management strategies to conserve/rehabilitate mangroves/saltmarsh areas and potential localised effects associated with the thermal discharges to the Lake from power stations. Therefore, management options to address these issues have been focussed on in this Study, However, all management options outlined in this study have also considered the protection of all significant ecological attributes of the Lake (benthic organisms, birds, etc.), to ensure a viable ecology is sustained in the Lake.

The maintenance (or improvement) of water quality in the Lake is essential for the protection of the entire ecosystem of Lake Macquarie (refer Section 4.1). Good water quality in the Lake will protect most of the ecological attributes of the Lake, including benthic organisms (which form an important part of the food chain), birds and shellfish. Some other ecological attributes may require more specific consideration, and background to these issues are addressed below.

4.2.1 Seagrass

Seagrass beds provide essential nursery, feeding and shelter areas for many commercially and recreationally important fish and crustacean species. They also provide habitat for molluscs and many important bait species. Additionally, in areas where mangroves are less abundant (such as many areas of Lake Macquarie), the importance of seagrass beds to juvenile fishes is increased (Laegdsgaard, 1996).

Seagrasses also aid in maintaining water quality as they slow water current velocities, resulting in deposition of suspended sediments. Further, seagrasses help to stabilise sediments. As such, seagrasses are an important integral part of the ecology of estuarine systems.

In Lake Macquarie, the majority of the foreshore area is fringed by seagrass beds (Figure 4.1) with four species occurring : *Zostera capricorni, Posidonia australis, Halophila ovalis* and *Rupia megacarpa*. Of these, *Zostera*, or eelgrass is by far the most dominant species (Conroy *et al.*, 1991, Lake Macquarie City Council, 1993, NFRI, 1995).

The extent of seagrass beds in the Lake appears to have declined since the 1960's, particularly in the northern part of the Lake. Precise estimates of the amount of decline are difficult, however Winning (1990) reported a decrease of 18% in the total area of seagrass beds in the Lake from 1961 to 1987.

Increases in seagrass have been reported in some parts of the Lake however, eg. the appearance of new *Posidonia* beds on the northern sides of Coal Point and Pulbah Island (AWACS, 1995), and vigorous growth of seagrass at Belmont (NFRI, 1995), Fennell Bay and in some foreshore areas used for recreation.

The overall extent and exact degree of change in the seagrass of Lake Macquarie is debatable and difficult to assess as seagrasses exhibit a high degree of natural variation and surveys such as the AWACS study (1995) have employed different methodologies, which limits their comparability to other studies. For example, seagrass surveys have been conducted at different times of the year and winter seagrass biomass is usually far greater than summer biomass (King and Hodgson, 1986). Therefore differences between surveys may relate to seasonal effects rather than actual longer term changes.

The major reason attributed to the significant loss of seagrasses in the northern part of the Lake is increased turbidity in the water, ie. a decrease in water clarity (AWACS, 1995). Other threats to seagrass in Lake Macquarie have been identified and described fully by AWACS (1995) and briefly are:

- boat moorings - the mooring chain eventually kills off the seagrass beds. Aerial surveys of Lake Macquarie indicated that mooring chains result in the loss of large circular areas of seagrass. In some areas, up to 50% of the shallow subtidal area of seagrass had been destroyed (see Figure 4.2). J. Holliday (*pers comm.*) reports that 12ha of seagrass in Lake Macquarie is currently affected by some of the 2,000 moorings. Given potential increase in population growth, with consequent increases in the number of boat moorings, this process is of significant concern;
- jetskis - physical damage resulting from jetskis operating over seagrass beds may adversely damage seagrass, whilst noise may disturb seagrass associated fauna;
- boat navigation - boats off-course plough through seagrass beds;
- sedimentation - runoff associated with catchment degradation has high sediment loads that smother seagrass;
- nutrient enrichment - increased nutrient loads in the waters of the Lake lead to excessive algal growths which smother and kill seagrass;
- beach formation - some residents actively remove seagrass in front of their properties to form sandy beaches;
- haul netting - repeated haul netting over seagrass beds on the landing beaches is considered by some to damage the seagrass;
- shading, altered current velocity, boating effects at domestic and commercial foreshore structures (eg. jetties, boat ramps, slipways); and
- thermal discharges - discharges near the power stations have caused some localised reductions and changes in seagrass distribution.

From an ecological perspective, it is essential to maintain and protect seagrass areas to ensure that there are sufficient areas to provide habitat to support and enhance both the water quality and key fisheries resources of the Lake. This requires consideration of management options to address and reduce the impacts of the above threats to the seagrasses of the Lake (see Section.6.3).

Figure 4.1 Distribution of Seagrass, Mangrove and Saltmarsh

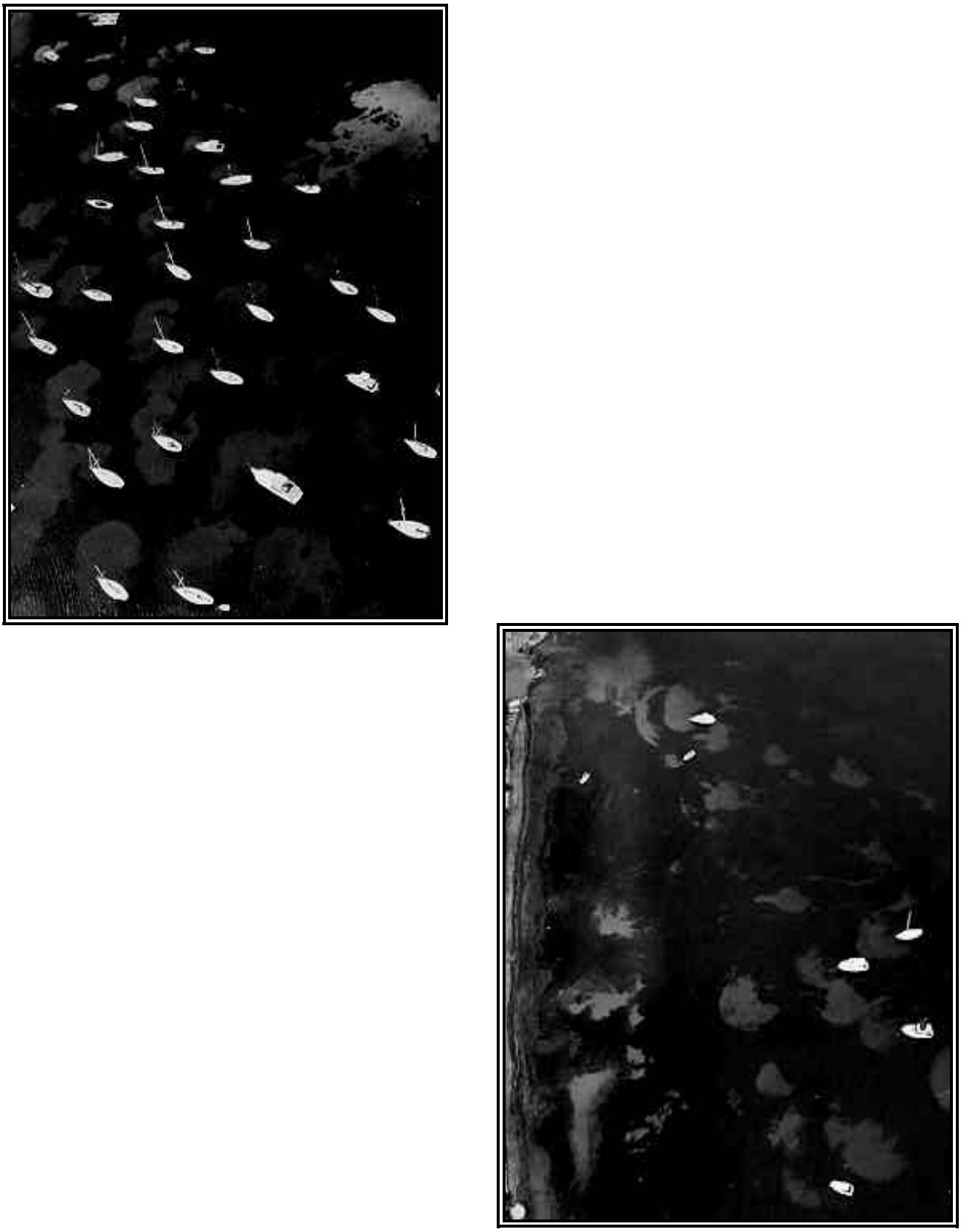

Figure 4.2 Oblique Aerial Photographs Illustrating the Damage to Seagrass Beds caused by Mooring Chains

Figure 4.3 Wetlands of Lake Macquarie

4.2.2 Wetlands

Wetlands (freshwater and estuarine mangroves and saltmarshes) are an essential component of aquatic ecosystems. They provide important habitats for fish and crustacean communities and contribute significantly to freshwater, estuarine and marine productivity by introducing large amounts of organic matter (detritus) into the system which forms the basis of many food chains. They are also significant habitats for other forms of wildlife, including migratory and native waterbirds, many of which are protected under international conservation agreements.

Wetlands also help to maintain water quality of their adjacent waters by filtering silt and urban pollutants from runoff, recycling nutrients and reducing flooding. They are also valued for their educational and recreational qualities.

Lake Macquarie has over 52 wetlands varying in size from 1 hectare to 220 hectares that cover an area of over 1130 hectares, Figure 4.1 and Figure 4.3 (as identified by Winning and Markwell, 1989). The study by Winning (1990) identified four broad wetland alliances occurring around Lake Macquarie :

- *Estuarine wetland complex* - Occurs on tidal mudflats in and around Swansea channel and in the mouths of major creek systems. Comprises mangroves, saltmarsh, and any adjoining brackish swamp forest.
- *Dunal wetland complex* - Occurs on coastal sand dunes, and comprises a variety of communities, including swamp forest, wet heath, reedland and rushland.
- *Vales Point wet heath* - Occurs on poorly drained low nutrient soils on the southern edge of the Lake, and comprises wet heath communities.
- *Floodplain wetlands* - A variety of remnant communities occurring on floodplain areas of major creeks (especially Dora Creek and Cockle Creek).

The loss of estuarine wetlands (mangrove and saltmarsh) around Lake Macquarie is an ecological concern raised repeatedly by community members and those who have undertaken environmental studies of the Lake region.

NSW Fisheries conducted an assessment of differences in the extent of saltmarsh and mangroves between 1966 and 1993, (Williams and Watford, 1996). This assessment was limited to the entrance channel area. It was found that the combined saltmarsh and mangrove area increased from 52.5 to 88.3 hectares. This change was mostly due to increases in mangroves from 11 to 47.5ha, while the area of saltmarsh reduced slightly from 41.5 to 40.8 hectares.

The extent and changes to wetlands throughout the Lake have been described by both Lake Macquarie City Council (1993) and AWACS (1994), and briefly summarised are :

- saltmarsh areas have reduced by 50% from 1961 to 1987, with 25% of the saltmarsh areas replaced by mangroves and the remainder lost to urban development;

- mangroves have increased by 60.5 hectares between 1961 and 1987. Most of the increases were in Black Neds Bay, Swan Bay, and Marks Point - Swansea. These increases are thought to be due to increases in sedimentation. There has been significant reductions in mangroves in other areas of the Lake associated with urbanisation of foreshore areas;
- freshwater wetlands have been lost by ash dams and urban development around the Lake;
- wetlands of Black Neds Bay would potentially be threatened if erosion at Salts Bay continues

As wetlands are of high fisheries/ecological significance, it is important to ensure that they are preserved and enhanced with any further declines minimised. The State Government has a policy to control disturbance/modification of wetlands - State Environment Planning Policy Number 14 - Coastal Wetlands (SEPP 14). This policy requires that an Environmental Impact Statement (EIS) is prepared for any development activities which may adversely affect wetlands and Council's consent be obtained for activities such as clearing, draining, filling and constructing levees on designated SEPP 14 wetlands. SEPP 14 wetlands in Lake Macquarie were identified and reported in the Lake Macquarie Wetland Inventory (Winning and Markwell, 1989).

Conservation of wetlands can only improve the ecological value of the Lake environment. As such, the prime management option is to manage the remaining wetlands. This is discussed in Section 6.3.

4.2.3 Thermal Discharges

Within the Lake, two electricity generating power stations, located at Vales Point and Eraring discharge warm waters into the Lake. Each of the power stations has inlets where they take in Lake water which is used to cool the station turbines. The water is then discharged via outlets at higher temperatures back into the Lake, where it dissipates out and finally assumes the background Lake temperature. The area of water with increased temperature is referred to as the cooling field. The discharge temperatures depend on the inlet water temperature, wind, flow rates and electricity output of the power station (AWACS, 1995). The Lake Macquarie Environmental Audit (SPCC, 1983) found that in the southern end of the Lake in association with the operation of the power stations, a slight elevation of water temperature has occurred.

The Environmental Protection Authority has set licence conditions that specify the discharged water must be less than 35°C though discharges up to 37ºC are allowed for periods of time. The power stations play an important role in the NSW economy as they generate electricity for a large part of the state. The stations will continue to use the Lake as a source of cooling water for the foreseeable future.

Many studies have been undertaken to assess the aquatic ecological impacts of the increased water temperature near the discharge points (eg. UNSW 1972, Sidabutar 1992, Negarestan 1993). In brief, the findings of these studies are :

- seagrass - localised (0.5 - 1.0 km) loss of seagrass in vicinity of outlets. Replacement of *Zostera* beds by *Halophila* in Wyee Bay (Vales Point power station);

- fish - changes in distribution - Snapper, squid, tailor, flat-tail mullet, cardinal fish, glassy perchlets, goatfish, toadfish, leatherjackets were all less abundant in the cooling field. Tarwhine, silver biddy, bream and southern butterfish were more abundant in the cooling fields. Additionally, angler effort in winter months was increased in the vicinity of Eraring Power Station warm water discharges; and
- benthos and plankton - effects are minor and localised close to the cooling water plumes.

Overall, the thermal discharges do have impacts on the aquatic biota in the vicinity of the power station outlets. On a regional scale though, these impacts have been reported as negligible (Marshman and Hodgson, 1991, Lake Macquarie City Council, 1993, NFRI, 1995).

4.2.4 Summary of Ecology Baseline Data

Based on the information pertaining to the ecological issues presented above, the following brief comments can be made:

- seagrass losses have occurred in the northern part of the Lake, mainly due to decreases in water clarity. The extent of change in seagrass beds in the remainder of the Lake is unclear, with both losses and increases in different areas reported;
- wetland losses have occurred, with large reductions in saltmarsh areas and foreshore mangroves. However, in some areas (eg. Swan Bay) sedimentation has resulted in additional mangrove areas;
- thermal discharges from power stations have localised impacts on a number of aquatic biota, however on a regional scale, these impacts are considered negligible.

Some of these ecological issues are closely linked to water quality issues. The quality of Lake waters can have a significant influence on Lake ecology. Degraded conditions are likely to adversely affect aquatic fauna and habitats.

The issue of heavy metal and/or selenium contamination of the Lake's biota is considered in Section 4.3 (Fisheries), as it is predominantly considered to be a fisheries issue.

4.3 Fisheries

4.3.1 Reduced Angler Catches

Commercial Fisheries

Commercial fishing has occurred in Lake Macquarie for at least 100 years. A history of the fishery from 1890 to 1956 is provided by Thomson (1959). Over the period 1971 to 1981, the Lake was the second most productive estuary in NSW in terms of estuarine fish production (annual average of 384 tonnes over the decade) but has recently been ranked the fourth most productive estuary in NSW following increased catches in other estuaries.

Commercial fishing for finfish in the Lake involves the use of mesh (gill) nets and haul (seine) nets. Prawning is also carried out using specialised haul nets.

NSW Fisheries collects catch and effort data on a monthly basis from all licensed fishers in the Lake (and elsewhere in NSW). This information forms the primary information base about commercial fishing. Catches from Lake Macquarie in 1993/94 totalled approximately 438 tonnes with the dominant (by weight) species being sea mullet (36%), yellowfin bream (9%), silver biddies (9%), luderick (7%) and tailor (7%).

Fishers are subject to a range of regulations that limit the nature and usage of nets. For example, net mesh size and length is prescribed, haul netting is prohibited in northern portions of the Lake and all netting is prohibited on weekends. At least nine (9) areas of the Lake are closed to commercial fishing (Figure 4.4).

In response to public concern in relation to declining individual angler catches, NSW Fisheries undertook a review of factors affecting the fisheries of Lake Macquarie (NFRI, 1995). The review concluded that:

- over the past 40 years the NSW Fisheries database indicates that the species composition of the commercial catch has remained relatively constant;
- on a weight basis (in declining order of importance) the 10 top species harvested were: sea mullet, yellowfin bream, silver biddies, luderick, tailor, greasyback prawns, squid, trumpeter whiting, fantail mullet, and dusky flathead. None of these showed any consistent downward trends in either long term catches over the past 50 years or Catch per Unit Effort over the past 10 years;
- *"approximately 50 commercial fishers reported fishing in the Lake during 1993/94, the last year for which data are available, an apparent reduction of approximately 40% over the last ten years"* (p7); and
- *"the market value of the reported commercial fisheries catch from Lake Macquarie averages about $1.0 million per annum, with the last ten years production estimated to be worth $9.7 million"* (p8).

With regards to commercial fishing pressure on the Lake, it needs to be recognised that although NSW Fisheries database indicated 50 commercial fishers fished in Lake Macquarie, this should not imply that all conducted their fishing operations exclusively within the Lake. The Lake would form part of a range of fishing locations used by fishers, each of which are fished depending upon fish distribution and weather conditions. In this regard, the numbers of commercial fishers operating does not provide an accurate assessment of historical commercial fishing effort in the Lake.

Figure 4.4 Area Closed to Commercial Fishing

Several fisheries related studies are being carried out in Lake Macquarie. These include studies by Pacific Power (water quality and biological monitoring) and Fisheries Research and Development Corporation research projects (as part of more extensive studies which include other NSW estuaries). However, other than the project assessing the impact of haul netting on seagrass beds (see Section 4.3.2), none are directed towards assessing or managing the commercial fisheries (or recreational fisheries) of Lake Macquarie specifically.

Recreational Fisheries

Recreation fishing is a popular activity in Lake Macquarie and an important tourist activity. Recreational fishing generally involves angling although crab hoops are also used. Most angling is boat and shore-based.

Anglers are concerned in relation to the health of fish stocks and individual angler catch rates. Numerous submissions have been made to Local and State Government Departments over the years with regard to potential impacts on the fish resources of the Lake, particularly in relation to habitat degradation and potential effects ascribed to commercial fishing activities. As noted in Section 4.2, it is probable that areas of wetlands/seagrass have decreased in extent over the past few decades. This may have contributed to declines in fish stocks and, potentially, individual angler catch rates.

In response to such submissions, NSW Fisheries undertook a review of commercial and recreational fisheries in the Lake and factors affecting the fisheries. The report (NFRI, 1995) concluded that:

- there is more information on fisheries issues in the Lake than for most other NSW estuaries with three studies of the recreational fisheries (Virginia, 1983, Scanes, 1988 and Lake Macquarie Concerned Anglers Group, 1995);
- whilst the three studies had differing objectives and techniques, there was no suggestion of declining recreational catch rates. This conclusion is disputed by anglers using the Lake. Considering the recent population growth in the area and associated increased fishing effort, it would be unlikely if individual angler catch rates did not decline;
- the operation of the power stations did not appear to significantly affect total populations of fish species of recreational interest;
- it was unclear from available information whether commercial fishing has adversely affected the catch of recreational anglers however two of the top three species taken by commercial fishers (sea mullet and silver biddies) are not captured by anglers;
- recreation fishing effort has increased substantially since 1981. Population growth in the region has increased by 20% between 1981 and 1995 and a commensurate increase in recreation effort would be probable. Additionally, angler gear and bait availability/quality has improved which would also contribute to increased recreational fishing effort; and
- by 1993/94, in common with many other NSW estuaries (West and Gordon, 1994), the recreational catch of many species probably exceeded the commercial catch.

4.3.2 Haul Netting

The use of haul nets in Lake Macquarie by commercial fishers has been occurring for decades. However, with increasing urbanisation and numbers of anglers using the Lake, there has been both increasing observation of this commercial fishing practice and a greater demand on the fisheries resource.

Anglers and members of the public have repeatedly raised strong objections to the practice of haul netting, calling for a net-free Lake. A "net-free Lake" petition containing 5000 signatures has been submitted to both WBM Oceanics Australia and Lake Macquarie Council. The major objections to haul netting are :

- haul netting is considered to have a large by-catch of non-target juvenile fish species that are of commercial and recreational value and of other fish that are of recreational value;
- repeated haul netting over the same area is considered to destroy the fauna and flora that inhabit the Lake bed; and
- where the nets are brought to shore over seagrass beds, the seagrass is damaged.

The AWACS (1995) study reported that :

- haul netting killed some juvenile fish;
- mussel based benthic communities were not affected by haul netting; and
- it appeared that haul netting resulted in minor (if any) damage to seagrass.

With regard to the first statement, commercial fishers operating in the Lake state that haul netting can kill juvenile fish, however if a haul shot is carried out correctly no juvenile fish are killed. However, if a haul shot is done where there is a high concentration of jellyfish or debris some mortality of juvenile fish can take place when the fish are concentrated in the 'bunt' of the net. Additionally, if the netting crew hauls the bunt onto the shore, juvenile fish may be killed. However, most crews ensure the bunt remains in the water where marketable fish are removed, thus minimising the death of non-target fish.

Recent research in the lake by NSW Fisheries (N. Ottway pers. comm.) has conclusively demonstrated that public concern with regard to seagrass damage and the capture of large numbers of juvenile fish by haul netting is largely unfounded. Such processes occur on occasions, but can be minimised by appropriate netting techniques. The results are to be made publicly available and will be of considerable public education value (NSW Fisheries contact - N. Ottway).

As described earlier, reviews of the status of fish stocks in Lake Macquarie (NFRI, 1995) have reported no decline in either the commercial catch or individual angler catch rates and little change in catch composition. It has been suggested that the major impact of haul netting results from the taking of juvenile fish, however, this is not reflected in the status of the Lake's fishery, based on current information. This is strongly refuted by the recreational fishers of Lake Macquarie.

In summary, public opinion is overwhelmingly opposed to haul netting, claiming it is destructive to seagrass beds and has a large by-catch of undersize fish. Available scientific data suggests this concern does not have a valid basis with regard to seagrass damage and may be overemphasised in terms of the taking of juvenile fish. Management options that include the phasing out of haul netting are described in Section 6.4.

4.3.3 Selenium and Heavy Metal Contamination in Biota

The Lake Macquarie Estuary Process Study (AWACS, 1995) presented an overview of the studies of heavy metal pollution in the Lake. The major conclusions of these studies have been that levels of heavy metals in sediments and biota of the Lake, particularly in northern regions, are a concern and are a potential human health risk. There is evidence that some of the contaminants entering Lake Macquarie are accumulating in marine organisms, such as zinc, lead and selenium in seagrass (*Zostera capricorni*), cadmium and selenium in cockles (*Andara trapezia*) and selenium in some fish in the Lake. The sediments of Cockle Creek and Cockle Bay are contaminated with lead, zinc, copper and cadmium with contamination decreasing southward in the Lake to levels that are similar to most other coastal lakes in New South Wales (Lake Macquarie City Council, 1993, AWACS, 1995).

As fish are higher in the food chain than many other biota, and are consumed by humans, the potential for bioaccumulation of heavy metals and/or selenium is considered to be most serious. However, preventing contamination of other biota (seagrasses, etc.) is also important to protect not only the fisheries, but also the biodiversity of the Lake.

A study of contaminants in various fish in a number of 'hot-spot' areas in the Lake near ash dams and power stations revealed that levels of zinc, copper and cadmium were relatively low, but that concentrations of selenium in the edible muscle of fish were high and may pose a human health risk (Roberts, 1994). Haul netting has been banned from the northern end of the Lake. This northern area of the Lake is still, however, fished by anglers.

As reported in the AWACS (1995) study, the Environment Protection Authority (EPA) identified the major sources of selenium in the Lake as the effluent, stack emissions and stormwater from Pasminco Metals-Sulphide Pty Ltd, Pacific Power ash dams, catchment erosion (originating from coal seams) and a small amount from the Hunter Water Corporation Wastewater Treatment Plants. Most sewage treatment plant discharges to Lake Macquarie have been halted and the Lake only receives sewage treatment plant discharges from West Wallsend Sewage Treatment Plant. Plans to divert this outfall exist and therefore selenium inputs from Wastewater Treatment Plants are minimal.

As a consequence of the potential human health risk, an assessment of selenium and heavy metals in seafood of the Lake was recently completed. The study was coordinated by the Hunter Public Health Unit (HPHU) and involved testing of fish and crustacea from ten (10) sites spread evenly around the Lake. Five (5) species were tested - mullet, flathead, bream, luderick and trumpeter whiting. At each site, ten (10) large, ten (10) medium and ten (10) small (total 30) individuals of each of these species were collected, providing a total of 150 fish from each site.

The study (HPHU, 1997) concluded that elevated selenium levels were found in some fish and crabs in Lake Macquarie. A subsequent risk assessment was performed and this assessment concluded that the levels found were not believed to be high enough to cause any illness in people in the short term and were unlikely to cause any long term health effects. However, people who eat large amounts of fish every week from the Lake may need to cut down. The selenium study addressed selenium levels in fish muscle and tissue, and not internal organs which may accumulate selenium (e.g. liver). The risk assessment recommended internal organs should not be consumed, or used for fish soup stock. The risk assessment details safe consumption limits for fish tissue only.

4.3.4 Summary of Baseline Fisheries Data

Based on the information pertaining to the fisheries issues presented in Section 4.3, the following brief comments can be made:

- over the past decades landings associated with the commercial fishery on the Lake have remained fairly consistent whilst the number of commercial fishermen has decreased;
- an assessment of recreational fisheries by NSW Fisheries found no declines in angler catches, however this is strongly refuted by local anglers;
- recreational fishing effort will increase in the future in conjunction with population growth, thereby placing additional pressure on the fish populations of the Lake with greater potential for decreased individual angler catch rates;
- haul netting by commercial fishers is perceived by some of the public as adversely affecting the fisheries of the Lake. NSW Fisheries studies report that this practice takes some juvenile fish on occasions but does not damage seagrasses; and
- sediments of the northern area of the Lake, particularly Cockle Creek are heavily contaminated with lead, zinc, copper and cadmium, with some selenium also present. An extensive assessment of selenium in a range of fish throughout the Lake was recently performed in response to the detection of levels of selenium in some Lake fish which may pose a human health risk. The Study found some elevation of selenium in fish tissue, and a subsequent risk assessment recommended a safe limit for fish consumption.

A review of information relating to Lake water quality (Section 4.1) and consideration of consequent effects to fauna of value to fisheries suggests:

- water temperatures in the Lake are adequate for sustaining fisheries resources;
- present fluctuations in water clarity, salinity and oxygen are unlikely to unduly influence the fisheries resources; and
- the effects of increased nutrient concentrations in Lake waters may be both beneficial and detrimental, highlighting the importance of monitoring nutrient levels.

Management measures available to protect and enhance water quality conditions are described in Section 6.2.

4.4 Foreshore Erosion and Public Amenity

In parallel with this Estuary Management process, LMCC is also implementing the NSW Government's Floodplain Development Policy, which will ultimately develop a Lake Macquarie Floodplain Management Plan. This Floodplain Management Plan will address management issues related to flooding from infrequent events, such as storm surges and heavy rainfall. Therefore, flooding aspects have not been considered in this Study, as they are being addressed in detail as part of the Floodplain Management Plan.

The Estuary Processes Study for Lake Macquarie (AWACS, 1995) discussed the implications of the Greenhouse Effect on the Lake. The Processes Study concluded that some increase in Lake water temperature may result from global warming, which could increase the productivity of the Lake. The Processes Study concluded that any increases in water level in the Lake, as a result of global warming, would result in little foreshore recession, and may increase erosion rates in some areas (eg. Salts Bay). However, as the impacts of global warming are believed to be minor, no specific management options for the Greenhouse Effect were included in this Study.

4.4.1 Foreshore Erosion

Foreshore areas of the Lake are recognised by Council and the community as important ecological and recreational assets. This is reflected in Council's on-going policy of acquiring foreshore lands, with over 60% (more than 600 hectares) of the Lake's foreshore now under reservation. In 1992, there were more than 180 foreshore reserves on the Lake, most of which are used for water based recreation activities (Lake Macquarie City Council, 1993).

Foreshores of the Lake are threatened in many areas by erosion which results from a number of processes including construction (such as slipways), development, the clearing of natural vegetation (Lake Macquarie City Council, 1993), wave action arising from boat wash and wind action. Sedimentation and excessive shoaling of shallow areas adjacent to Lake foreshores is also a problem in certain areas.

Erosion processes can directly impact on the aquatic productivity of the Lake via fragmentation and reduction of foreshore habitat. Erosion processes are due to both direct and indirect human intervention. Indirect effects can occur from the presence of solid retaining walls as these walls reflect and concentrate wave energy that can cause erosion in adjacent areas where no walls exist (Lake Macquarie City Council, 1993). Activities such as clearance of natural vegetation and accumulated seagrass/algae (which can act as a buffer to wind/wave erosive action), development and construction activities and boatwash from boat launching, boat traffic, jetboats and jetskis can all directly cause foreshore erosion.

The consequences of foreshore erosion are of considerable importance in terms of Lake management, not only for aesthetic reasons, but also due to:

- potential loss of public and private property (ie. land) and assets (eg. bikeways);
- adverse ecological impacts (eg. smothering of nearshore seagrass beds);

- localised degradation of water quality;
- reduction of tree cover and shade;
- loss of water access for recreational purposes; and
- increases maintenance cost for Council.

4.4.2 Excessive Sedimentation

An issue which arose from the community consultation work performed as part of this Study (refer Appendix A) was the major concern about sedimentation in some areas of the Lake. Many areas of the Lake are experiencing excessive sedimentation, which is caused by high sediment loads to the Lake. Sediment sources include untreated urban runoff, foreshore erosion and erosion from construction sites, rural erosion, erosion from unsealed roads/drains and erosion from other exposed areas in the Lake's catchment. Urban runoff contains a high sediment load, which arises from residential developments, unsealed roads, road shoulders and vehicles.

Excessive siltation can result in limited navigational access to creeks, decreased visual amenity in foreshore areas, loss of recreational amenity, smothering of seagrass beds and mangroves, in addition to adverse water quality impacts. Nutrients can be bound onto sediment particles, and nutrients can be re-released into the water column under some conditions.

Sedimentation in some embayments of the Lake can result in new seagrass beds establishing. This may have some positive ecological consequences, as seagrass beds provide an important nursery, food and shelter function in the Lake. However, these newly established seagrass beds can have some adverse impacts, particularly when they occur at creek entrances.

These newly created seagrass beds further decrease flows at the creek entrances, which result in increased settlement and accelerated sedimentation in these areas. This rapid sedimentation reduces navigability of the creeks, flushing in the creeks until eventually, the seagrass beds will be smothered and the area becomes intertidal.

These intertidal areas can lead to increases in breeding sites for biting midges, establishment of mangroves and further decrease in navigability and flushing in the creeks. Therefore, if sedimentation is permitted to continue without management, this problem has the potential to affect the Lake's ecology, water quality and recreational values. As this scenario is not considered acceptable to the community, management of excessive sedimentation is favoured.

4.4.3 Seagrass Removal from Subtidal Foreshore Areas

In urbanised foreshore regions of the Lake, some residents actively remove live seagrass. Shallow waters containing seagrass/algae are considered by some residents to be "unpleasant" areas in which to swim and they attempt to increase the recreational value of the area by creating sandy beaches (AWACS, 1995). Such uncontrolled removal has the potential to affect the Lake's productivity if it occurs on an extensive basis.

Seagrass (or other marine vegetation) removal without a permit issued by NSW Fisheries is an offence under Section 204 and 205 of the Fisheries Management Act (1994). Fines of up to $50,000 apply.

4.4.4 Seagrass/Algae Accumulation

In some foreshore areas of the Lake, large amounts of seagrass and algae proliferate. Seagrass naturally loses leaves. These leaves and detached/floating algae are sometimes washed up on the foreshore. Dead seagrass/algae in shallow waters may become a public nuisance due to the odour associated with rotting material and the reduction in beach amenity (eg. beaches are unpleasant when they contain rotting algae, or become covered with piles of dead seagrass leaves). Regular clean-ups of these areas by residents and Council occur.

These masses of algae/seagrass can form a barrier protecting the foreshore from wave and wind erosive action. These areas provide habitat for invertebrates and could contribute to the Lake's ecosystem. Therefore, careful consideration should be given to areas of removal, and appropriate removal methods, so as not to damage foreshore areas.

4.4.5 Litter/Pet Faeces

The issue of litter in the Lake, around the shores and on nearby roads (which then washes into the Lake) has also been raised during community consultation activities for this Study and means of prevention/removal and maintenance need to be considered in order to improve visual amenity and recreational/tourism value of the foreshores and Lake waters. Pet faecal material (when not appropriately disposed of) can decrease visual and recreational amenity of public parks and impact on Lake water quality. Council has been proactive in this regard by erecting signs, providing faecal bins and bags in parks for dog owners and has introduced fines for failing to collect and dispose of faeces in public areas. Funds for rigorous enforcement of these policies need to be allocated to ensure optimal results.

4.4.6 Summary of Baseline Data on Foreshore Erosion and Public Amenity

Based on the information pertaining to the public amenity issues presented in Section 4.4, the following brief comments can be made:

- erosion of the foreshores is occurring due to practices such as clearing of natural vegetation, foreshore development and construction and boatwash;
- excessive sedimentation occurs in some areas of the Lake, which reduces navigability and decreases public amenity, water quality and ecological values;
- some residents are actively removing live seagrass and algae (an illegal activity without the relevant permit) from subtidal areas;
- accumulated dead seagrass/algae is removed to prevent odours and increase recreational amenity; and
- litter/pet faeces are problems in some areas around the Lake.

5 MANAGEMENT PLAN IMPLEMENTATION

WBM Oceanics Australia has become aware through community consultation, liaison with Lake Macquarie City Council and by observation, that the existing management system for Lake Macquarie and its catchment is fragmented. Various local and government departments all hold management responsibilities for various attributes/uses of the Lake and its catchment.

This fragmented management system prevents many of the difficult environmental questions to be adequately addressed in a timely manner, as environmental problems identified by one authority may be caused by activities which are not under their immediate control. Environmental problems are typically complex and require an integrated, holistic approach.

Overlapping jurisdiction responsibilities of Government Departments and Local Authorities can be problematic in identifying lead agencies to manage an issue, allocation of funding from the various agencies and ensuring a cooperative approach is taken by all parties. Delays in implementation have also occurred, due to differences in the preferred approach of the separate agencies and their differing funding priorities.

In an attempt to improve communication between these organisations and other relevant parties, the Lake Macquarie Estuary & Coastal Management Committee was founded (see Table 5.1). Many of the organisations which are responsible for some aspect of Lake Macquarie or its catchment are represented on this Estuary & Coastal Management Committee, including input from:

- Environmental Protection Authority (EPA) - regarding water quality, licensed discharges to the Lake and other environmental issues;
- Waterways Authority - responsible for boating, navigational and other marine facilities in the Lake;
- Department of Land and Water Conservation (DLWC) - both the River & Estuaries and Crown Land Sections of DLWC are involved with aspects of Lake Macquarie, particularly as legal owners of the Lake "bed";
- NSW Fisheries - responsible for the management of the fisheries and fisheries habitats in the Lake;
- Lake Macquarie City Council and Wyong Shire Council - responsible for many of the activities in the catchment of the Lake;
- Lake Macquarie Catchment Management Committee;
- Hunter Water Corporation;
- Delta Electricity Authority;
- Commercial Fishing Sector; and
- Various Community Groups (eg. Lake Macquarie Concerned Anglers Groups and URGE).

Table 5.1 Representations on the LMECMC

Organisation / Group	Roles and Responsibilities
Lake Macquarie City Council (LMCC)	• Development approvals • Provision of services • Land management • Completion of this and previous studies according to the NSW Government's Estuary Management Policy • Implementation of this Plan in conjunction with other relevant organisations
Department of Land and Water Conservation (DLWC)	• Promotion and administration of the NSW Government's Estuary Management Policy • Land management responsibilities including foreshore development and crown lands (which includes the Lake bed) • Provision of funds to assist local government in implementing the guidelines • Administration of Total Catchment Management Policy in NSW • Provision of technical advice, expertise and reviews
Environment Protection Authority (EPA)	• Environmental objective setter • Regulator of activities with a major potential to pollute • Auditor of environmental performance • Educator of the community • Provision of advice and guidelines on EPA policy • The EPA's mission statement: "Guiding the community to achieve and maintain a healthy environment in a productive New South Wales"
Lake Macquarie Catchment Management Committee (LMCMC)	• Carry out activities under the NSW Government's Total Catchment Management (TCM) framework • Secure sustainable management of natural resources by facilitating inter-agency coordination • The vision statement of the LMCMC is "A healthy, productive and attractive Lake and catchment where balanced and coordinated management of resources ensures the future viability of diverse natural systems whilst meeting community needs"
Waterways Authority	• Management of the Lake's waterways/boating
Delta Electricity	• Representation of the interests of Delta Electricity and other power supply organisations
United Residents Group for the Environment of Lake Macquarie (URGE)	• Representation of the interests of community conservation groups within the Lake Macquarie catchment
University of Newcastle	• Provision of technical advice and reviews
Lake Macquarie Concerned Anglers Group	• Community group representing the interests of recreational fishers
Commercial Fishing Sector Newcastle Fishing Co-op	• Representation of the commercial fishing interests in the Newcastle region
NSW Fisheries	• Administration and management of NSW's fisheries resources including policing and education • Management of aquatic habitat and aquatic species • Management of commercial and recreational fishing activities and aquaculture • Responsible for marine reserves and aquatic species under the TSC Act (excluding aquatic mammals)

To date, subsequent implementation of the recommendations of the Estuary Management Plan (when completed) has been intended to be the responsibility of the Estuary & Coastal Management Committee, and Lake Macquarie City Council. This Study has, however, considered various management options for the Lake which will require input, consensus and concerted action from a variety of State and Federal Government Departments and Wyong Shire Council. Coordination of these bodies to implement, fund and monitor the recommendations of the Estuary Management Plan is likely to prove to be difficult, time consuming and may not achieve maximum efficiency.

In this regard, there are several possible options which could be considered for optimising management plan implementation. These options which must make all efforts to coordinate actions in the catchment **and** Lake, include the following:

- develop closer links between all interested parties involved in Lake and Catchment Management, and expand these links to include government departments not necessarily directly involved in the Catchment/Estuary Management Process (eg. DUAP) and focus upon determining areas/issues of responsibility for applying existing legislative and planning tools. This option is largely an enhancement of the existing management system. Measures such as a signing of a Memorandum of Understanding between the various organisations may be appropriate. This cooperative approach could extend as far as a Lake Macquarie Catchment Development Control Plan which links with the existing Development Control Plan for the Lake itself. This could well build on the recommendations of the Estuary Management Plan.
- establish a Lake Macquarie Authority (or similar) with statutory powers over the Lake or establish some form of Lake Macquarie Catchment Trust with the ability to closely coordinate activities in the Lake and catchment. Either an Authority or Trust would remove the fragmented management system. However, the formulation of such a body would require considerable effort and coordination between all stakeholders. It is likely to require many years to formulate such a body and perhaps several more for the body to operate efficiently.

Although one of these two management structures should be adopted for the long term management of the Lake, the discussion and selection of the preferred management structure should not delay management actions being initiated. The Estuary Management Plan (presently being developed) will outline recommended management actions needed to ensure all the values of the Lake are protected. Some of these management actions will be given a high priority, and implementation of these actions should be implemented under the current management structure, in parallel with discussions and decisions over the future management structure of the Lake.

Therefore, in formulating the overall strategy for the management structure to implement the Plan, it should be recognised that:

- The LMECMC has been actively pursuing the State Government's Estuary Management Policy and should continue with an active involvement, at least in the short-term, with the implementation of the Management Plan;
- The setting up of an Authority or a Trust will take time to formulate which could delay the implementation of high priority actions. An Authority or Trust may be appropriate in the long-term;
- Lake Macquarie City Council does not have the personnel to solely implement the Plan; and
- The performance of the management structure should be regularly reviewed.

Whilst the above options address options for the umbrella structure, it should not be forgotten that it is essential that resources are committed to the implementation of the Estuary Management Plan. Without people actively involved and committed to locating funds, seeking approvals and commissioning activities, there will be little progress in the betterment of Lake Macquarie.

Regardless of the umbrella structure adopted, a unit or section, which we shall refer to as the Lake and Catchment Unit (LCU), should be set up and this LCU would have "responsibility" for the catchment and waterways of Lake Macquarie. This responsibility would encompass enforcement, implementation, operation, maintenance and liaison type roles. One of the key roles of the LCU would be coordinating the activities of the relevant government departments, with the ultimate objective of protecting and enhancing the environmental and recreational value of Lake Macquarie. As previously discussed, government departments have disparate roles which affect Lake Macquarie, however there is presently very little overall coordination of these roles. The LCU is intended to enable such coordination.

The Estuary Management Plan will examine the concept/operation of the LCU in more detail.

6 LAKE MANAGEMENT OPTIONS

The options outlined in this volume of the Lake Macquarie Estuary Management Study relate to the issues of the Lake proper. Volume 1 of the Study (WBM Oceanics Australia, 1997) details issues and management options relating to the physical processes of the entrance channel.

The identification of Lake management options and the interrelationships between the various options needs to take into consideration the broad implications of the measures to be undertaken. Many of the water quality, ecological, fisheries management and public amenity issues are interrelated, and options to address one issue may influence another. Hence, the opportunity exists for management options to address more than one issue.

Generic management options for the Lake are discussed below. Consideration has been given to the advantages and disadvantages of the various options. In addition to the advantages and disadvantages of the various options, an indication of the order of direct cost and the level of community acceptance for each management option is provided for consideration in ranking or prioritising of options. The level of community acceptance is derived from the community consultation program, which discussed issues of concern and acceptability of various management strategies (refer Appendix A). The comments column in Tables 6.1 to 6.4 indicates comments raised during community consultation, government liaison and additional comments considered to be informative by WBM Oceanics Australia.

It should be noted that the order in which options are presented/discussed does not reflect a preference for any particular option.

Options will be ranked in the next phase of the process, the Estuary Management Plan, where preferred strategies will be identified. The Estuary Management Plan will also provide specific examples of how the preferred strategies can be applied to areas with severe problems, such as the Fennell Bay/Edmunds Bay area.

It should be recognised that the cost of specific works will depend greatly on the design details, type of equipment etc and that the costs presented here are only a broad guide for planning purposes. Costs estimated relate to only the immediate costs to implement/maintain each action. Associated costs which may be passed on to the community through increases in rates, land prices, etc., have not been included as many of these “flow-on” costs are highly dependent on other factors also. The maintenance costs could be regarded as those costs associated with the full implementation of the management options every two to five years (ie. across whole catchment/Lake, as appropriate).

6.1 Management Aims

The generic management aims for the Lake that have been developed by WBM Oceanics Australia in order to assist with determining the necessary scope of management options are as follows.

Water Quality	*To maintain or improve existing water quality in Lake Macquarie to a level consistent with expected waterway uses. This approach is compatible with ongoing EPA management activities.*
Ecology	*To maintain or improve the ecological status of Lake Macquarie.*
Fisheries	*To maintain or improve the fisheries of Lake Macquarie.*
Foreshore Erosion and Public Amenity	*To maintain and enhance the public amenities of Lake Macquarie, including prevention of foreshore erosion around the Lake.*

6.2 Management Options for Water Quality Related Issues

Management Aim: To maintain or improve existing water quality in Lake Macquarie to a level consistent with expected waterway uses.

There are a number of strategic management options to address the water quality related issues which have been identified as part of this Study, including:

- Degraded water quality (Table 6.1A);
- Excessive sedimentation in the Lake (Table 6.1B);
- Poor community attitudes to Lake water quality (Table 6.1C); and
- Selenium inputs to the Lake (Table 6.1D).

Each of these options is presented in Table 6.1 and is also discussed in greater detail in the section following the relevant section of the table. For each option, advantages, disadvantages, cost and level of community acceptance of the management options are summarised.

6.2.1 Issue A: Degraded Water Quality

A major issue which arose from the community consultation work performed as part of this Study (refer Appendix A) was the concern that the water quality of Lake Macquarie was deteriorating. This concern arose both from the wish to preserve visual and recreational amenities presently gained from the Lake, but also was related to many of the other issues raised, such as declining fish stocks, siltation, ecosystem protection and many others.

Degraded water quality is a problem at all freshwater entry points in the north of the Lake, but examples of particular problems which have been reported include the areas of:

- Cockle Creek;
- Toronto;
- Fennell Bay;
- Mudd Creek and Stony Creek;
- Carey Bay, near Dewey Point;
- Fishing Point;
- Lake Eraring;
- Secret Bay;
- Swansea;
- Dora Creek;
- Black Neds Bay; and
- Gwandalan.

These sites are marked on Figure 6.1 with an 'A' to indicate some of the areas with degraded water quality. It is reported that the water quality in these areas are worse following rainfall events and many have high sediment loads and resultant sedimentation problems. Sedimentation is discussed as a separate (although related) issue (refer Table 6.1B and Table 6.4L).

Management options to address degrading water quality in the Lake are as follows:

i) Do nothing.

ii) Managing urban growth in the catchment (through the adoption of water sensitive urban design).

iii) Develop and implement a Catchment Management Strategy (which identifies and prioritises key areas requiring stormwater treatment).

iv) Educate community on the implementation of the Catchment Management Strategy.

v) Halt and/or reduce point source discharge to the Lake by increasing licence fees.

vi) Dredge particular areas of the Lake, to remove nutrient laden sediments.

vii) Stop all sewage discharges to the Lake.

viii) Develop and enforce a limit urbanisation area in the catchment.

ix) Reduce hydrocarbon contamination from powerboats.

A. Issue - Degraded Lake Water Quality.

(i) Do nothing

Lake water quality will only worsen in the absence of implementing management strategies for this issue. This will cause increasing community dissatisfaction, and will eventually adversely impact the Lake's ecology and the local economy.

(ii) Managing urban growth in the catchment (through the adoption of Water Sensitive Urban Design principles)

Urban development has many environmental consequences, including increased pollutant loads to waterways, loss of vegetation, modification of the catchment's hydrology, increases in runoff volumes and velocities, alterations to the local and downstream flooding regime, and adverse air quality impacts.

Conventional urban design practices have been recognised for many years as causing significant environmental degradation, particularly to water quality and hydrology (Whelens *et al*, 1994). An alternative, more sustainable approach to urban design has been recently emerging, known as Water Sensitive Urban Design (WSUD). The principles of Water Sensitive Urban Design attempt to mitigate the environmental degradation caused by urban development.

Conventional urban development principles aim to rapidly convey stormwater downstream, sometimes install large "end of pipe" treatment options at the downstream end of the catchment and then dispose of the stormwater. However, Water Sensitive Urban Design aims to retain stormwater, look for opportunities to utilise stormwater within the catchment, maximise infiltration in the catchment and use a sequence of smaller treatment devices throughout the catchment to improve stormwater quality and reduce the hydrological implications of catchment development.

The key objectives of Water Sensitive Urban Design include:

- to manage the water balance of a catchment;
- to maintain and where possible enhance water quality;
- to encourage water conservation; and
- to maintain water related environmental and recreational values.

Some of the management practices which are included in WSUD include:

- preservation of vegetation;
- grassy swales, as opposed to kerb gutters;
- infiltration trenches;
- sequenced detention and retention basins;
- gross pollutant traps;

- oil/grit separators;
- artificial wetlands;
- non-potable re-use of stormwater; and
- rainwater tanks.

LMCC and Wyong Shire Council (WSC) need to embrace the principles of WSUD, in order to lessen the environmental degradation caused by urban growth. As the water quality on the Lake is approaching Australian Water Quality Standards (refer Section 4.1.16), the importance of preventing environmental degradation from urban growth should be a high priority for both Councils.

Both LMCC and WSC need to modify their visionary and planning strategies and plans to incorporate WSUD principles, such as buffer zones along waterways (and the periphery of the Lake, where possible) to protect riparian/foreshore vegetation. Council should require all new developments to demonstrate "no nett increase in pollutant loads" is caused by the proposed development, through the incorporation of water quality treatment devices such as GPT's, wetlands and sedimentation basins. New developments in unsewered areas should also be required to demonstrate that the soils and system design are adequate to treat sewage from the proposed development, and that no additional nutrient or bacterial load will enter the Lake (or local waterways).

Sediment and erosion control measures also need to be applied to all construction sites (refer Option iv below and Issue B.)

However, if the impact of all new urban growth areas are mitigated through such measures, the water quality of the Lake will only be maintained at present levels. Treatment of stormwater from existing urban areas is needed to lower pollutant loads and should result in water quality improvements, particularly in some localised areas (refer Option iii below).

(iii) Develop and implement a Catchment Management Strategy (which identifies and prioritises key areas requiring stormwater treatment)

Water quality modelling of Lake Macquarie (performed as part of this Study) demonstrated that stormwater (particularly urban stormwater) is a significant source of pollutants to the Lake. Stormwater may contribute up to 40% of the total nutrient load to the Lake (refer to Appendix B for details of water quality modelling). Predictive assessments with the model showed improvements in water quality could be achieved if the nutrient loads from all urban stormwater were reduced.

Catchment management strategies provide methods to reduce the source of pollutants in the catchment **before** they enter stormwater, as opposed to water quality treatment strategies which aim to reduce pollutant loads once they **have entered** stormwater/waterways. Catchment management strategies require considerable community participation, and therefore education of the community can be the key to implementing successful catchment management strategies. Council and Government bodies also need to be totally committed to implementing

such strategies, as many of the strategies include changing the way polluting activities are performed through regulation and Council approvals, such as clearing and construction activities.

A Catchment Management Strategy (CMS) will identify and prioritise areas which require stormwater treatment and other catchment management actions.

Stormwater Treatment

Stormwater and urban development runoff management measures endeavour to remove pollutants from runoff close to the pollutant source, ie. treating stormwater before it enters the local creeks and subsequently Lake Macquarie.

The method to reduce the pollutant load to the Lake which will be most effective is to install a network of pollution control devices in existing urban areas. These devices could include gross pollutant traps (GPT's), wetlands and sedimentation basins. Lake Macquarie City Council presently has more than 150 pollution control devices in the Lake's catchment (wetlands, GPT's etc.) and they are continuing to identify more locations for devices to be installed. However, it is unlikely that all developed areas will be treated by such devices, due to areal and cost constraints.

GPT's have been demonstrated to effectively remove litter, debris and coarse sediment from catchment runoff (particularly urban runoff). By installing a network of GPT's in key areas, reductions in litter and sediment loads entering the Lake could be achieved. The nutrient load to the Lake may also be slightly reduced by the installation of GPT's in key areas, as organic debris (containing nutrients) are removed by GPT's, in addition to limited nutrient removal from settling of sediment with adsorbed nutrients on the sediment particles.

GPT's can require a high amount of maintenance, because to maximise their ability to remove pollutants from stormwater, GPT's should be cleaned and 'desilted' after significant rainfall events. However, removal of silt and litter from GPT's is easier than removal from ponds or wetlands.

Further research of the efficiencies and costs associated with the existing GPT's (installed in the Lake Macquarie region) should be undertaken to ensure they provide a cost effective pollution control technique. However, pollutant loads from stormwater to the Lake are known to be high, and these loads should not be permitted to increase. Therefore, installation of GPT's or other pollution control devices should not be halted until exhaustive studies on their design criteria are completed, as such studies are an ongoing process. Further understanding and new technologies are constantly occurring and actions are required in the immediate future to prevent water quality degradation in the Lake.

Wetlands and sedimentation basins will remove sediment, and are more efficient at removing nutrient loads from stormwater than GPT's alone. Wetlands and sedimentation basins need to be appropriately designed and constructed, for the size and land uses of the catchment. Development of a "treatment train" of pollution control devices is often beneficial, to ensure maximum treatment efficiencies. For example, GPT's can be used as pre-treatment devices to

capture litter and coarse sediment upstream of a sedimentation basin or wetland. This extends the maintenance period (for desilting) required for the sedimentation basin or wetland.

Wetland filters provide a flexible treatment system, as wetland plants are adapted to cope with a wide range of flows and nutrient inputs. Wetland plants have evolved to deal with the extremely unpredictable nature of rainfall and runoff in a wide range of conditions making them ideal for stormwater treatment. In addition to the water quality improvement that can result from treatment with wetland filters, they can also have many ecological benefits. Wetlands provide both food and habitats for a variety of terrestrial and aquatic species, particularly for birds and fish.

Creating wetland filters around the Lake Macquarie Catchment and Lake periphery, particularly where urban stormwater enters the Lake, could improve the overall water quality in the Lake, as well as providing attractive and ecologically viable habitat areas. However it is not practicable to treat all urban stormwater from developed areas by retrofitting treatment devices, due to insufficient area and resources. Therefore, treating most stormwater from existing urban areas will only marginally improve overall water quality. However, some localised water quality benefits will result from stormwater treatment.

The approach of constructing stormwater treatment facilities would be most effective in conjunction with water sensitive urban design in developing areas, the further implementation of catchment management activities and community education, which all aim to lower the nutrient loads washing off a catchment (refer option iv below).

Installing GPT's, artificial wetlands and other such measures to treat a large proportion of stormwater from the Lake's catchment has the potential to improve overall water quality in the Lake, and should particularly provide improved local water quality in some areas. Benefits would also be provided by reducing siltation and litter problems in the Lake (refer to Issues B, L and N).

Other Catchment Management Activities

The Lake Macquarie Catchment Management Committee, EPA, LMCC and WSC have endeavoured to implement catchment management activities and to better educate the Lake Macquarie community. The Catchment Management Committee has been instrumental in the introduction of the Erosion and Sediment Control Policy (further discussed under Issue B), stencilling of drains (to increase public awareness that stormwater flows directly to Lake Macquarie) and general community education with talks, brochures and other community projects. The EPA and the LMCC provide funding for programs such as the "Solutions to Pollution" grants scheme which recently sponsored a "Let's Clean Up Winding Creek" project.

Further measures which may be successful in the Lake Macquarie catchment, to reduce pollutant sources to the Lake, include:

- Encouraging water sensitive urban design (refer Option (i) for a more detailed discussion). Water sensitive urban design ensures that urban development gives due consideration to

land capability/characteristics (eg. soil types, slopes, etc), and typically encourages the replacement of traditional piped stormwater networks with such measures as grassy swales, natural waterways and porous pavements. This water sensitive type of development approach attempts to minimise the proportion of impervious areas and maximises retention in urban areas, thus reducing the volume of runoff produced. By reducing runoff volumes, water sensitive urban design can also decrease the flows which need to be conveyed by downstream creeks, which reduces erosion in these creeks. Encouraging water sensitive urban design requires a considerable commitment from Council to ensure that developments which include these principles are favoured over traditional urban design principles, which do not attempt to address the problems of urban stormwater;

- Expansion of the street sweeping program: Street sweeping can remove sediment and litter from the roadways, thus preventing it from being washed into the Lake. This strategy may also reduce the oil and heavy metal input to the Lake, which arise from vehicle emissions. Lake Macquarie City Council has an existing street sweeping program, which could be upgraded/expanded to capture more pollutants from the catchment's roadways;
- Allocation of riparian buffer zones: Riparian vegetation (vegetation adjacent to waterways) plays a very important role in the stabilisation of the banks and the bed of waterways. Bed and bank erosion from waterways can contribute large sediment loads to the Lake. Adequate riparian buffers could therefore assist in reducing sediment/pollutant loads to the Lake, in addition to providing ecological benefits (such as habitat creation).
- Sediment and erosion control measures: Sediment and erosion control measures can reduce the sediment load from construction activities and clearing for subdivisions. Developers and public authorities in areas of Lake Macquarie City Council jurisdiction are presently required to support building and development applications with details of the sediment and erosion control measures which will be adopted during the construction phase. This requires considerable Council commitment and technical skills to assess the suitability of each development's sediment and erosion control measures and ensure methods are correctly adopted and maintained. Council has recently appointed an Erosion and Sediment Control officer to assess and enforce existing Council regulations. This issue is further discussed under Issue B in Table 6.1B; and

(iv) Educate community on the implementation of the Catchment Management Strategy

Many members of the community in the Lake Macquarie catchment are probably not aware that their attitudes and behaviour may cause environmental damage to the Lake. Council and the Catchment Management Committee already have public education programs in place, however expansion of these programs may be beneficial. The existing programs explain to the public that dumping of waste to stormwater drains, or leaving waste in areas where it can subsequently enter stormwater drains, results in this waste being flushed directly into the Lake. Typical examples of wastes which are being dumped into stormwater drains include grass clippings, litter, pet faeces, fertilisers, waste oil and detergents from car washing. The community should be strongly encouraged to act responsibly themselves and also encourage others in the catchment to be environmentally responsible. Educational material and/or advertisements for environmentally friendly products may be included with rates notices.

Continuation of children's education programs in schools and formation of more school and community groups to monitor local water quality may further encourage the community to 'adopt responsibility' for the Lake and induce a feeling of stewardship over the Lake. Several community groups do presently exist in the Lake Macquarie area (Streamwatch, various Landcare Groups Concerned Anglers Group etc.) and these groups should be fully supported and widely promoted.

Catchment management actions can significantly reduce the pollutant loads to the Lake, and have the capacity to improve the Lake's water quality. The most important aspect of many catchment management actions is community education. Implementation can therefore be slow, as community attitudes, beliefs and habits need to be changed.

(v) Halt and/or reduce all point source discharges to the Lake by increasing licence fees.

Industrial discharges to Lake Macquarie will continue if this is the cheapest option for effluent disposal. By increasing industry licence fees for Lake discharges, many industries would be encouraged to investigate and implement alternate strategies for waste recycling and disposal, as these alternatives may be cheaper in comparison to licence fees. This strategy would be met with considerable opposition by industry in the catchment. The revenue raised by the increased licence fees could contribute to the environmental management of the Lake and implementation of strategies to improve the water quality in the Lake.

This is the approach being introduced by the EPA, in the form of load based licence fees for industry discharges. These load based licence fees will encourage industries to lower or cease discharges to the Lake. However, it should be noted that existing discharges of most pollutants to the Lake are minimal and halting discharges will only have minor water quality benefits, particularly with regard to nutrient levels. Halting point source discharges may have some localised ecological benefit, but would not affect the entire Lake's ecology greatly.

(vi) Dredge particular areas of the Lake, to remove nutrient laden sediments.

Water quality modelling of Lake Macquarie has demonstrated that sediment nutrient release is a significant source of pollutants to the Lake, and may contribute approximately 30% to 40% of the nutrient loads to the Lake, during an average rainfall year (refer Appendix APPENDIX B:). An experiment to measure the sediment nutrient release rate in Lake Macquarie was performed as part of this Study, and details of this measurement are also included in Appendix B. These sediment nutrient release measurements showed the nutrient release rates in Lake Macquarie appeared to be lower than results from similar studies in both Lake Illawarra and Port Phillip Bay. It should be noted that sediment nutrient release rates are strongly temperature dependant, and differences in water temperatures between these waterbodies may have some influence over the differences in release rates observed. However, the sediments of Lake Macquarie still contribute an important load of nutrients to the Lake.

The experiment performed showed that sediments in some areas of the Lake contribute higher loads than others. Therefore it would not be considered necessary to reduce sediment nutrient inputs across all of the Lake, but rather focus on areas which have the higher nutrient release

rates. These areas would be those which receive large nutrient and sediment inputs from catchment runoff (particularly urban runoff) and which are poorly flushed, such as the mouth of Cockle Creek. Removing nutrient laden sediments from these areas could decrease the nutrient load arising from sediment release. Consideration and management of contaminated sediments (selenium, heavy metals, etc.) and potential acid sulphate material would be required if dredging works were to be considered. Issue J discusses management options for contaminated sediments.

A predictive assessment was performed with the water quality model, which simulated the removal of 20% of the sediments from Lake Macquarie. This removal could be achieved by dredging and subsequent removal of the nutrient laden sediments. It is recognised that dredging this area may not be logistically feasible, however, this predictive assessment indicated that some improvement in the water quality of Lake Macquarie could be achieved if dredging was performed.

Dredging of "ventilation channels" in highly silted bays will improve tidal exchange between the bays and the main body of the Lake. This can lower sedimentation rates (through increased tidal velocities in the bays) and improve water quality (through increased exchange with the cleaner water of the main lake). Dredging such "ventilation channels" (and the possible formation of an island with dredged material) can therefore improve circulation patterns and water quality in some highly silted bays, and is an alternative to dredging the entire bay.

The major benefit of this dredging is not that it would improve the overall Lake water quality, but rather it could have a much larger effect in localised areas, where the existing sediment nutrient release rate contributes high loads of nutrients to the water column. This benefit can also be significant in terms of local area amenity, ecological enhancement and general waterway aesthetics. However, dredging needs to be carefully investigated before it is undertaken, as dredging can have numerous water quality and ecological impacts.

(vii) Stop all sewage discharges to the Lake.

Most sewage treatment plant discharges to Lake Macquarie have been halted and the Lake only receives sewage discharges from West Wallsend Sewage Treatment Plant. Plans to divert this outfall exist and this Lake discharge will therefore be halted in the near future.

Modelling predictions have demonstrated that halting the sewage treatment plant discharges to the Lake will decrease phosphorus levels in the Lake, but only decrease nitrogen levels minimally. As the Lake is nitrogen limited (ie. the availability of nitrogen limits algal growth in the Lake), the difference in water quality from a nutrient perspective will be minimal. However, sewage discharge would also contribute a significant bacterial load to the Lake, and the reduction in the bacterial load should result in an improvement in Lake water quality and general health.

The Lake does however still receive sewage from sewer overflows, septic areas and boat waste. These sewage sources may contribute nutrients and bacteria to the Lake, although precise quantification of the loads is difficult.

Reducing these discharges to the Lake could provide some water quality improvement, but the amount of improvement is difficult to estimate. Reductions in the number of sewer overflows could be achieved by improving the sewer design capacities, ensuring regular maintenance occurs and plant shutdowns/responses to reported problems are quickly dealt with. These issues are presently being investigated in an EIS, being prepared by Hunter Water Corporation.

Poorly managed septic systems may also contribute nutrients and bacteria to the Lake. No data is available on the nutrient/bacterial load from overloaded septic systems in the catchment.

Boat sewage discharges are an issue in some areas of the Lake. These discharges could be reduced by the provision of more discharge facilities around the Lake, similar to the facility provided at Toronto. Many boats would also require holding tanks for sewage to be installed and education of boat owners/users.

(viii) Develop and enforce a limit on urbanisation area in the catchment.

As outlined above, water quality modelling simulations of Lake Macquarie have shown that nutrient loads from urban stormwater are a large source of nutrients to the Lake. Should urbanisation continue in the catchment without limit, the water quality of Lake Macquarie would deteriorate. A water quality model simulation was performed with inputs from an entirely urbanised catchment, and the results (presented in Appendix B) show a massive increase in both nitrogen and phosphorus levels in the Lake.

These increases are sufficiently large that there would be real risk of significant algal blooms in the Lake. Such algal blooms in the Lake would be likely to shade the seagrasses in the Lake, causing them to die off. As a worst case scenario, excessive algal blooms could also be toxic to many fish and birds and could generally cause a collapse of the existing ecosystem. However, this extreme scenario is not presently being approached, and provided management of urban growth occurs, this should not eventuate.

The treatment of urban stormwater could reduce the predicted nutrient increases, however it is doubtful whether the Lake could support an entirely urbanised catchment, even with stormwater treatment. Sewer overflows, road runoff and other sources of pollution associated with increasing urbanisation which are often not able to be adequately treated would deteriorate water quality in the Lake. Therefore, in order to maintain the water quality at its present level (or better), some limit on the amount of urbanisation permitted in the Lake catchment will be needed.

A model simulation was performed for the Lake Macquarie catchment with the population predicted for the year 2006, (a total population of approximately 195,000, refer to Appendix B for details). This simulation showed a slight decrease in the water quality of the Lake, with the resulting increase in urban area (with no treatment of urban stormwater). The amount of water quality degradation predicted could probably be adequately mitigated by the implementation of stormwater treatment for the majority of existing and future urban areas. Therefore, it is believed that the increase in population predicted to occur by the year 2006 could be achieved with no degradation of the Lake water quality, provided sufficient mitigation strategies to

prevent increasing the nutrient and sediment loads to the Lake were implemented. It is recognised that runoff from some developments may not be able to be treated, due to slope or soil types. Provided these developments are few, the impacts should be able to be absorbed by the Lake's assimilative capacity. However, numerous or large developments which cannot adequately mitigate the potential increases in pollutants may need to be prevented by Council, to ensure water quality degradation in the Lake does not occur.

(ix) Reduce Hydrocarbon Contamination from Powerboats.

As banning or discouraging powerboat usage on the Lake would not be practicable in Lake Macquarie, management of adverse impacts from powerboats is the only solution to hydrocarbon contamination in the Lake. Reducing hydrocarbon contamination from powerboats could be achieved through education of boat owners, improved technology and/or improved controls on powerboat motors (eg. emission testing requirements). A US study on powerboat pollution concluded that "two-stroke outboard motors pass fully 25 percent of their total hydrocarbon intake, fuel and lubricating oil, out the tail pipe and into the environment" (Mele, 1993).

Improved technologies, which consume less fuel and produce less pollutants, would be more readily adopted by motor buyers if the "cleaner" technology motor was similar in price or cheaper than a traditional motor. This price difference could be achieved by creating subsidies on new technology which produce less pollution or by increasing the price on the motors, which create more pollution.

Emission limits for boats could be set by regulatory authorities, similar to car emission limits which are set in some states and countries. Research and development of cleaner, non-polluting technologies should be encouraged by authorities, wherever possible.

Overseas research suggests that hydrocarbon contamination may reduce aquatic biota's ability to reproduce. There are only a limited number of areas in Lake Macquarie which presently have the potential to become affected by hydrocarbon contamination eg. Marmong Cove Marina. It is believed that a study of gastropod mollusc at Wangi showed contamination from aliphatic hydrocarbons, reflecting industrial and boating activities (R. Economos, pers. comm.). Management of hydrocarbon contamination will become increasingly important as powerboat usage grows in the Lake.

6.2.2 Issue B: Excessive Sedimentation in the Lake (Water Quality).

An issue which arose from the community consultation work performed as part of this Study (refer Appendix A) was the major concern about sedimentation in some areas of the Lake. This issue was given the highest aggregate score in the community consultation workshop, indicating the strong community concern regarding this issue.

Examples of particular areas with siltation problems are shown on Figure 6.1 and are also discussed in Section 6.5.2. Many of these areas are experiencing sedimentation due to urban runoff. Sources of sediment in urban catchments include residential development, unsealed roads, road shoulders and vehicles. Sediment accumulated on roadways can contain high

levels of toxicants, such as heavy metals and oil residues and these pollutants can also have adverse impacts on the Lake's water quality and ecology. Heavy metals and other toxic chemicals in sediments can affect the health of many benthic feeding organisms such as prawns and some fish.

Excessive sedimentation is therefore not only a water quality issue, but also is an issue for ecology (particularly seagrasses), visual amenity, navigational access, flood control and other public amenity concerns. These issues are closely related, as excessive siltation is typically caused by high sediment loads in urban runoff, which also contributes to poor water quality in the Lake. However, where sedimentation results in restricted navigational access and decreased visual amenity, it is considered to be a public amenity issue (Issue L). Additionally, sedimentation in areas with industrial inputs, sediments may become contaminated and fish and other aquatic fauna can be affected. Therefore, siltation in the Lake has been addressed separately as a water quality issue (Issue B, Table 6.1B), as a public amenity issue (Issue L) and a fisheries issue (Issue J). These issues are interrelated as they can be caused by some (or all) of the same activities. However, management actions may differ, depending on the attribute being adversely affected (water quality, public amenity or fisheries). Therefore, management options are separately discussed under Issue B (water quality), Issue J (fisheries) and Issue L (public amenity).

Management strategies which involve the removal or disturbance of sediments should consider the potential for the sediments to be contaminated or contain potential acid sulphate material. For example, the contaminated sediments at Cockle Creek, where discharge of contaminants from the Pasminco Smelter and other industries occurs, would need careful consideration not only of ecological impacts during sediment removal (eg. contaminant re-mobilisation) but also appropriate sediment disposal considerations. Additionally, atmospheric discharges that enter the Lake via the stormwater may also be contributing contaminants to Cockle Creek.

The management options for consideration of sedimentation in the Lake (from a water quality perspective) include:

i) Do nothing.

ii) Treatment of stormwater, increase roadside silt traps in the catchment and catchment management activities.

iii) Control construction site activities in the Lake catchment.

iv) Dredging shoaled areas.

v) Substantial dredging in conjunction with other training/reclamation works at Lake Entrance.

vi) Restore foreshore/riparian vegetation.

This issue is also addressed as Issue L in Table 6.4L, in the Foreshore Erosion and Public Amenity Section (Section 6.5).

B. Issue - Excessive Sedimentation in the Lake.

(i) Do nothing.

This issue will only worsen if strategies for reducing sediment loads and removing accumulated sediment in the Lake are not implemented. The absence of any action to address the high sediment load to the Lake will cause continuing sedimentation problems and increasing community dissatisfaction. Continuing sedimentation in the Lake would eventually adversely impact on the Lake's ecology (particularly seagrasses), water quality, visual amenity and as well as restricting navigation to some areas of the Lake. This would subsequently affect the recreational value of the Lake and this could have adverse economic impacts, due to reduced tourism, decrease in land prices and decreased quality of life for the community.

(ii) Treatment of stormwater, increase roadside silt traps in the catchment, and catchment management activities.

As previously discussed, water quality modelling simulations of Lake Macquarie have shown that pollutants from urban stormwater inputs are degrading the water quality of Lake Macquarie (refer Section 4.1.17 and Appendix APPENDIX B:). Treatment of urban stormwater from existing urban areas could improve the water quality in Lake Macquarie, as well as removing large amounts of sediment which is derived from urban stormwater.

Developing urban areas contribute high sediment loads to the Lake, if adequate control measures are not in place. This has been discussed separately in Option (ii) below. Established urban areas also contribute large sediment loads, as particles accumulate on impervious areas between rainfall events, and are then washed by runoff directly into downstream waterways. Sources of sediment in urban catchments include erosion from unsealed areas (eg. gardens), unsealed roads, road shoulders and vehicles emissions. Higher flow rates in urban creeks (caused by urbanisation) cause bed and bank scour, which also contributes to high sediment loads to the Lake.

Wetland filters and sedimentation basins (when correctly designed) are efficient sediment traps, as slower water velocities are created to maximise treatment efficiency. This encourages sediments to settle out of the water column. In wetlands, settled particles are then bound into the sediments by the root systems of the wetland plants, thereby reducing the sediment load entering the Lake. Settled sediments in sedimentation basins need to be physically removed to prevent the sediment washing into the Lake during subsequent storm events.

Some wetland filters have already been created in the Lake Macquarie catchment, however the creation of more wetland filters around the Lake to treat urban stormwater could improve the overall water quality in the Lake, as well as providing attractive and ecologically viable habitat areas. These wetland filters should notably reduce the sediment load from catchment runoff. Installation of several pollution control devices in a series (also called a "treatment train") can also be beneficial, as pretreatment devices such as GPT's reduce the debris and coarse sediment load (and maintenance requirements) for the wetland.

Sediment accumulated on roadways can contain high levels of toxicants, such as heavy metals and oil residues and the removal of these pollutants would also be beneficial to the Lake's water quality and ecology. Installation of roadside silt traps can assist in lowering the sediment load from these sources.

Rural areas also contribute sediment from sources such as unstabilised cultivated areas and unsealed roads. Education of rural landholders on best farm management practices to reduce erosion from rural areas and directing unsealed road runoff to grassy swales or vegetated areas may be sufficient to prevent high sediment loads from rural areas entering the waterways and Lake.

It is understood that approximately 150 pollution control devices are presently located in the Lake Macquarie catchment. Proposals to install more devices in the future should consider the existing and future catchment land uses, to ensure maximum benefit from their installation. Road silt traps and other pollution control devices need to be regularly maintained to ensure their effective operation. Council also has a program in place to stabilise road verges, by the use of jute mesh and grass sprays, to further reduce sediment loads to the Lake.

Catchment management activities should also be increased to lower the loads of sediment at the source. Catchment management strategies largely rely on education of the community and have been previously discussed in Issue A, option (iv).

These management options would require considerable further commitment from Council, as the expense of installing and maintaining numerous road silt traps, public education campaigns, implementing catchment management strategies and other pollution control devices would be high. It is understood Council is investigating optimum locations for pollution control devices and has budgeted and planned to install more.

(iii) Control construction site activities in the Lake catchment.

Construction activities and clearing for subdivisions can be large sources of sediment, particularly when erosion control measures are not properly installed or maintained. Cleared areas represent a large area of exposed ground, which can suffer extensive erosion during even a medium sized rainfall event.

Vegetation plays a large role in sediment stabilisation and subdivisions and construction activities typically involve wide scale clearing, in order to allow easy access to the site and building areas.

In order to reduce the sediment load from construction activities and clearing for subdivisions, sediment and erosion control measures are one condition of building approvals by Lake Macquarie City Council. Most developers are required to support building and development applications with details of the erosion and sediment control plan (ESCP) which will be adopted during the construction phase. Sediment and erosion control measures need to be in place before the site is cleared and construction/earthworks begin.

However according to Council's Erosion And Sediment Control Policy, sites which do not require a site ESCP to be developed/approved are still required to comply with conditions for controlling site erosion, some of which include :

- Diversion of upstream runoff from exposed areas;
- Minimising the extent of exposed areas;
- Use of filter fences, catch drains and temporary sedimentation ponds on the construction site to capture sediment eroding from exposed areas; and
- Revegetation of exposed areas when construction/subdivision works are complete.

Council ensures developers can easily access sediment and erosion control guidelines, so that they understand Council's requirements and understand how to develop appropriate sediment and erosion control measures for their site(s) and Codes of Practice detail their requirements for maintenance. Sediment and erosion control measures can only be effective if the sediment collected is subsequently removed from the collection point and placed back onto the site. If sediment traps remain uncleared, future runoff events will wash more sediment into the traps, which will fill and become ineffective.

Council needs to rigorously enforce and police these sediment and erosion control measures, to ensure they are adopted and properly maintained. This will require considerable Council resources. Council has recently appointed an Erosion and Sediment Control officer to better implement Council's ESC Policy.

Areas in the catchment which have been already cleared, but have not been stabilised should be identified. Once identified, Council should encourage/enforce implementation of sediment and control measures, to prevent further erosion from such sites.

(iv) Dredging shoaled areas.

This strategy addresses one of the immediate problems (ie. improving navigability), but does not address the cause of the problem or prevent the problems from recurring. Problems with sediment properties would need to be addressed in areas with actual or potential acid sulphate soil characteristics, and in some areas with possibly contaminated sediments (particularly Cockle Creek and some heavily urbanised catchments). This issue is discussed in more detail in Table 6.3J, Section 6.4.

(v) Substantial dredging in conjunction with other training/reclamation works at Lake Entrance.

This strategy addresses the immediate problem of poor navigability at the entrance of the Lake, and also ensures the entrance remains open and tidal exchange to the Lake is maintained. This issue has been addressed as a separate study (WBM Oceanics Australia, 1996). This Entrance Channel Study showed that dredging of the Lake entrance channel could marginally increase tidal velocities in the Lake, but it is unlikely that these increases would be sufficient to prevent shoaling at creek entrances. Increasing tidal flushing in the Lake would result in minimal

water quality benefits (refer Appendix B), but could result in adverse impacts such as entrance erosion and stability problems (WBM Oceanics Australia, 1996).

This approach would not reduce the sediment load to the Lake, and therefore it seems likely that sedimentation would continue in the Lake. This will cause continuing sedimentation problems and increasing community dissatisfaction, and possible adverse ecological and water quality effects.

(vi) Restore foreshore/riparian vegetation.

Vegetation plays a large role in sediment stabilisation and the loss of foreshore vegetation can result in significant erosion problems which can in turn contribute sediment loads to the Lake. Riparian vegetation (vegetation along waterways) also plays an important stabilisation role. Riparian vegetation can reduce bed and bank erosion from waterways, and provide a buffer to intercept/treat runoff from adjoining urban areas.

Foreshore stability would be best achieved by restoration of this vegetation with species native to the area. Replanting of native species to the area is important as the local species should be best adapted to cope with the range of conditions which occur in the Lake. Vegetation should be protected until it is well established, to ensure a successful revegetation program. This issue is further discussed in Table 6.4K in Section 6.5.

6.2.3 Issue C: Poor Community Attitudes to Lake Water Quality

Poor community attitudes and lack of awareness regarding the sources of pollutants to the Lake result in higher pollutant loads entering the Lake. An expansion of existing community education programs can have a positive effect. Not only will some areas of the community develop an understanding of the Lake's problems and how their actions can decrease/prevent pollution of the Lake, but also these areas of the community can further educate/encourage others to act responsibility. Management options discussed include:

i) Do nothing.

ii) Implement catchment management strategies/education of the community.

C. Issue - Poor Community Attitudes to Lake Water Quality.

(i) Do nothing.

The absence of any action to address this issue will cause continuing deterioration of the Lake's water quality as a result of poor community practices and increasing nutrient loads to the Lake. This will eventually have an adverse effect on the Lake's water quality, visual amenity, recreational value and ecology which will cause community dissatisfaction. These impacts will in turn cause adverse economic impacts as a result of decreased tourism to the area, decreased land prices and decreased quality of life for the community.

(ii) Implement catchment management strategies /education of the community.

Catchment management strategies provide methods to reduce the source of pollutants in the catchment. Catchment management strategies require considerable community participation and therefore education of the community can be the key to implementing successful catchment management strategies. Council and Government bodies also need to be totally committed to implementing catchment management strategies, as many of the strategies include changing the way polluting activities are performed through regulation and Council approvals, such as clearing and construction activities. Measures which may be successful in the Lake Macquarie catchment to reduce pollutant sources to the Lake have been outlined previously in Section 6.2.1.

Results from implementing catchment management strategies and community education may be slow, but effective, as both require a turn-around of community attitudes and habits.

6.2.4 Issue D: Selenium Inputs to the Lake

Selenium inputs to the Lake are a concern to the Lake water quality and ecology. Management options discussed for this issue include:

i) Do nothing.

ii) Further decrease selenium inputs to the Lake.

iii) Identify and remediate areas where selenium contaminated sediments are contributing to water quality degradation.

D. Issue - Selenium Inputs to the Lake

(i) Do nothing.

Although the discharges of selenium to the Lake have been reduced, through increase of ash dam capacities and recirculation of ash dam waters, the inputs of selenium to the Lake may still be sufficient to cause a deterioration in the Lake's water quality and could adversely impact on the Lake's ecology and fisheries as well causing community dissatisfaction and a possible public health risk. Remobilisation of selenium from the sediments and bioaccumulation may also continue, unless selenium inputs to the Lake are further reduced.

The absence of any action to address this issue could cause continuing contamination of the Lake, from ash dams overflows and industrial/tradewaste discharges.

(ii) Further decrease selenium inputs to the Lake.

Actions related to ash dams have already been implemented by Pacific Power and Delta Electricity. Major civil works have been performed at the dams to increase dam capacities (to ensure ash does not escape to the Lake) and the introduction of ash dam water recycling. These actions, with EPA further industrial discharge regulation, should ensure selenium inflow to the Lake are considerably reduced. The EPA will also be introducing load based licence fees, which will ensure that polluters have a financial incentive to lower or halt discharges to the Lake.

Both Vales Point and Munmorah Power Stations have adopted a water management system that minimises water discharges through reuse and recycling (Delta, 1996). Other long term strategies aimed at minimising potential environment effects of the ash dams include:

- maximising ash sales and minimising placement of fly ash and furnace ash into the dam;
- minimising ash dam discharges through continued updating of practices;
- keep abreast of research of selenium removal technologies (such as wetland efficiencies for selenium removal);
- progressive rehabilitation of completed storage areas; and
- monitoring of the systems operation and potential environmental impacts.

Maximising ash sales is only an acceptable management option in situations where no leachate will be generated, or where leachate can be collected and treated/recycled appropriately.

An assessment of selenium and heavy metals in seafood in the Lake has been recently completed, and results are discussed in Section 4.3.3.

(iii) Identify and remediate areas where selenium contaminated sediments are contributing to water quality degradation.

It is not known whether selenium in sediments is contributing to selenium contamination of the water column, or whether there is the potential for them to do so. A study is needed to assess whether selenium contaminated sediments are contributing to water quality degradation (or biota contamination), such that appropriate management actions can be performed. If the sediments are not releasing selenium or contributing to seafood contamination, it is recommended they remain undisturbed. If they are found to be a problem, then an assessment of all the advantages and disadvantages of disturbing the sediments needs to be assessed. Disturbing the sediments may remobilise quantities of selenium back into the system far greater than are presently being released.

6.3 Management Options for Ecology Related Issues

Management Aim: To maintain or improve the ecological status of Lake Macquarie.

The water quality enhancement measures proposed in Table 6.1A, if implemented, would benefit all the Lake's ecology, as improved water quality would beneficially affect saltmarsh/mangrove/seagrass communities, benthic organisms, birds, etc. Therefore, maintenance (or improvement) in water quality of the Lake will ensure a viable and healthy ecosystem can be maintained in the Lake and will protect the ecological status of Lake Macquarie. The issue of heavy metal/selenium contamination in the Lake's biota is addressed in Section 6.4 as Issue J. Other ecological issues that have been identified in this Study through the process of information review, community consultation and liaison with Government Departments which require specific management are:

- decline in area of seagrass (Table 6.2E)
- wetland conservation (Table 6.2F); and
- thermal discharges (Table 6.2G).

A range of management options exist for each of these ecology issues identified. These options, advantages, disadvantages, cost and level of community acceptance of the management options are summarised and presented in Table 6.2, with more detailed discussions following the relevant sections of the table.

6.3.1 Issue E: Decline in Area of Seagrass

Preventing seagrass areas from declining in the Lake is important, as seagrasses provide essential nursery, feeding and shelter areas for many aquatic fauna. Threats to seagrasses in Lake Macquarie have been identified and management options discussed to address this issue of seagrass loss include:

i) Do nothing.

ii) Develop user based strategy for conservation of seagrass beds.

iii) Adopt water quality improvement measures.

iv) Investigate and replace boat mooring type.

v) Relocate mooring areas/rehabilitate affected areas.

vi) Increase mooring licence fees.

vii) NSW Fisheries to require seagrass disturbance permit for moorings.

viii) Monitoring of seagrasses.

E. Issue - Decline in Area of Seagrass

(i) Do nothing

In the absence of management intervention, it is possible that seagrass in Lake Macquarie will decline further in the long term. This decline will probably result from potentially deteriorating water quality, increased sedimentation, and increased boating usage of the Lake (eg. as a result of increased boat mooring). Options need to be considered to ensure that seagrass resources in Lake Macquarie are protected to maintain a viable and productive aquatic ecosystem.

(ii) Develop user based strategy for conservation of seagrass beds

Fisheries productivity can be maintained by preservation and protection of significant areas of seagrass beds (eg. those known to be used as nursery areas). All marine vegetation within Lake Macquarie is protected under the Fisheries Management Act. State Government Planning Policy SEPP-14 covers all significant wetland areas. These provide a mechanism to ensure any proposed works, including direct impacts to wetlands, are subject to environmental impact assessment procedures and appropriate approvals.

The water quality enhancement measures options discussed in Section 6.2, if implemented, would benefit all wetland types, as improved water quality would beneficially affect wetland communities.

However, the existing legislation and proposed water quality enhancement actions need to be complemented by lake-specific policies/procedures to cater for impacts associated with various lake uses that, generally in the long term, adversely affect seagrasses (eg. boating, mooring, jetties). Effective management of the Lake's seagrass beds requires an overall plan describing which and how specific seagrass areas should be utilised by the public, taking into account both seagrass bed characteristics (eg. extent, location, species diversity) and anticipated human usage patterns.

The strategy to achieve such management involves designating certain seagrass areas for certain levels of access and types of usage. For example, some areas may not be available for access by jetskis, speed boats or permanent boat moorings. This strategy would link with that proposed in Section 6.5 where issues associated with "excessive" seagrass growth are discussed.

This use/access concept of designating seagrass areas for various activities has received a high level of public support, however to be successful it needs to be formulated taking into account the views of all Lake users and Government Departments responsible for implementing/managing the nominated seagrass areas. It needs to be recognised that this concept is innovative. As such, it may take some time to implement, particularly considering the public consultation phase could be extensive as individual beds would need to be discussed and determination of the responsible government department may require some discussion.

This use/access concept could be extended to cover other areas of the Lake as a second phase, but seagrass areas should take priority.

Seagrass bed damage by boat moorings could be minimised by replacing boat mooring types, or clustering moorings. Several viable designs are available locally and at a reasonable price. The proposed use/access concept for seagrass beds would be of assistance in reducing the overall effects of mooring damage by designating only some seagrass areas suitable for mooring activities using an appropriate mooring type. This could result in existing mooring types and/or alternate mooring types being installed in the future.

Development of a Lake Macquarie strategy to manage seagrass beds will need to take into account that NSW Fisheries has recently (January 1997) released Draft Fish Habitat Protection Plan No. 2 - Seagrasses. Some of the management strategies in the Fisheries Plan relate to those discussed in this Study (eg. collection of dead seagrass, boat mooring in seagrass beds, removal of "excessive" seagrass growth).

(iii) Adopt water quality improvement measures

The options for managing water quality problems in the Lake have been previously discussed in Section 6.2 (Issues A-D).

(iv) Investigate and replace boat mooring type

Conventional, or swing, moorings consist of a single heavy block connected to a surface buoy by a long length of heavy chain. This chain drags along the bottom and in areas of seagrass, eventually scours the beds, creating circular areas of stunted and patchy seagrass clearly visible from the air.

In an aerial survey of Lake Macquarie, these circular patches around concentrated areas of boat moorings were particularly obvious (see Section 4.2.1). The loss of significant seagrass areas as is presently occurring is of concern, particularly if mooring areas were to increase in the future, which is likely. Investigations into the extent of such seagrass losses and their effect on the ecological and fisheries productivity of the Lake needs to be performed.

Seagrass damage from moorings could be minimised by discouraging the use of swing moorings, replacing them with alternative mooring systems. The Great Barrier Reef Marine Park Authority (GRMPBA) and the Brisbane Water Plan of Management (1995) have addressed this issue of mooring damage with regard to minimising reef damage and can provide relevant information.

Various alternative mooring systems have been recently tested in Lake Macquarie. NSW Fisheries in conjunction with the Waterways Authority have developed a strategy to replace boat moorings in seagrass beds, with those near Belmont/Swansea being targeted initially.

A number of mooring systems are available that can minimise chain drag and the resultant scouring effect on seagrasses. Briefly, these are :

- cyclone moorings;

- moorings with a riser buoy;
- seaflex moorings;
- screw/cluster moorings.

An investigation of these moorings, their applicability and costs needs to be undertaken to assess the practicality of mooring replacement.

Cyclone moorings are installed by divers. Three radially arranged holes are made for the installation of anchor weights. These are connected by heavy chain to a central ring on a swivel, which is connected via another chain to a surface buoy. These moorings still cause some degree of scour, however it has been reported to be ten times less in area than that of swing moorings (Walker et al, 1989) .

The use of a riser buoy should act to greatly minimise chain drag. There are various means of attaching riser buoys, for example that designed by a local Lake Macquarie producer.

Seaflex moorings, which involve an elastic mooring system, have been successfully used in Europe for over 20 years and have been trialed in Lake Macquarie. Trial results were very encouraging. Although the costs of the mooring are twice those of existing moorings, maintenance is less (inspection required only every 5 years and the mooring life may exceed 20 years) and they could be a viable option to reduce seagrass damage. Screw and cluster moorings also utilise the seaflex system. Screw moorings involve an auger that screws into the seabed (to a pre-determined depth) and an elastic mooring is attached to a shackle on the screw (150-200mm of the bed). This system can withstand considerable force and has been successfully used elsewhere in Australia. Cluster moorings are ideal for restricted areas where many boats need mooring (up to 80 boats/ha). The cluster mooring system can accommodate up to 8 times as many boats as the existing swing moorings.

The proportion of seagrass damage from scouring relative to the total areas of beds in Lake Macquarie may be quite small overall, but substantial on a local scale. Additionally, the seagrass beds lose their physical integrity which decreases their ecological value as fisheries habitat. This type of seagrass damage has a much greater ecological effect than if an equivalent area was lost from the edge of the beds (Walker *et al.*, 1989). Further, this scouring increases the length of beds vulnerable to erosion, particularly during storms. As such, deployment of alternative mooring types has the ecological advantage of restoring habitat with potential subsequent increases in fish productivity.

There would, however, be costs associated with replacing existing moorings that could create some opposition from users of moorings.

(v) Relocate mooring areas

The seagrass damage from moorings could be reduced by relocating moorings to unvegetated areas or clustering moorings in particular areas (some of which could contain seagrass).

Locating sufficient areas to move moorings to may be difficult without causing conflict with foreshore residents and other users of the Lake. Additionally, moorings are presently located near support facilities/infrastructure (eg. yacht clubs) and relocation may create difficulties in terms of inconveniencing boat users (eg. logistical support access). There may be the opportunity to focus moorings in some areas, and remove mooring from other more sensitive or significant seagrass beds. However, this option should be considered by both the community and the relevant Government Departments (MSB, EPA, NSW Fisheries) as a long term strategy. This strategy could be incorporated into the user based strategy for seagrass conservation (refer Option (ii)).

The cost of relocation of moorings could be high.

(vi) Increase mooring licence fees

An alternative to changing or moving moorings would be to increase the licence fee for the moorings. The extra fee could be used to fund enhancement of key seagrass habitats in the Lake.

This option, though, will not reduce the immediate seagrass damage around moorings. Furthermore, the continuing loss of seagrass habitat integrity may not be adequately offset by seagrass habitat enhancement elsewhere, particularly, if as anticipated, the number of boat moorings increases in the future. The issue of extra licence fees may also receive public criticism, depending on their cost and the public perception of the value of habitat enhancement.

Alternatively, Council may explore other regulatory mechanisms such as placing a requirement for a Development Application on new moorings. This would give Council the opportunity to impose appropriate controls and conditions on moorings.

(vii) NSW Fisheries to require seagrass disturbance permit for moorings

Disturbance of seagrass requires a permit under Sections 204 and 205 of the Fisheries Management Act (1994). NSW Fisheries could require this permit be obtained for all moorings that damage seagrass. Permit applications must be accompanied by a fee. A mechanism could be developed to use the fees to fund enhancement of seagrass habitats elsewhere in the Lake. However, as noted above, this option would not reduce seagrass damage and enhancement works may not compensate for losses, particularly in the future. Increased annual costs associated with boat owners maintaining mooring types that damage seagrass could however prompt owners to change to moorings types that do not damage seagrass.

(viii) Monitoring of Seagrasses

Seagrass has high ecological and fisheries values. The overall extent and exact degree of change in the seagrass of Lake Macquarie is debatable and difficult to assess as seagrasses exhibit a high degree of natural variation and some surveys have employed different methodologies, which limits their comparability to other studies. For example, seagrass

surveys have been conducted at different times of the year and winter seagrass biomass is usually far greater than summer biomass (King and Hodgson, 1986). Therefore, differences between surveys may relate to seasonal effects rather than actual longer term changes.

Developing a seagrass monitoring program specifically designed to take into account implemented Lake management actions would be of value to assess the success of the implemented actions and monitor any long term trends in seagrass extent. This monitoring program would need to be developed and implemented in close conjunction with NSW Fisheries. This monitoring program may also assist in the identification of more sensitive/significant seagrass beds.

6.3.2 Issue F: Wetland Conservation

Conservation of wetland areas (both around the periphery of the Lake and in the catchment) is an important issue in the Lake Macquarie area, raised repeatedly by community members and in environmental studies in the Lake region. Management options which address this issue are as follows:

i) Do nothing.

ii) Include wetlands within Council land zoning system.

iii) Manage access to specific wetland areas.

iv) Identification of wetland rehabilitation requirements.

F. Issue - Wetland Conservation

(i) Do nothing

On-going population growth is likely to result in further pressure being placed on wetlands. This issue of particular community concern and the need for management measures to protect wetlands was identified throughout public consultation. In the absence of management measures, community concern will increase and the ecological/fisheries values of the Lake will be reduced, as wetlands diminish.

(ii) Include wetlands within Council land zoning system

Lake Macquarie City Council has been reassessing options to zone wetlands identified in the Lake Macquarie Wetlands Inventory, undertaken by the Wetlands Centre in 1989.

Some specific wetlands of high conservation value that should be considered are the estuarine wetland complex of Swansea environmental province and the dunal wetland complex (Jewells environmental province). One other particular wetland of note is Black Neds Bay. Studies of Black Neds Bay have found that it includes the largest area of estuarine wetland in the Lake and has a high degree of saltmarsh zonation which is of both scientific and educational value. According to Winning (1990), Black Neds Bay has a higher conservation value than other estuarine wetlands of the Lake, and consequently the Lake Macquarie City Council (1993) recommended an investigation into the possibility of its gazettal as a Nature Reserve under the National Parks and Wildlife Service.

Wyong Shire Council has developed a draft Local Environmental Plan which proposed a special "Wetlands Management Zone" for significant wetlands. This includes a Developmental Control Plan which includes buffer areas for significant wetlands. These plans cover wetlands on the southern edge of Lake Macquarie, many of which are too small to be covered by SEPP 14 (Winning, 1990).

If Lake Macquarie City Council implemented wetland conservation zonings there may be a loss of some foreshore areas for general use and property development. However, the total proportion of areas lost is likely to be minimal and should not be a major impact to recreational and other users of the Lake.

(iii) Manage access to specific wetland areas

There may be benefits in managing public access to wetlands regularly frequented by the public or those close to urbanised areas. Uncontrolled pedestrian and domestic animal access can lead to litter and vegetation trampling problems whilst boating traffic may result in boat wash and propeller damage effects.

Such effects are likely to become of greater concern in conjunction with population growth and increased recreational usage of the Lake. Management options include designated walking trails, areas where access (pedestrian and boating) is prohibited, boat speed limits and boat no-

wash areas. If this option was to be pursued, susceptible wetlands would need to be identified and management strategies for the specific wetlands evaluated.

(iv) Identification of wetland rehabilitation requirements

Many of the wetlands fringing the Lake would benefit from rehabilitation works to improve their ecological value and functioning. A study directed towards identifying the necessary works, prioritising various activities and determining funding requirements would be beneficial. Once this has been completed, Council could seek the funds necessary for such activities. It is understood that Power Coal is currently undertaking such a study (R. Economos LMCC, pers. comm.)

6.3.3 Issue G - Thermal Discharges

Thermal discharges from power stations to the Lake have localised impacts on seagrass, fish, benthic and planktonic communities. Management options relating to this issue are as follows:

(i) Do nothing.

(ii) Redirect/recycle the water to avoid Lake discharges.

(iii) Cool the water before it is discharged into the Lake.

G. Issue- Thermal Discharges

(i) Do nothing

If current thermal discharges were to continue, the associated impacts to the Lake's aquatic biota would remain. Such impacts are well documented as being relatively localised and do not have significant adverse effects to the ecology of the Lake as a whole (UNSW 1972, Sidautar 1992, Negarestan 1993). Options to reduce thermal impacts are relatively few as this would require cooling water treatment systems, which are likely to be considerably expensive and require large areas. Sufficient land for treatment may not be available.

(ii) Redirect/recycle the water to avoid Lake discharges

This option would be beneficial to the aquatic biota in the vicinity of the outlets as ecological impacts from the input of warmer waters would be reduced and the affected areas may return to their pre-discharge state. However, this option may be limited by the availability of land to redirect the waters for storage, as this may require the creation of a substantial water body. As estuarine water is used for cooling, land disposal would need to occur in either unvegetated areas or areas where the vegetation is salt tolerant to avoid damage to terrestrial vegetation. One option is a cooling tower, which may be unpopular with local residents. The costs associated with redirection of the discharge waters may be very high.

There is also the potential for a decline in winter angling effort if the warm waters are no longer discharged into the Lake. The angler and wider community need to weigh the ecological advantages of cessation of discharges (which would be localised) against the potential loss of some angling opportunities and the cost to the community of diversion of the thermal discharges.

(iii) Cool the water before it is discharged into the Lake

As for the previous option, this would also be beneficial to the aquatic biota in the vicinity of the outlets as the discharged waters would no longer have a thermal impact. The cost of cooling the discharge waters would be expensive but may be less than that of completely ceasing all discharges from the power stations into the Lake.

As for the option of cessation of discharges, there is also the potential for a decline in winter angling opportunities near the outlets if warm waters are not discharged into the Lake.

The benefits of pursuing this option, or option (ii) above are uncertain given the localised area where warm water influences occur and the likely significant associated costs.

6.4 Management Options for Fisheries Related Issues

Management Aim: To maintain or improve the fisheries of Lake Macquarie.

The issues that have been identified in this Study which relate to fisheries are:

- reduced angler catches (Table 6.3H);
- haul netting (Table 6.3I); and
- selenium and heavy metal contamination in biota (Table 6.3J).

A range of management options exist for each of these fisheries issues identified. For each management option, advantages, disadvantages, cost and level of community acceptance of the management options are summarised and presented in Table 6.3, with more detailed discussions following the relevant sections of the table.

It needs to be recognised that management of commercial and recreational fisheries is the responsibility of NSW Fisheries. Accordingly, proposals to adopt any new management strategies for the Lake would need to be agreed with, and implemented by, NSW Fisheries. Additionally, some of the potential management strategies identified in Table 6.3H may be new within NSW (eg. lake-specific bag limits) and as such may generate discussion perhaps delaying their implementation. The options provided below could be utilised in Council discussions with NSW Fisheries.

The protection of fisheries is strongly related to both water quality and ecological health in the Lake. Management actions outlined under water quality, sedimentation and ecology, if implemented, will all play an important role in the protection of the Lake's fisheries. Management options which particularly relate to the protection of the Lake's fisheries are detailed below.

6.4.1 Issue H - Reduced Angler Catches

It is possible that the total angler catch in the Lake has not altered appreciably, however there may have been a decrease in individual angler catches (this phenomenon has reportedly been observed in other NSW estuaries). Should this be the case, then it is possible that catches will decrease further as recreational fishing effort will increase in the future as a result of population growth, increased available leisure time and improved gear efficiency. Management options which address this issue include:

(i) Do nothing.

(ii) Reduce and/or phase out commercial fishing effort by license purchase.

(iii) Establish artificial reefs.

(iv) Lake specific bag limits.

(v) Greater enforcement of existing fisheries legislation/community education.

(vi) Establish aquatic reserves / fish sanctuaries to manage specific fishing activities.

(vii) Habitat restoration.

(viii) Monitoring/research of angler catches.

H. Issue - Reduced Angler Catches

(i) Do nothing

The current concern expressed by anglers regarding declining catch rates and conflict between recreational and commercial fishing sectors is only likely to increase in the absence of implementing a management strategy for this issue. It needs to be recognised, however, that this issue is common for many New South Wales estuaries. In most areas increased recreational fishing effort is occurring as a result of the expanding coastal population. This increased recreational fishing effort in some instances may lead to reduced individual angler catches. For example, as noted by Kearney (1993) in relation to the tailor fishery, *"most of the declines in recreational catch per effort can be explained by increased recreational effort"*.

Decreased individual catch rates do not necessarily relate to a decreased total fish population (although this may be the case in a few specific fisheries). In many instances, the decline is a result of more anglers receiving a proportionately smaller share of a total available fish catch. Pollock (1984) noted in relation to decreasing angler catches of yellowfin bream at Jumpinpin (Qld), *"this decreasing trend does not indicate a reduction in the number of spawning fish each year since 1970, but results from the rapid increase in total angling effort"*.

Alternatively, angler catch rates may reduce as a result of an actual decline in fish stocks (perhaps due to overfishing, habitat reduction or deterioration of water quality). Sections 6.2 and 6.3 provide management options to improve fish habitat quality.

Although an issue of key concern, insufficient data are available to actively identify whether or not there has been a decrease in individual angler catch rates. This problem is typical of NSW estuaries.

This issue appears to be of greater prominence in Lake Macquarie than many other New South Wales estuaries. Unless resolved, public concern will continue to increase, angler dissatisfaction will increase, and there is the potential for Lake Macquarie to be perceived as an area where fishing is poor and hence adversely affect tourism and the local economy.

(ii) Reduce and/or phase out commercial fishing effort by license purchase

Discussions with members of the Lake Macquarie Commercial Fishing Industry have indicated that some members would be satisfied with buy-outs of their licences. Under a scheme of licence buy-backs, the licences in the fishery are bought by an authorising agency and permanently removed from the fishery. This could well be a satisfactory solution to the conflict between the recreational and commercial fishers and undoubtedly warrants strong consideration.

If commercial licenses are to be bought, the main issues that need to be addressed are to determine a reasonable sum for each license and who will meet the costs. The actual sum would need to be debated and confirmed by all stakeholders concerned, and may vary according to the extent that a commercial fisherman relies on fishing for an income.

License buy-out has the potential to increase individual angler catches. A reduced number of commercial fishers would reduce fishing effort and, hence, a proportion of the fish presently taken by commercial fishers may become available for capture by anglers. This would reduce community concern, the conflict between the two fishing sectors, and could improve tourism in the area. Estimation of the potential increase in individual angler catch (if any) is difficult. There are insufficient catch effort data on both fishing sectors in the Lake and there have been no scientific studies specifically directed at assessing the increase in recreational fishing catch when commercial fishing catch is reduced.

Additionally, it needs to be recognised that most of the fish taken by commercial fishers are not targeted by anglers (eg. mullet, silver biddy) and the angler catch increases would relate mainly to those species that are targeted by both groups (eg. bream). These species commonly leave the lake for a period (eg. to spawn) where they also are subject to fishing pressure (both commercial and recreational) and the "proportion" that would be available to anglers in the Lake is unknown.

It would be difficult to estimate a period of time in which recreational fishers would benefit from the reduced level of commercial fishing effort because recreational fishing effort will increase in conjunction with population growth. There is some potential for any period of increased catches to be short-lived (eg. less than 5 years) unless the increase in recreational effort is slowed or "capped". Several management options are discussed below (eg. lake specific bag limits) which would reduce the growth in recreational fishing effort.

There are some potential negative impacts associated with license buy-outs, as summarised in Table 6.3H. With a market value of the reported commercial fisheries catch from Lake Macquarie of, on average, $1.0 million per year (NFRI, 1995), there would be the direct loss of this income for the region and an indirect loss of a greater amount resulting from backward and forward economic linkages (eg. suppliers of commercial fishing gear/vessels, processors). There may also be a consequent reduction in the community seafood supply from local sources with a reduced number of commercial fishers. The proportion of the commercial catch that is currently sold in local markets is approximately 12-15% (based on figures for fish caught by Mannering Park Fish Co-operative in 1994/95). This lost local supply could be replaced by fishers operating outside the Lake (ie. an increase in commercial fishing effort outside the Lake, particularly when fish leave the Lake periodically) or by imports from intra/inter-state sources.

A reduction in the number of commercial fishers in Lake Macquarie may encourage more anglers to fish the Lake, with the potential positive benefit to the area of increased recreational fishing tackle boat sales and tourism. On a regional scale, the economic advantage may outweigh the loss of economic activity resulting from departure of some commercial fishers. A regional economic analysis would be required to quantify this issue which is beyond the scope of this report, but could be addressed through several Government Departments and/or subject to funding by Lake Macquarie Council's Economic Development Department.

If commercial fishing is reduced in the Lake, there may be the perception that recreational catches will increase, when compared with other NSW estuaries. This perception may result

in a rapid increase in the numbers of recreational anglers frequenting the Lake and the possible benefit to individual angler catches may only be short-lived.

(iii) Establish artificial reefs

Artificial reefs are structures that are deployed to increase habitat for, or concentrate populations of, fishes and other marine organisms. They may enhance the natural aquatic productivity of an area by supplying new habitats for permanently attached organisms such as algae, barnacles and mussels which then provide food for fishes. They also provide shelter for fishes in otherwise barren areas, and can act as nursery areas for small juvenile fishes (State Fisheries, 1979, White *et al.*, 1990).

Various studies have been undertaken on the effectiveness of artificial reefs (reviewed by State Fisheries, 1979 and White *et al.*, 1990) however at this stage it is still not known if such reefs actually increase the fish stocks of a region or only act to concentrate them. To some extent, the process may be area/site specific.

In Lake Macquarie, a number of experimental tyre reefs have been lain, the first in 1966, with four more in 1969/70. Some have deteriorated over time as the tyres have variously spread out, silted over, and been buried. However a barge reef at Belmont Bay is still apparently in good condition and has recently been the subject of surveys by NSW Fisheries.

The Concerned Anglers Group (CAG) have recently approached NSW Fisheries to investigate the feasibility of constructing more artificial reefs in the Lake. NSW Fisheries are reportedly pursuing the matter and will conduct further investigations on the Belmont Bay barge reef in addition to assessment of environmental impacts, liabilities and responses from other recreational users of the Lake to the placement of more artificial reefs. CAG are also undertaking to prepare a discussion paper and formal development proposals that addresses possible locations and designs, environmental and liability assessment and costs and benefits. A barge presently in Cockle Creek has been identified by CAG for use as an artificial reef. NSW Fisheries has indicated no funds are available for artificial reef construction.

The major benefits of more artificial reefs in Lake Macquarie are the potential for increased fish productivity, which could increase individual angler catches. They may provide good fishing spots in the Lake and have the potential to attract more anglers to the area, that is, to increase tourism.

However, as it is unknown whether these structures actually increase or merely concentrate number of fish, there is a potential for fish stock depletion due to concentration of angler and spear fishing pressure.

Artificial reefs can also become navigational and diving hazards and may cause conflicts over use of an area (for example with sailing). Hazards and conflicts may be overcome by careful design and public consultation regarding reef location, construction materials and type. Additionally there is the question of who is to fund artificial reefs within the Lake.

DLWC will probably charge rent for the reefs and have approached NSW Fisheries with regard to existing reefs.

(iv) Lake specific bag limits

As an option to increase or maintain individual angler catches, it may be appropriate to impose stricter recreational bag limits, rather than to apply the bag limits employed throughout NSW. This requires an amendment to current Fisheries Regulation which could take some time.

Specific local limits may result in a "better" spread of the catch among anglers and have the potential for fish stock conservation (particularly as recreational fishing effort will increase in the future). However, defining specific bag limits would first require accurate determination of fish stocks and recreational catches and such information is presently unavailable.

The introduction of specific bag limits would need to be accompanied by extensive education and enforcement, both of which would incur costs. Lake specific bag limits could also create adverse publicity for angler fishing in the Lake with a potential for a reduction in tourism to the region. It may be preferable to introduce stricter bag limits in a staged manner involving a few species only initially and as community familiarity increases, extend the concept to include a greater number of species.

(v) Greater enforcement of existing fisheries legislation/community education

A creel survey of angler catches in the Lake organised by CAG (LMCAG, 1995) suggested most anglers abided by Fisheries Regulations on bag and size limits. However, other anglers showed disregard for the regulations retaining undersize fish, while some tourists were only vaguely aware of the regulations, and inadvertently had undersize fish.

These findings point to the need for greater enforcement of regulations along with increased angler education. These actions could be beneficial to the fisheries productivity of the Lake via greater protection of juvenile fish and a reduction in the potential for angler overfishing. The potential fish stock enhancement may then lead to an increase in individual angler catches.

As with the introduction of bag limits, there could be adverse public reaction to more stringent enforcement which may result in a decrease in visiting angler numbers, ie. tourism.

Community consultation indicated that some members of the public are concerned that commercial fishers apparently do not abide by fisheries regulations (eg. setting extra nets, capture and sale of undersize fish). Greater enforcement of activities than currently occurs with only two Fisheries officers for the whole of Lake Macquarie would reduce the potential for such activities and the perception that such operations are occurring.

Increased enforcements to ensure greater adherence to fisheries regulations may not necessarily lead to a noticeable increase in fish catch. Although no data are available, it is probable that the level of the illegal fishing activities is not sufficiently great so as to result in a substantial decrease in individual angler catches.

Increased enforcement would result in a need for additional funding. The funding sources for additional enforcement officers would need to be determined.

Community education is also vital in ensuring fish stock conservation, responsible fishing attitudes (e.g. catch only what you can eat) and observance of existing/future fisheries legislation.

(vi) Establish aquatic reserves / fish sanctuaries to manage specific fishing activities

There are a number of types of protected areas, reserves and marine parks that vary in their extent of fishing restrictions, ranging from sanctuaries which have complete bans on all fishing activities to general use areas where fishing is permitted, but habitats are fully protected.

Within Lake Macquarie there are already significant areas available only to recreational fishers, where commercial fishing of various types is excluded (refer Figure 4.4). Haul netting is also totally prohibited in the northern half of the Lake. Such areas reduce the potential for use conflict between commercial and recreational fishers but disadvantage commercial fishers, with uncertain benefits to recreational fishers.

The CAG and other stakeholders have proposed a "Lake Macquarie Marine Reserve Area", or "Marine Conservation and Habitat Plan" to be developed and implemented in the Lake.

The potential ecological benefits of a Marine Reserve or Conservation Plan are significant. It could provide for habitat protection with possible subsequent increases in fish stocks and aquatic productivity recognising that many of the fish species targeted by anglers (eg. bream) migrate within/outside the Lake.

The implementation of a Conservation Plan has the added benefit of resolving conflicting fisheries sector interests in the favour of the fishery itself, for example, via the protection of key nursery grounds.

The most common form of aquatic reserves are those declared to protect the habitat of fish and other fauna by preserving areas such as seagrass beds, mangrove stands and shallow water sand banks which are essential for the maintenance of fish and prawn stocks. Such Reserves are intended as management measures to enhance rather than restrict fishing activities. Depending upon their type, aquatic reserves can be declared over Crown land, land dedicated for public purpose, leased land or private land. The consent of the landowner, lessee or relevant authorities is required.

Alternatively to the designation of various areas as reserves, a user based zoning plan (for example, similar to that used the Great Barrier Reef Marine Park) could be created specifically for Lake Macquarie. A zoning system provides various levels of resource protection and use activities depending on the management objectives for a particular management zone (see also Issue E).

Designation of areas as Fish Sanctuaries (no fishing allowed) is a further option that could be considered. Commercial fishers have expressed their support for a fish sanctuary, preferably in one of the areas where commercial fishing is presently prohibited. Such areas need to be carefully selected and a clear understanding held of the objectives and likely benefits of declaring such areas. Whilst Fish Sanctuaries have been shown to be effective in increasing

catches in adjacent areas to reef areas, their effectiveness in estuaries is uncertain as most estuarine fish species migrate within the estuary and from the estuary to coastal areas.

Reserves, or protected areas should be selected on a number of criteria, including presence of existing commercial and recreational fisheries, existing nursery areas, habitat quality and diversity, size, species abundance and diversity and existing proposed levels of disturbance.

NSW Fisheries are responsible for managing fishing activities and protection of marine plants within the Lake. NSW Fisheries priority for reserve declaration is the identification of biogeographically representative areas, and advises that Lake Macquarie is low on the list for Reserve declaration (J. Holliday pers comm).

It needs to be recognised that if NSW Fisheries introduced reserves or zones in the Lake which prevented (or restricted) fishing in an area, this would reduce the area available for fishing. This may then concentrate commercial/angler effort, decrease stocks and reduce catches. In the longer term, the beneficial impacts of the reserves on fish stocks, however, may be significant in specific areas and lead to reduced user conflicts.

The enforcement of the use of no-fishing zones (Fish Sanctuaries) or a management strategy based upon various permitted activities for specific areas may be difficult and could require additional officers.

(vii) Habitat restoration

Restoration of areas important for fish and crustaceans that are currently degraded could result in improved individual angler catches and ultimately, increased tourism. However, it is probable that large areas would need to be restored to result in a noticeable long term increase in recreational angler catch. This is particularly the case considering recreational fishing effort will increase in the future.

Whilst habitats in specific areas of the Lake have been degraded, most involve relatively small areas (eg. near stormwater drains or in selected embayments). No large areas are degraded to the extent where restoration, as a viable option, will result in a major increase in fish populations. The exception to this relates to boat mooring areas, where mooring chains cause loss of considerable areas of seagrass.

Habitat restoration works would probably best be achieved as a consequence of other management options, particularly those associated with and improving Lake water quality and/or replacement of boat mooring systems (see Issues A and F).

(viii) Monitoring/research of angler catches

The Concerned Anglers Group (CAG) and many members of the public (as evidenced by the 5000 signatures on a petition calling for a "net free lake") believe that their catches have declined significantly. However, the information gathered by NFRI (1995) on commercial and recreational fishing in Lake Macquarie over the past decades does not support that there has been a decline in recreational catches. Concerns have been expressed both by those who reviewed the information and by anglers, regarding the scientific validity of the fisheries data

reviewed by NFRI (1995) and the confidence that can be placed upon comparisons between studies conducted at different times.

One option to address this conflict may be to undertake a thorough and scientifically valid investigation of angler catches in Lake Macquarie. NSW Fisheries should be involved in such a study with the degree of their participation determined through consensus among the key stakeholders, including Council.

As noted previously, several fisheries related studies are being conducted in Lake Macquarie, however none are specifically directed towards assessing or managing the commercial and/or recreational fisheries of the Lake (Section 4.3).

Monitoring of recreational fisheries by fisheries management agencies is undertaken in other countries (eg. USA) generally with regard to stocked or declining fisheries. However, such programs need to be long term (eg. 3-5 years) and have significant funding to provide information of direct value to fisheries management. Most recreational fisheries studies completed in NSW tend to be short-term creel surveys.

Whilst this option could be expensive (a significant ongoing monitoring exercise would be required to provide quantitative data), it would offer considerable benefits in terms of assessing the effects of fisheries management options adopted for the Lake.

6.4.2 Issue I - Haul Netting

Haul netting is considered by many recreational fishers and residents to result in damage to seagrass beds and the capture of large numbers of juvenile fish. Management options which address this concern include:

(i) Do nothing.

(ii) Phase out haul netting.

(iii) Rotate haul netting areas.

(iv) Commercial fishers establish public education program.

(v) Aquatic Reserves/Fish Sanctuaries.

I. Issue - Haul Netting

(i) Do nothing

Haul netting is an issue of significant public concern. There is the perception that haul netting damages Lake fish stocks and habitats. However, the available scientific data on impacts of haul netting indicates that haul netting does not damage seagrass beds and that levels of juvenile fish deaths are low (see Section 4.3.2 for more detail). Unless this issue is addressed and incorrect perceptions rectified, the existing conflict between commercial and recreational fishers will continue. Potentially, continuation of conflict could result in reduced tourism as the Lake could be perceived as a poor place for anglers.

(ii) Phase out haul netting

This option is strongly requested by recreational fishers of the Lake, as evidenced by 5000 signatures on a petition calling for a "net-free Lake". For some commercial fishers who undertake haul netting as a part of a varied fishing operation, phasing out of haul netting would make their operations unviable. Some members of the Lake Macquarie Commercial Fishing Industry, have however indicated their willingness to allow buy-outs of their licenses.

The majority of the advantages and disadvantages for this operation are as for Issue H (buy-out of commercial fishing licenses, option ii).

(iii) Rotate haul netting areas

By rotating areas available to haul netting there would be a reduction in any perceived localised impacts of the practice. However, as noted previously, NSW Fisheries advise that haul netting does not damage seagrass beds.

This option, though, has the potential to create confusion between commercial and recreational fishers and also with other recreational users of the Lake as it could be difficult for some to easily ascertain whether an area was "open" or "closed". Additionally, it could reduce the landings of haul netters as fish schools may not be present in the "open" area. It would also incur additional costs and difficulties associated with education of commercial fishers, the public and enforcement for relatively few environmental or fisheries benefits.

(iv) Commercial fishers establish public education program

The practice of haul netting may, to some members of the public, appear much more destructive than it necessarily is. For example, the capture of large numbers of mullet or biddies (the major species captured by haul netters and which are not taken by anglers), may cause concern. Additionally, the hauling of nets over seagrass beds is often incorrectly assumed to damage the seagrass. These perceptions could be addressed via a community education program organised by the Commercial Fishing Industry in conjunction with NSW Fisheries. This option could result in better informed anglers and public, with a subsequent reduction in animosity towards commercial fishers by some sections of the public. However, the extent of its benefits to the commercial fishers is difficult to gauge. It would require a

concerted effort by the Commercial Fishing Industry, and would undoubtedly involve costs. The proposed release of scientific studies on this issue by NSW Fisheries will undoubtedly be beneficial.

(v) Aquatic Reserves/Fish Sanctuaries

The implementation of a system of Reserves to manage fishing activities (see Issue H) could consider involving management of haul netting areas (from a fisheries perspective) alongside ecological management (see issues E and F). This may reduce conflict with the other users of the Lake.

6.4.3 Issue J - Selenium and Heavy Metal Contamination in Sediments and Biota

The issue of selenium and heavy metals in Lake Macquarie seafood has been addressed by a study which has recently been undertaken (see Section 4.3.3). The results of that a risk assessment subsequent to that study indicate that selenium levels in fish are high and that consumers should limit their fish intake. Provided excessive quantities of fish are not regularly consumed over a long period, no adverse health effects are likely. However, only fish tissue should be consumed, internal organs should not be consumed and fish should be used for soup stock. Management options are therefore:

(i) Do nothing - leave contaminated sediments undisturbed.

(ii) Remove contaminated sediments via dredging.

(iii) Implement further controls on contaminant inputs.

It should be noted that these management options address heavy metal/selenium contamination of all biota, but have been developed particularly to ensure the protection of health of fish consumers, as this was identified to be an issue of high community concern.

J. Issue - Selenium and Heavy Metal Contamination in Sediments and Biota

(i) Do nothing - leave contaminated sediments undisturbed

The thickness of the contaminated sediment layer in affected areas of the Lake varies from 150 to 350 mm (AWACS, 1995). The AWACS report suggested that much of the sediment contamination in the Lake is a legacy of past industrial activities. However, in some areas such as Cockle Creek, discharge of contaminants still occur (for example, from Pasminco Metals Sulphide Smelter), albeit with controls on contaminant inputs in place, with inputs reduced by more than ten fold of past inputs.

Environmental problems can arise when contaminated sediments are disturbed. Buried heavy metals are available only to those marine organisms that actively disturb and/or bioturbate the sediment layers. Selenium can also be available to organisms which reach down to the subsurface sediments, such as some bottom feeding fish, shellfish, benthic animals and seagrass roots. With on-going sediment accretion, these buried contaminated sediments become less available.

When contaminated layers are disturbed (eg. by dredging), brought to the sediment surface and into direct contact with water, metals may be remobilised and enter the water column. As the metals move from the sediments to the water they often also become more toxic as their state changes and they become available to a wide range of aquatic organisms (Goosens & Zwolsman, 1996). This has the potential to cause greater pollution problems to the aquatic environment than if the contaminated sediments are left buried and undisturbed.

Assessment of suitable areas for disposal of the contaminated sediments also needs to be considered. The presence/absence of potential acid sulphate soils would need to be determined prior to dredging as disposal of such soils needs to avoid prolonged exposure to air to prevent the generation of acid waters, which are toxic to aquatic biota.

In areas of the Lake where discharges containing heavy metals are still occurring (albeit in reduced levels), it may be advisable to do nothing and leave the sediments undisturbed. Repeated dredging may be necessary in these areas, which could cause greater environmental problems than if the sediments remain undisturbed.

(ii) Remove contaminated sediments via dredging

There is evidence that some of the contaminants entering Lake Macquarie are accumulating in marine organisms, such as zinc, lead and selenium in seagrass (*Zostera capricorni*), cadmium and selenium in cockles (*Andara trapezia*) and selenium in some fish in the Lake. Removal of contaminated sediments would prevent such bioaccumulation. However, as noted above, contaminant removal operations need to be carefully considered as they may result in adverse environmental effects (eg. as a result of resuspension of heavy metals), both to the Lake and potentially in disposal areas.

It is unclear whether sediments contaminated with selenium are contributing to water quality degradation or selenium levels in biota. An investigation into the influence of these sediments

is also needed before an assessment is made of whether dredging is an appropriate management option.

In areas of the Lake where there are no discharges of contaminants into the Lake waters, either currently or likely in the future, removal of contaminated sediments by dredging may only need to occur once and is an option worth consideration, as the potential pollution problems would be limited to one event. Identification, assessment and prioritisation of contaminated areas could be performed as part of a dredging strategy for the Lake (refer Issue L).

(iii) Implement further controls on contaminant inputs

As noted in Section 6.3 (Issue A), there is considerable community pressure to reduce the level of pollutant input to the Lake. There have been reductions in some pollutant inputs to the Lake, with most sewage now discharged to the ocean. Pasminco has and continues to decrease pollutant discharges and ash dam waters are being recirculated. Reduction or complete removal of contaminant inputs would ensure the long term viability of the Lake ecosystem. Potential problems that may arise from bioaccumulation and associated health risks would therefore be avoided.

This option would require the cooperation of relevant industries, could be enforced by the EPA, perhaps supported by Council in the process of development approval, and would probably involve a considerable cost associated with treatment of industrial effluents. This was the approach recommended by the recent study on heavy metal and selenium contamination in Lake Macquarie's seafood (HPHU, 1997).

6.5 Management Options for Public Amenity Related Issues

<u>Management Aim</u>: *To maintain and enhance the public amenities of Lake Macquarie, including prevention foreshore erosion around the Lake.*

The public amenity issues that have been identified in this Study through the process of information review, community consultation and liaison with Government Departments are:

- foreshore erosion (Table 6.4K);
- excessive sedimentation (Table 6.4L);
- removal of algae and seagrass in foreshore recreational areas (Table 6.4M);
- dead seagrass/algae accumulation on foreshores (Table 6.4N); and
- litter/pet faeces (Table 6.4P).

A range of management options exist for each of these public amenity issues identified. For each management option, advantages, disadvantages, cost and level of community acceptance for each management strategy are summarised and presented in Table 6.4, with more detailed discussions following the relevant sections of the table.

6.5.1 Issue K - Foreshore Erosion

Foreshore erosion results in a loss of waterfront land and public and private assets that typically have conservation, recreational and economic values. Foreshore erosion can additionally result in increased sediment loads to adjacent areas, typically to the detriment of aquatic ecosystems in these areas.

Erosion of foreshores is of concern in many areas of the Lake including Marmong Point (some rehabilitation works have recently been undertaken), Croudace Bay, Marks Point and some southern areas of the Lake. Areas which have been identified by WBM Oceanics Australia, Lake Macquarie City Council and the public to experience foreshore erosion problems are illustrated Figure 6.1.

(i) Do nothing.

(ii) Identify foreshore areas experiencing erosion and assess the need for remedial works.

(iii) Reduce boat speed in sensitive areas/prohibit illegal boat ramps.

(iv) Enhance and maintain foreshore vegetation.

(v) Community education.

(vi) Revetment works, groynes, foreshore stabilisation and other management methods.

K. Issue - Foreshore Erosion

(i) Do nothing

Allowing existing foreshore erosion processes to continue is not considered to be a viable option. Foreshore erosion results in a loss of waterfront land and public and private assets that typically have conservation, recreational and economic values. Foreshore erosion can additionally result in increased sediment loads to adjacent areas, typically to the detriment of aquatic ecosystems in these areas.

Erosion of foreshores is of concern in many areas of the Lake including Marmong Point (some rehabilitation works have recently been undertaken), Croudace Bay, and Marks Point as shown in Figure 6.1.

(ii) Identify foreshore areas experiencing erosion and assess the need for remedial works.

This will ensure works are performed in a systematic and cost effective manner. Prioritisation for remedial works should include consideration of the rate of erosion, the recreational and ecological amenity, the zoning/value of eroding ares, the proximity to significant seagrass areas and the cause of erosion.

(iii) Reduce boat speed in sensitive areas/prohibit illegal boat ramps

Speed limits for boats and prevention of boat landings in the vicinity of eroded and sensitive foreshore areas would reduce foreshore erosion. However, it could generate conflict with some water based recreational activities, such as jet and waterskiers. As such the opinions of all stakeholders need to be taken into consideration. The Waterways Authority could be approached to implement speed limits or no-wash areas for regions of the Lake, where this issue is of concern.

(iv) Enhance and maintain foreshore vegetation

Enhancement and maintenance of foreshore vegetation would result in a reduction in foreshore erosion. Revegetation could be undertaken in key foreshore areas (both from an ecological, visual and recreational point of view), though it would involve costs and decisions as to establishment and maintenance works (eg. community groups, Council and State Government).

(v) Community education

Education of the community could reduce foreshore eroding activities and prevent erosion from human activities.

(vi) Revetment works, groynes, foreshore stabilisation and other management methods

A wide variety of engineering techniques are available for foreshore stabilisation and protection, such as rock revetments, groynes, bank stabilisation etc. These may be expensive to install, but do not require the same level of maintenance as vegetation. However, many revetment structures (primarily used for public land and reserves) are less aesthetically appealing than natural vegetation and particular emphasis needs to be placed upon the visual values of the foreshore area (see Appendix D). Other options for foreshore stabilisation (eg. beach reworking/shaping/renourishment etc) may be more appropriate in areas with high visual values.

6.5.2 Issue L - Excessive Sedimentation (Public Amenity)

This issue has been previously raised in a water quality context (refer Issue B), however excessive sedimentation in the Lake is also a public amenity issue. The issue of siltation in the Lake was given the highest aggregate score during the community consultation workshop (refer Appendix A). Excessive siltation results in limited navigational access, decreased visual and recreational amenities, in addition to water quality and ecological impacts.

Many areas which are experiencing excessive sedimentation problems have been identified by WBM Oceanics Australia, Lake Macquarie City Council and the community. The concerns raised were frequently related to the decreased public amenity caused by the siltation, as well as water quality and ecological concerns. Examples of the particular areas identified are shown on Figure 6.1 (marked with the letter L) and these areas include:

- Cockle Creek;
- Black Neds Bay;
- Toronto and Fennell Bay;
- Kooroora Bay;
- Speers Point and Warners Bay;
- Croudace Bay (mouths of North, South and Shepherds Creeks);
- Belmont Bay;
- Secret Bay, Balmoral;
- Gwandalen;
- Myuna Bay; and
- Swansea.

Many of these areas are experiencing sedimentation due to urban runoff.

The Lake Macquarie Estuary Management Plan (to be prepared following the completion of the Estuary Management Study) will focus on areas with particularly severe problems, such as the Fennell Bay/Edmunds Bay area, and provide guidance on how the management strategies identified can be implemented in these impacted areas. The management options for consideration in this issue of sedimentation in the Lake (from a public amenity perspective) are:

i) Do nothing.

ii) Dredge shoaled areas and reduce the sediment loads entering the Lake.

L. Issue - Excessive Sedimentation.

(i) Do nothing.

As outlined previously in Issue B (refer Section 6.2.2), the absence of any action to address the high sediment load to the Lake will cause continuing sedimentation problems and increasing community dissatisfaction. Continuing sedimentation in the Lake would eventually adversely impact on the Lake's ecology (particularly seagrasses), water quality, restricting navigation to some areas of the Lake, visual amenity and as well as recreational amenity. This would subsequently affect the recreational value of the Lake and this could have adverse economic impacts, due to reduced tourism, land prices etc.

(ii) Dredge shoaled areas and reduce the sediment loads entering the Lake.

As previously discussed, water quality modelling simulations of Lake Macquarie have shown that pollutants from urban stormwater inputs are degrading the water quality of Lake Macquarie (refer Appendix B). Treatment of urban stormwater could improve the water quality in Lake Macquarie as well as removing large amounts of sediment from urban stormwater. Options discussing specific management strategies to improve stormwater quality and decrease sediment loads to the Lake have been previously discussed in more detail in Section 6.2. Management strategies which are expected to reduce the sediment load to the Lake include further community education, expansion of existing catchment management strategies, better regulation of Council's Erosion and Sediment Control Policy and installation of additional pollution treatment devices (such as GPT's and wetland filters).

Lowering the sediment load to the Lake will not be sufficient in isolation to address the existing sedimentation problems in the Lake. Dredging to remove accumulated sediment may also need to be considered to restore public amenity values in some areas (such as navigational access, visual amenity and flushing in some shoaled creeks). Problems with sediment properties would need to be addressed in areas with actual or potential acid sulphate soil characteristics, and in some areas with possibly contaminated sediments (particularly Cockle Creek and some heavily urbanised catchments). This issue of contaminated sediments is discussed in Table 6.3J, Section 6.4.

To ensure dredging is most effectively performed, some dredging guidelines and a dredging strategy need to be developed by Lake Macquarie City Council and/or EPA. These guidelines and/or a dredging strategy need to address the issue of prioritising dredging of creeks and monitoring requirements. Monitoring is important to prioritise areas requiring dredging and to assess the efficiency of management actions to lower sediment loads. Initially, dredging works could be scheduled for the areas with the highest rates of siltation, such as the Fennell Bay/Edmunds Bay area. These guidelines should also consider the issue and problems associated with the removal/disposal of contaminated sediments and potential acid sulphate material.

Dredging addresses one of the immediate problems (ie. improving navigability), but does not address the cause of the problem or prevent the problems from recurring. Therefore, a

combination of dredging and lowering of sediment loads to the Lake is the optimal management strategy to restore and protect public amenity values.

6.5.3 Issue M - Seagrass and Algae Removal from Foreshore Recreational Areas

In some parts of the Lake large amounts of seagrass and algae proliferate. Seagrass/ algae beds are considered to be unpleasant swimming areas and accumulated material in subtidal may result in increase sedimentation in the Lake. Some residents actively remove foreshore areas of seagrass and algae to create sandy beaches adjacent to their properties. Seagrass removal without a permit (issued under the Fisheries Management Act 1994) is illegal as all marine vegetation is protected. Unmanaged removal activities could adversely affect Lake productivity. Management options regarding this issue are as follows:

(i) Do Nothing.

(ii) Managed removal of live seagrass and algae.

M. Issue - Seagrass and Algae Removal from Foreshore Recreational Areas

(i) Do Nothing

Unless management options are defined to address the issue of seagrass and algae in foreshore recreational areas, it is likely that the existing pattern of illegal and uncontrolled removal will continue to occur. This is of particular concern as the number of persons using the Lake for recreational purposes will only increase in the future. A management strategy needs to be clearly defined to avoid uncontrolled removal and to ensure an appropriate strategy is in place so that if removal is deemed necessary, it can occur with minimal environmental impacts.

(ii) Managed Removal of live seagrass and algae, only in major recreational foreshore areas

The fringing growth of seagrass in shallow waters, as occurs extensively throughout the Lake, is not always seen as compatible with the desired recreational use of the foreshore. The option of seagrass removal in some main recreational areas may be appropriate, if the area removed is as small as possible, and it does not occur in areas of key ecological significance, such as the seagrass beds near to the Lake entrance. Allocation of an ongoing budget for such management activities would also need to be addressed.

Not all seagrass areas are likely to be of equivalent ecological value. For example, Hannan (1989) found that areas of seagrass beds that had low levels of juvenile fish recruitment were in the south-west corner of the Lake, that is Vales Point, Chain Valley Bay and towards Bonnells Bay. Prior to any approval for seagrass removal, confirmation of the fisheries value of specific seagrass areas would be necessary.

The advantage of seagrass removal would be to increase the value of the shallow subtidal area for recreation, as sandy substrates are preferred by swimmers to seagrass beds. However, it needs to be recognised that the loss of significant areas of seagrass will reduce fisheries productivity and as such be detrimental to the aquatic ecosystem of the Lake.

Seagrass removal may be appropriate in areas where seagrass has established as a result of alterations to natural processes. For example, seagrass has recently established in some areas (eg. Edmunds Bay) as a result of excessive sedimentation. Seagrass results in further sedimentation by slowing current velocities and could ultimately result in subtidal areas becoming intertidal. Mangroves may establish in such areas and prevent boating access/recreational activities. Removal of selected areas of seagrass may be beneficial in such areas, with regard to recreational activities, providing removal is carefully planned and managed.

Clearly, this issue would need to be discussed further with NSW Fisheries with regard to specific areas and the benefits (both social and environmental) evaluated prior to applications being made for seagrass removal permits.

6.5.4 Issue N - Accumulation of dead seagrass/algae on beaches

Wind and waves cause dead seagrass and algae to accumulate on beaches. Large amounts of seagrass and algae on beaches limits recreational activities and rotting vegetation may result in offensive odours. Management options which address this issue include:

(i) Do nothing.

(ii) Remove accumulated seagrass/algae from beach areas.

N. Issue - Accumulation of Dead Seagrass/Algae on Beaches

(i) Do nothing

Failure to remove accumulated seagrass/algae will continue to limit the recreational amenity of beaches. This issue is likely to become of greater concern as recreational usage of the Lake will increase, as a result of population growth.

Council does remove dead seagrass/algal material in some areas already, and removed material is mulched. It may also be an option to allow members of the public to remove dead seagrass in designated areas, (see comments below) mulch it using Council's recommended methods and apply it to their own private gardens. Other beneficial uses for the material could also be investigated.

(ii) Remove accumulated seagrass/algae from beach areas.

Further removal of dead seagrass/algae from beaches would be beneficial in that it increases beach recreational amenity and reduces potential odour problems associated with rotting material. Removal is unlikely to result in adverse ecological effects (although relatively little data is available in this regard), provided it is undertaken using techniques that do not damage beach/foreshore integrity. Previous uncontrolled and irresponsible removal of weed have resulted in damage to some foreshore areas in the past. Manual removal would be preferable.

Given the uncertain ecological role/value of accumulated seagrass/algae, there would be considerable benefits in commissioning a study to assess this issue.

In some areas these masses of algae/seagrass form a barrier protecting the foreshore from wave and wind erosive action. Therefore, careful consideration should be given to areas of removal, possibly leaving accumulated seagrass/algae in areas particularly sensitive to foreshore erosion. Additionally, it maybe ecologically beneficial to leave smaller areas of build-up, which do not affect recreational activities. These areas provide habitat for invertebrates and could contribute to the Lake's ecosystem.

Appropriate disposal locations for removed material need to be identified. Recycling of the dead seagrass material (eg. composting for mulch) is one beneficial use for the removed material (which is presently done).

6.5.5 Issue P - Litter/Pet Faeces

Litter decreases the visual amenity and recreational and tourism value of the Lake and its foreshores. Faecal contamination may affect water quality and ecology in the Lake, particularly in localised areas. Unremoved faecal material also decreases visual amenity. Management options which address this issue include:

(i) Do nothing.

(ii) Install Gross Pollutant Traps (GPT's) at key locations.

(iii) Public education and clean-up campaign.

(iv) Encourage/enforce catchment management policies in the catchment to reduce litter/faecal loads to the Lake.

P. Issue - Litter/Pet Faeces

(i) Do nothing

Council currently does address this issue by giving out penalty notices for littering and dog faecal contamination. Litter significantly degrades the visual appeal of the Lake in some locations. In extreme cases, litter can adversely affect Lake ecology (eg. shading and contaminant inputs) and reduce recreational activities. This issue is particularly important to residents who live on the Lake foreshores. Faecal material from pets (particularly dogs) in the catchment decreases visual amenity of parks and increases bacterial loads to the Lake.

The community are unlikely to accept a management option which involved the acceptance of existing litter and pet faeces problems.

(ii) Install Gross Pollutant Traps (GPT's) at key locations.

This issue has been previously discussed in Section 6.2 on water quality management. A pilot project on litter interception devices (grates and baskets) was undertaken by Newcastle University and Lake Macquarie City Council during 1996. The project which was carried out at Toronto, indicated that baskets were more efficient than simple grates over the stormwater sump. Both methods had a very high maintenance burden and for this reason it was recommended that existing street sweeping programs be expanded. GPT's would remove litter (but not pet faeces) from stormwater entering the Lake.

(iii) Public education and clean-up campaign.

This issue has been previously discussed in Section 6.2 on water quality management. Public education on the sources of pollution, and prevention strategies which should be adopted to reduce pollutant loads may be sufficient for many to alter their attitudes and actions. Encouraging more community and State Government groups (such as Streamwatch) in the catchment may increase the sense of ownership over the Lake and can be an effective strategy to further educate the catchment community.

Introduction of measures such as biodegradable bait bags and other innovative/environmentally friendly consumer products could be investigated and promoted by community groups, government authorities and/or Council.

Further encouragement for dog owners to clean up after their pets, and provision of additional disposal bins in more dog recreation areas, may decrease the faecal load entering the Lake. The use of street sweepers to remove litter could be increased, to reduce litter loads entering the Lake, or Community Service Order Teams could be utilised to collect litter. Council could possibly increase their level of surveillance with respect to the issue of penalty notices (refer Option (iv)).

(iv) Encourage/enforce catchment management policies in the catchment to reduce litter/faecal loads to the Lake.

The community would be more likely to adopt catchment management practices (outlined above) and Council regulations against littering and dog faecal contamination, if they were better enforced (eg. by the more frequent issuing of fines). This would require additional resources to be allocated by Council for stricter enforcement of these regulations than is presently being done.

Figure 6.1 Locations of Some Site Specific Management Issues

6.6 Discussion of Options and Strategies

As presented in the previous sections, there is a range of options to address the various management issues and often there is an interaction between one management option and another management issue. In addition, there are varying degrees of 'urgency' between the issues. Accordingly, there is a need to consider the interactions and combinations of options as well as priorities during the preparation of the Management Plan. The following discussion is presented to give some further guidance as part of this consideration process.

Water Quality

Many of the estuaries in eastern Australia are experiencing pressures from increasing urbanisation of their catchments, which result in conflict of uses, sedimentation and deteriorating water quality. Lake Macquarie generally maintains good water quality and shows few of the water quality problems that other estuaries are presently experiencing. However, unless effective management strategies are implemented for the Lake, water quality will deteriorate. Increasing Lake catchment populations will result in:

- greater modification of the Lake's catchment (eg. clearing of vegetation, more impervious areas, construction of roads), leading to additional stormwater input (and associated pollutants) to the Lake. This increase in pollutant loads to the Lake will result in a greater potential for water quality deterioration. Deteriorated Lake water quality will result in degraded conditions for aquatic flora/fauna and reduced recreational/visual amenity. Sediment carried by stormwater to the Lake also has the potential to affect aquatic ecosystems (eg. by smothering seagrass, degrading sediment quality, and decreasing water clarity);
- greater use of the Lake for recreational purposes, increasing the potential for adverse impacts on the Lake ecology (eg. boat mooring damage, litter inputs, additional petroleum hydrocarbons from motorboats) and conflict between users of the Lake (eg. between commercial and recreational fishers); and
- increased nutrient loads to the Lake, which can lead to algal blooms and ecosystem deterioration.

The key focus of Lake management should therefore relate to managing the potential water quality impacts associated with past and future population growth in the catchment, as this would ensure many of the ecological, fisheries and recreational values of the Lake are maintained at existing levels.

Various management options are presented in this report with respect to water quality. Those most likely to be of greatest value (eg. those relating to the management of urban stormwater) would require substantial funding, although some options with lower capital costs (eg. public education) could be of considerable benefit. Funding of water quality management options would have direct benefits to the Lake's ecology and fisheries.

Ecology and Marine Reserves

The community places particular emphasis on protecting aquatic habitats (eg. seagrass, mangroves) recognising that this is crucial to ensuring the Lake remains a sustainable recreational and fishing area. Numerous suggestions were made during public consultation that areas of the Lake be declared Marine Reserves, designated for specific uses, or similar.

This approach has considerable merit and several management options are available for its adoption. The key issues to be considered in reviewing these options are determination of the objective of the Reserve declaration and the designation of a relevant Responsible Authority. For example, NSW Fisheries is the managing agent for aquatic reserves in NSW which are declared to provide biogeographically representative areas for protection. NSW Fisheries advises that the Lake is of low priority in terms of designation for a Reserve.

However, there may be other mechanisms/procedures that could be used to manage activities that are detrimental to the ecological resources of the Lake. The high fisheries/environmental value of seagrass beds, the extensive areas of seagrass present and their susceptibility to a variety of Lake uses (eg. boating, mooring, stormwater discharge) implies that this habitat type should be considered as highest priority for protection mechanisms, additional to these afforded by the Fisheries Management Act. Considerable community support was evident for a form of user based strategy for conservation of seagrass beds (eg. jetskis, mooring). This issue needs to be pursued further with regard to the relevant responsible authority, regulatory mechanisms, enforcement procedures, etc. as it has not been adopted previously for NSW seagrass beds.

Fisheries

One of the key issues raised in community consultation was the concern expressed with regard to commercial fishing activities in the Lake and the perceived linkage between such activities and declining individual angler catch rates. This issue needs to receive urgent attention as it is resulting in conflict between the fishing sectors.

Individual angler catch rates are declining in most estuaries of New South Wales. This, to a large extent, relates primarily to population growth, as recreational fishing effort is increasing at a rapid rate, in conjunction with population growth.

Habitat degradation is also likely also to have contributed to declining catch rates. Environmental enhancement activities (including water quality improvement options) presented in this report would be of benefit in this regard.

In contrast, commercial fishing activities in most estuaries have generally decreased. Within Lake Macquarie, the number of commercial fishers has decreased over the past few decades and landings have been similar for a significant period of time.

Options are presented in this Study to increase angler catch rates. These include reducing commercial fishing operations and controls on recreational catches. A reduction in

commercial fishing effort via license buy-out is favoured by a significant proportion of the recreational fishing community and could be accepted by some commercial fishers. However, quantification of the benefits to recreational fishers is difficult.

The key issues to be resolved with this option are buy-out values and funding sources. In assessing this option it needs to be appreciated that any increase in angler catch rates, due to reduced commercial fishing activities, will be short-term (probably less than five years), due to population growth unless recreational fishing is limited. The most appropriate option to manage recreational fishing would appear to involve bag limits specific to the Lake. This would require amendment of NSW Fisheries Regulations, which could take some time.

Several public submissions proposed that a system of Reserves or similar be adopted whereby areas of the Lake could be designated for specific fishing activities (eg Fish Sanctuaries) to compliment existing regulations (eg. areas of the Lake are presently closed to various types of commercial fishing activities and a weekend closure is present). This approach has benefits in terms of conserving the Lake's fish stocks and needs to be pursued further with NSW Fisheries, which is responsible for management of fisheries within the Lake. This management option should be integrated with the option (Issue E Option (ii)) to develop a user based strategy for the conservation of seagrass areas within the Lake (eg boat mooring, jetskis) and reassess haul netting activities (Issue I Option (v)).

Foreshore Erosion and Public Amenity

Public amenity issues, except for excessive sedimentation, were identified by the community during the liaison process associated with this Study as being of lower priority than water quality, ecology and fisheries on a Lake-wide basis. However, public amenity issues are of considerable importance in specific areas (eg. areas where dead seagrass accumulates and foreshore erosion). Such areas need to be identified (this Study has defined some, but not all, areas) and the management options defined in this report evaluated with respect to those specific areas. Foreshore erosion causes the loss of waterfront land, which has conservation, recreational, ecological and economic values.

Excessive sedimentation is considered to be both a public amenity and a water quality issue. Management options which address high sediment loads to the Lake will also reduce the continuing sedimentation problem which particularly affects the public amenity of creeks and delta areas. Although water quality management strategies will decrease future sedimentation problems, restoration of public amenity values will be required in some areas. This could be achieved by dredging. This dredging is therefore required from a pubic amenity perspective, rather than a water quality improvement perspective. Dredging will only provide limited water quality benefits, but will address this loss of public amenity in particular areas (eg. Fennell Bay/Edmunds Bay area).

6.7 Monitoring

WBM Oceanics Australia, Lake Macquarie City Council, environmental reports prepared for this region and other interested parties have all indicated that water quality and the ecological "health" are key issues for Lake Macquarie. Many other issues relate either directly or indirectly to the water quality and ecological health of the Lake. Therefore, monitoring of the Lake and tributary water quality and ecology is recognised to be an important component of Lake management. Monitoring of the Lake will allow the status of the Lake to be examined and the success of management strategies to be assessed.

In recognition of the importance of water quality monitoring in Lake Macquarie, the Lake Macquarie Estuary & Coastal Management Committee established a working group to investigate the monitoring requirements of the Lake. This working group was aware of the need for monitoring of the estuary and catchment health, as well as monitoring the water quality in the Lake. WBM Oceanics Australia were invited to participate in this working group, which includes representatives from the following organisations:

- ◊ Lake Macquarie City Council;
- ◊ Lake Macquarie Estuary & Coastal Management Committee;
- ◊ Lake Macquarie Catchment Management Committee;
- ◊ EPA;
- ◊ DLWC;
- ◊ NSW Fisheries;
- ◊ Streamwatch;
- ◊ Pacific Power;
- ◊ Eraring Power Station;
- ◊ Hunter Water Corporation;
- ◊ Delta Electricity; and
- ◊ Pasminco Metals Sulphide.

This working group was formed to discuss such issues as the various objectives of a Lake Macquarie monitoring program, parameters to be measured, measurement locations and appropriate implementation strategies for the Lake monitoring program. The objectives of the monitoring program determine the other factors listed. Various objectives which were considered by the working group included:

- Overall Health of the Estuary and Catchment - routine and event monitoring throughout the Lake and in the Lake's catchment for a range of standard parameters. This data will provide baseline monitoring data;
- Evaluation of Impacts/Management Options - locations, sampling frequency and parameters to be tested will depend on specific impacts/options being assessed;

- Design monitoring - to determine if design techniques/methods are appropriate;
- Incident Investigation - procedures need to be in place such that events/incidents can be monitored without delay; and
- Environmental Promotion and Community Awareness - monitoring to address community concerns, may be performed by community groups or other organisations with the intention of publishing the data to the community regularly.

Recommendations for a water quality monitoring program to address these points will be detailed in the Estuary Management Plan.

7 CONCLUSIONS

This report presents the Estuary Management Study for Lake Macquarie. Management options are presented for consideration in preparation of the Estuary Management Plan. The Estuary Management Plan will identify preferred management options and discuss how these preferred options can be implemented. Community consultation has played a key role in the Study, particularly in the identification of issues and consideration of options.

The key issues associated with Lake management relate to :

(a) Water Quality

- degraded Lake water quality;
- excessive sedimentation;
- poor community attitudes to Lake water quality; and
- selenium inputs.

(b) Ecology

- decline in area of seagrass;
- wetland conservation; and
- thermal discharges.

(c) Fisheries

- reduced individual angler catches;
- haul netting; and
- selenium and heavy metal contaminants in biota.

(d) Public Amenity

- foreshore erosion;
- excessive sedimentation;
- live seagrass and algae removal from foreshore recreational areas;
- accumulation of dead seagrass/algae on beaches; and
- litter/pet faeces.

The majority of these issues have arisen as a result of the population growth and consequent increased urbanisation of the Lake catchment and use of the Lake for recreational purposes. The issues are likely to become of greater community concern as population growth continues, unless appropriate management strategies are adopted.

Management strategy options have been identified for each of the above issues. Implementation of strategies for improving Lake water quality will have direct benefits to the

Lake's ecology and fisheries (ie. water quality works would address more than one issue). Many of the water quality management options are associated with the improvement of urban stormwater quality and management of increased population growth in the catchment.

Issues relating to fisheries are primarily associated with declining angler catch rates (a phenomenon common to many NSW estuaries). This had led to conflict between commercial and recreational fishers. This issue needs to receive urgent attention and options are presented in this report. A key aspect of resolving this issue will be an acceptance by recreational fishers that their numbers/fishing effort are increasing and unless fishing activities are managed, angler catch rates will decrease further.

Implementation of many of the management options described in this report may be difficult due to overlapping jurisdiction/responsibilities of Government Departments and Local Authorities and funding considerations. In the former regard, the benefits of enhancing collaboration between the management agencies needs to be considered (see Section 5). Funding considerations of the various management options will also require consideration, as many of the management options will require long term funding commitment.

The ranking of preferred options, implementation strategies and funding considerations will be considered during the development of the Lake Macquarie Estuary Management Plan.

8 REFERENCES

ANZECC, 1992. Australian Water Quality Guidelines for Fresh and Marine Waters.

AWACS, 1995. Lake Macquarie Estuary Process Study. Report 94/25 prepared for Lake Macquarie City Council.

Brisbane Water Plan of Management (1995). Prepared for Gosford City Council, NSW.

Conroy, B.A., Lake, P. Buchhorn, N., McDouall-Mill, J. and Hughes, L. (1991). Studies on the effects of heavy metals on seagrass in Lake Macquarie. (pp 55-65). *In* : Whitehead, T.J.; Kidd, R.W. and Bridgman, H.A. (1991). Lake Macquarie. An Environmental Reappraisal Review Seminar, University of Newcastle

Delta Electricity (1996). Vales Point Power Station, Ash Dam Long Term Strategy Report. August 1996. Vales Point Power Station, NSW.

Goossens, H. and Zwolsman, J.J.G. (1996). An evaluation of the behaviour of pollutants during dredging activities. Terra et Aqua, 62, 20-28.

Hannan, J. (1989). Seagrass fish fauna of Lake Macquarie. Masters Thesis. School of Marine Science, University of NSW.

Hunter Public Health Unit (1997). Heavy Metals in Seafood in Lake Macquarie: A Cross-Sectional Survey.

King, R.J. and Hodgson, B.R. (1986). Aquatic angiosperms in coastal saline lagoons of New South Wales. IV Long term changes. Proc. Linn. Soc. NSW 109, 1, 51-60.

Kearney, R.E. (1993). Tailor stocks need further research. The Queensland Fisherman, March 1993.

Laegdsgaard, P. (1996). The ecological significance of subtropical mangrove habitats to juvenile fish. PhD. Thesis. The University of Queensland.

LMCAG. Lake Macquarie Concerned Anglers Group (1995). Creel Survey of Recreational Catches in Lake Macquarie.

Lake Macquarie City Council (1993) Lake Macquarie City 1993 State of the Environment Report, NSW.

Marshman N and Hodgson B. (1991) Thermal discharges from power stations to Lake Macquarie. (pp 9-16). *In* : Whitehead, T.J.; Kidd, R.W. and Bridgman, H.A. (1991). Lake Macquarie. An Environmental Reappraisal Review Seminar, University of Newcastle.

Mele, A. (1993) Polluting for Pleasure. W.W. Norton & Company Inc.

Negarestan, H (1993). A comparison among benthic macrofauna in three environments around Vales Point Power Station, Lake Macquarie. M.Sc. Thesis - University of New South Wales.

NFRI (New South Wales Fisheries Institute) (1995). A review of the information on the factors affecting the fisheries of Lake Macquarie.

NSW Government, 1992. Estuary Management Manual.

NSW State Fisheries (1979). Guide to Artificial Reefs. Leaflet No. 6. NSW Government Printer.

Pollock, B.R. (1984). Management of the fishery for yellow-fin bream. In: Focus on Stradbroke. (eds. R.J. Coleman, J.C. Covacevick & P. Davie) Boolarong Publications, Brisbane, pp 348-355.

Roberts, B. (1994). The accumulation and distribution of selenium in fish from Lake Macquarie, NSW. Honours Thesis. Applied Science, University of Canberra.

Scanes, P (1988) The impact of Eraring Power Station on the fish and fisheries of Lake Macquarie. NSW Fisheries Institute. Report prepared for Electricity Commission of NSW.

Sidabutar, T (1992). Zooplankton in the cooling field and in the vicinity of Vales Point Power Station in the southern part of Lake Macquarie, M.Sc Thesis - University of New South Wales.

State Fisheries, (1979) Guide to Artificial Reefs. NSW State Fisheries Leaflet No 6.

State Pollution Control Commission (1983). Environmental Audit of Lake Macquarie

Thomson, J.M. (1959) Some aspects of the ecology of Lake Macquarie with regard to the alleged depletion of fish. Australian Journal of Marine and Freshwater Research, 10, 354-408.

UNSW (1972) Ecology of selected estuarine organisms Data List No. 1 and No.2. Project 12-045-16. School of Zoology, University of NSW, Sydney.

Virgona, J.L. (1983) Lake Macquarie fish study. NSW State Fisheries. Report prepared for Electricity Commission of NSW.

Walker, D.I., Lukatelich, R.J., Bastyan, G. and McComb, A.J. (1989). Effect of boat moorings on seagrass beds near Perth, Western Australia. Aquatic Botany (36) 69-77.

WBM Oceanics Australia (1997) Lake Macquarie Estuary Management Study. Volume 1 - Report on Entrance Issues. Prepared for Lake Macquarie City Council.

West, R.J. and Gordon, G.N.G. (1994) Commercial and recreational harvest of fish from two Australian coastal rivers. Australian Journal of Marine and Freshwater Research, 45: 1259-1279.

Whelans and Halpern, Glick Maunsell, in association with Thompson Palmer and Institute for Science and Technology Policy, Murdoch University (1994). Planning and Management Guidelines for Water Sensitive Urban (Residential) Design.

White, A.T., Ming, C.L., de Silva, M.W.R.N., Guarin, F.Y. (1990). Artificial Reefs for Marine Habitat Enhancement in South-east Asia. Association of South-east Asia Nations / United States Coastal Resource Management Project. Education Series 7.

Williams, R.J. and Watford, F.A. (1996). Restoration of estuarine fisheries habitat NSW Fisheries Project 94/041.

Winning, G and Markwell, K (1989) Lake Macquarie Wetlands Inventory. Shortland Wetland Centre. Report prepared for Lake Macquarie City Council.

Winning, G. and Gilligan, B. (1991). Wetlands of Lake Macquarie (p 67 - 73). *In*: Whitehead, T.J.; Kidd, R.W. and Bridgman, H.A. (1991). Lake Macquarie. An Environmental Reappraisal Review Seminar, University of Newcastle.

Winning, G. (1990). Lake Macquarie littoral habitats study. The Wetlands Centre, Shortland, Lake Macquarie Research Grant Project (89-3).

APPENDIX A: COMMUNITY CONSULTATION

APPENDIX B: WATER QUALITY MODELLING AND SEDIMENT NUTRIENT RELEASE INVESTIGATIONS

APPENDIX C: PLANNING FRAMEWORK FOR LAKE MACQUARIE

There are various planning policies and strategies influencing foreshore and lake usage within a local, regional, state and national planning context. These are administered by local, state and federal government.

LOCAL GOVERNMENT

Lake Macquarie Local Environmental Plan 1984

Landuse immediately adjacent to the Lake (above mean high water mark) is principally controlled by Lake Macquarie Local Environmental Plan 1984.

The LEP sets out landuse zonings, nominates general aims and objectives for the control of development and activities within the City, and sets out general restrictions on development.

The aims and objectives of the plan particularly relevant to the Lake are:

(a) to ensure that the development of the land does not exceed the environmental capacity of the City of Lake Macquarie;

(b) to protect areas of high landscape value and natural areas of conservation and recreation significance, including coastal wetland.

(c) to protect Lake Macquarie from the adverse effects of urbanisation and improper recreational use, and specifically from increased siltation and from pollution from sewage, industry, power generation and mining.

(d) to maintain and improve access to, on and around Lake Macquarie in a manner which provides for its greatest use and enjoyment.

(e) to ensure that any use permitted on public land adjacent to Lake Macquarie confers a positive benefit to the public.

All development within the Lake Macquarie catchment potentially impacts in some way or other on the Lake. Council has developed various Development Control Plans which set in place performance criteria to be met by development. This criteria effectively seeks to minimise environmental impact and protect existing community amenities.

Development Control Plan No. 3

Development Control Plan (DCP) No. 3 provides an extension of the planning framework established by the Lake Macquarie Local Environmental Plan, 1984, and is a mechanism by which detailed strategies can be implemented. DCP No. 3 outlines development policies, guidelines and standards which are applicable to certain categorise of development for which specific controls exist under the Lake Macquarie Local Environmental Plan. These categories include:

- development of, or the construction of, any structure on any land below deed mean high water mark;

- development on any land forming part of the bed of a river, creek, bay, lagoon or other natural watercourse;
- development on any land which has been reclaimed;
- development for a purpose for which consent is specifically required under the Local Environmental Plan (Clause 10 zoning table);
- the subdivision of any land;
- the erection of any building exceeding 9 metres in height;
- the clearing, injury or destruction of trees exceeding 3 metres in height, and all species of mangroves, irrespective of height; and
- the control of erosion and sediment deposition within the Lake system.

This plan also establishes guidelines for the erection of structures otherwise prohibited by a foreshore building line. Such departures are permitted only in accordance with State Environmental Planning Policy No. I (Development Standards).

DCP No. 3 applies to all land which:

- comprises the bed of Lake Macquarie and its tributaries which is Crown (Public) Land;
- abuts the deed mean high water mark (DMHWM) of Lake Macquarie; or
- shares a common title boundary with a public road or a public reserve which abuts the deed mean high water mark of Lake Macquarie.

Lake Macquarie Environmental Management Plan

The Lake Macquarie Environmental Management Plan (LMEMP) provides a plan for the protection and management of the environment of Lake Macquarie. It considers social, economic, physical and environmental issues as factors affecting environmental protection and management and as an influence on the quality of life of the community. The plan addressed several environmental themes: environmentally sensitive areas; environmental restoration projects; energy and water conservation; polluted areas and pollution; significant landscapes and vegetation; wildlife habitats and corridors; and waste management and litter. A vision for the protection and management of each of these themes was developed and broad strategies on how to achieve these visions outlined.

The LMEMP was developed as a means of satisfying the recommendations contained in Agenda 21. Agenda 21 is a document which arose from a global conference known as the `Rio Earth Summit' held in Rio de Janeiro in 1992. Agenda 21 states that "By 1996, most local authorities in each country should have undertaken a consultative process with their populations and achieved a consensus on a `local Agenda 21' for the community". Agenda 21 recommends that `each local authority should enter into a dialogue with its citizens, local

organisations and private enterprises and through consultation, learn from citizens and acquire the information needed for formulating the best strategies for environmental management.

Vision Statement And Policy Plan

This document provides a broad policy base for future development of the City of Lake Macquarie and sets out a vision statement together with a policy plan.

The vision statement reinforces the Lake as having unique environmental and economic potential to be one of the most desirable areas in Australia.

Five visions have been formulated of which the following are most relevant to the environment:

- the City will be a place where the environment will be protected and enhanced and where people and native flora and fauna will co-exist in harmony;
- the City will encourage a community spirit which promotes fulfilling lifestyle choices, allows opportunities to participate in sport and recreation and promotes equal access to all services and facilities as well as enables all citizens to contribute to the City's economic and social development.

To support the vision five success factors are identified in relation to the environment:

- conserving and enhancing the character of the Lake;
- preserving quality examples of the natural environment;
- planting;
- encouraging and caring for native flora and fauna; and
- improving and/or restoring spoilt areas and implementing the principles of ecologically sustainable development.

Additionally, a number of specific environment objectives are identified which are particularly relevant. These are:

- to safeguard and improve public access to foreshores;
- to develop pedestrian and cycle routes which will allow for convergent and safe movement by pedestrians and cyclists between all developed parts of the City.
- to eliminate sedimentation for the purposes of controlling the sources of erosion, thus preventing the mobilisation of earth into creeks and stormwater and consequent sedimentation in waterways;
- to improve water quality of creeks, the Lakes, and beaches and reduce to on absolute minimum the impacts of erosion, nutrient loading, heavy metal pollution and thermal pollution; and
- to reduce impacts by the public on natural systems through public education programs.

Plans Of Management

Under the Local Government Act 1993 the Council is required to develop Plans of Management for Community Land (all land vested in Council). Community land must be the subject of a Plan of Management and be categorised according to its function as prescribed under the Act.

A number of these draft plans variously influence/impact on foreshore land management. In particular the Draft Plan of Management - Natural Areas of Community Land No. 15 and Draft Plan of Management - Park Land Areas of Community Land relevant reference document for development of the Management Plan.

Newcastle / Lake Macquarie Open Space Study

The Newcastle / Lake Macquarie Open Space Study sets out the framework for development of recreational land use strategies and management plans for the area. This study was undertaken in 1987, and while it is somewhat dated it nonetheless provides an important precursor to further open space related studies and plans, particularly in terms of sub-regional context.

REGIONAL

Hunter Regional Environmental Plan 1989

The HREP 1989 provides a long term planning strategy for the development of the Hunter Region, based upon information and assumptions regarding growth. The Plan deals with social economic, settlement access, natural resources and ecological issues, particularly as they relate to the use of land for public and private purposes. It sets requirements and provides guidance to both State and Local Authorities and the private sector on issues which must be considered when development is contemplated, or where a change in land use status is proposed.

Relevant Issues

Lake Macquarie City area is expected to continue to account for approximately 40 per cent of the subregional growth in residential land development. A settlement strategy is outlined in the Plan which is generally the way which Lake Macquarie continues to grow.

It can be expected that the Eastlakes will accommodate a decreasing proportion of the City's total growth. Population growth will develop further on the western side of the Lake with implementation of the Westlakes Sewerage Scheme and availability of redundant mining land.

Implications of increased urban development for the Lake are two fold. Firstly there is likely to be greater demands on water based and foreshore based recreation activities. Secondly, and from an environmental impact viewpoint, increased urban development of the catchment could result in further siltation and contaminated stormwater entering the Lake.

Hunter Coastal Settlement Strategy

In August 1994, the NSW Department of Planning released "Hunters Coast - Hunter Coastal Settlement Strategy. The strategy was prepared having regard to the existing and expected

development pressure along the Hunter's coastal area. Land releases within the Lake Macquarie City Area are consistent with this strategy. Significantly further urban development is expected to occur, particularly in the West Lakes area.

Lower Hunter Regional Environmental Management Strategy

The Lower Hunter Regional Environmental Management Strategy is the outcome of regional co-operation amongst lower Hunter communities. The Strategy recommends ways that councils may work together and in partnership with various authorities and the wider community to better manage environmental issues on a regional basis (LMCC, 1996). Six Lower Hunter Councils and their communities, including Lake Macquarie, were involved in the development of the strategies which provides a regional perspective to environmental management.

STATE

Draft Revised Coastal Policy for NSW

In early 1994, the Coastal Committee of NSW released a revised draft Coastal Policy for NSW. The draft policy statement was developed following extensive consultation and review of the provisions of the NSW Government's Coastal Policy released in 1990. The draft policy statement contains a vision for the coast:

The Vision

A coastal environment which is conserved and enhanced for its natural and cultural values while also providing for the economic, social and spiritual well-being of the community; and a strategic policy framework comprising nine goals to give effect to the vision and to guide decision making, namely:

Conservation

1. To protect, restore and enhance the natural environment

2. To protect and enhance the aesthetic qualities

3. To protect and conserve cultural heritage

4. To recognise and accommodate natural processes

Social Economic

1. To provide for ecologically sustainable development and use of resources

2. To provide for appropriate human settlement

3. To provide for appropriate public access

Implementation

1. To provide information to enable effective management

2. To provide for integrated planning and management

Principles, objectives and strategic actions are provided in respect to each goal. Agencies responsible for implementing the actions are listed.

While the document makes no direct reference to a locality, it does give substances to the decision to develop a management plan for Lake Macquarie.

Crown Land Foreshore Tenures Policy (Non-Commercial Occupations)

The policy sets out guidelines for the effective and appropriate administration of non-commercial water front occupations of Crown tidal and adjoining foreshore land administered under the Crown Lands Act, and to Crown Foreshore lands, whether reserved or otherwise, immediately above the mean high water mark.

Basically the Policy confirms the need to properly manage foreshore lands in a coordinated manner consistent with Total Catchment Management philosophy.

Environmental Planning and Assessment Act

There are approximately 50 State Environment Planning Policies (SEPP's) which operate under the Environmental Planning and Assessment Act. The SEPP's which have particular relevance to the management of Lake Macquarie include:

- SEPP No. 14 - Coastal Wetlands.
- SEPP No. 19 - Bushland in Urban Areas.
- SEPP No. 35 - Maintenance Dredging of Tidal Waterways.
- SEPP No. 46 - Protection and Management of Native Vegetation.

REFERENCES

Clouston, 1994 Draft Lake Macquarie Recreation and Open Space Plan - Visual Quality Study.

Lake Macquarie City Council, 1996. Lake Macquarie Environmental Management Plan.

APPENDIX D: RECREATION CONSIDERATIONS OF LAKE MACQUARIE

Lake Macquarie and its foreshore are utilised for a range of recreation pursuits. Information regarding the nature and extent of different activities was gained through discussions with known user groups, personal observations and the community consultation programme. There is very little up to date data regarding recreational activity on the Lake currently available. The most up to date study is the Lake Macquarie Recreation and Open Space Plan (Clouston, 1994) which is still in draft form. While this study is still a working draft document it nonetheless provides the most recent overview of recreation across the City. The principal components of the study are:

- Establishment of Recreation and Open Space Needs Assessment;
- Development of a Landscape Structure Policy addressing Scenic Quality;
- Review of the City's Open Space Inventory;
- Review of Zoning and Development Controls;
- Review and revision of the City's Section 94 Contributions Plan for Open Space;
- Review of Open Space and Recreation Management and Maintenance.

The intent is to provide a range of strategies and implementation procedures for an Outdoor Recreation and Open Space Plan.

The recreation component of the Plan is considered within a City wide context. While the plan does not strictly identify the Lake as a recreation setting in the open space network it is regarded as "a central focus of much of the City's recreation opportunity .... with 28 launching ramps, 16 sailing clubs, more than 2,000 registered moorings and seven regional jetties around the Lake, the opportunities to get on the water are considerable". (Clouston, 1994).

While this study seeks to identify the principal recreation users, it is likely that an individual utilises part of the Lake area for an activity which has not been identified. This is primarily due to the size of Lake Macquarie and the fact that many people make use of its environs as individuals and these users may not be known to others. Those recreation activities known to occur on the Lake and it's immediate foreshore are set our below.

WATER BASED ACTIVITIES

A 1984 survey of boat ramp users indicated that up to 7,000 craft of varying types would use the Lake on any given weekend in summer. This would translate to in excess of 13,000 people on the water over weekend.

Accessibility to Water

In 1996, there are actually 40 boat launching ramps in Lake Macquarie City Council area of the Lake and 3 ramps in Wyong Shire, in the southwestern most extremity of the Lake (refer to Figure 2).

Additionally there are currently 2,200 registered moorings (MSB Waterways pers. comm.) on the Lake as well as four commercial marinas.

Lake Macquarie City Council have identified 35 structures on the Lake which are in varying states of repair and potentially offer access particularly for fishing and passive pursuits such as part of a walk around the foreshore.

A high proportion of Lake foreshore is under public reservation. There are 183 Foreshore reserves of which the majority are water orientated, with approximately equal quantities being land orientated and undeveloped (Newcastle/Lake Macquarie Open Space Study, 1987).

Boating

The precise extent of boating activities on the Lake is difficult to quantify in empirical terms. Boating numbers indicated hereunder are estimates only which have been collated as a result of discussions with various user groups and responsible authorities.

Many boating activities occur on the Lake and they include:

- Yachting (either racing or pleasure sailing);
- Dinghy (racing or pleasure);
- Cruisers (commercial sight-seeing and private);
- Fishing vessels
- Motor speed boats
    - ⇒ skiing
    - ⇒ fishing
    - ⇒ sight-seeing

The following are indicative numbers of yachts and dinghies on the Lake.

Yachts	
Clubs	**Approximate Number of Yachts Racing on Weekends**
Lake Macquarie Yacht Club, Belmont	90
Croudace Bay	25
Royal Motor Yacht Club, Toronto	35
Wangi Wangi Sail club	35
South Lake Yacht Club	20-25
Mannering Park	40

Approximately 80 per cent would use yachts for recreational sailing at least once during the week.

Dinghies	
Clubs	**Approximate Number of Dinghies Racing on Weekends**
Belmont 16' Sailing Club	120
Speers Point/Mannering Park	40
Toronto	25
Newcastle Cater	25
Newcastle/Hunter Trailer Yacht Club	25

In addition to the approximate numbers of yacht and dinghies some 200 to 250 craft would visit the Lake to take part in various regattas.

There are approximately 75 vessels within Lake Macquarie which belong to clubs (both cruising and racing) which are equipped for open sea conditions and are able to navigate Swansea Channel. These vessels are on average likely to sail "outside" twice per year.

A general consensus of opinion indicates another 30 to 40 vessels are capable of sailing outside Lake Macquarie.

The following table represents the approximate number of motor cruisers within Lake Macquarie which would not generally sail outside.

These vessels are either moored on private swing moorings or at a marina.

Location	**Number of Vessels**
Belmont Bay	25
Valentine	20
Marmong	60-70
Toronto	40
Other moorings throughout the Lake	50-60

According to figures obtained from the Volunteer Coast Guard (pers com.), the total number of vessels for a 7 year period from 1 July 1989 to 30 June 1996 through Swansea Channel was 20,669 comprising 11,122 cruisers and 9,547 yachts. The Swansea Bridge was opened 10,643 times during this period.

The following table lists the number of bridge openings and vessels through the channel for each twelve month period commencing May 1988.

Period	No. of Openings	No. of Vessels
12 months up to June 1989	1,293	2,638
1991	1,438	2,608
1992	1,444	2,764
1993	1,593	3,290
1994	1,667	3,391
1995	1,615	3,237
June 1996	1,593	2,812
Total	10,643	20,669
Source : Volunteer Coast Guard, 1996		

Vessel numbers and bridge openings peaked in 1994 and have since declined. Anecdotal evidence suggests that this decrease in vessel movements is attributed to increased siltation of the channel and resultant navigational difficulties.

Fishing

There is a general perception that fish stocks in the Lake have been declining, although no empirical research to date supports this. Indeed anecdotal evidence indicates an increasing number of people are fishing the Lake.

Artificial reefs were laid in the Lake in the 1960/70s, in order to improve fish stocks.

The southern most reef is off Wangi, west of a buoy directly off the Headland, approximately 200 m offshore. Across the Bay the second is located off Pelican “dropover”. Two more reefs are off the southern side of Coal Point, while the fifth reef is located off Warners Bay (refer to Figure 3.)

Water Skiing

Tends to be concentrated in the Myuna Bay, Nords Wharf and Warners Bay areas. Although water skiing takes place in other protected areas of the Lake.

There is no data regarding the number of water ski boats using the Lake.

These higher powered boats occasionally conflict with sail boats but this tends not to be extensive nor is regarded as a serious problem. Like most activities on the water peoples behaviour tends to be self regulating and conflict between users is mostly avoidable.

Jet Ski

This more recent activity is carried out in a number of areas including the Warners Bay area. Nearby residents in Warners Bay have expressed some concerns for noise levels from jetskis. Lake Macquarie City Council have engaged an acoustical consultant to investigate the issue and advise of its seriousness.

Sail Boarding

A relatively recent activity which is popular in the Warners Bay area as well as Swansea Channel.

Sight-seeing and Pleasure Cruises

There are three commercial pleasure cruise operators on the Lake. A number of house boat hire operations are conducted principally from the commercial marinas.

Scuba Diving

Within the Lake Macquarie area there are five scuba diving schools. Other dive schools from Newcastle would also scuba dive in the Lake. Some dive training is carried out in Warners Bay while the main area for recreational diving is in the Swansea Channel underneath Swansea Bridge.

FORESHORE USES /ACTIVITIES

The foreshore area of the Lake is extensively used for a range of active and passive recreational activities.

Probably most common is picnicking and associated informal sporting activities such as touch football and cricket.

Walking and cycling are increasingly popular along the foreshore. Recent construction of a cycleway around the northern side of Warners Bay to Speers Point is evidence of cycling's popularity.

Development of a connecting walking track around the Lake foreshore is a long standing proposal which would add to the Lake's recreational value.

Dog walking along the foreshore is popular. Unleashed dogs are not permitted in public parks. The actual extent of dog walking is unknown.

The following landuses occur on the foreshore:

- marinas;
- sailing clubs;
- sporting fields - complexes;
- private residential property; and

- yacht clubs.

The Green Point area is the largest undeveloped land remaining on the foreshore. The land is partially owned by Council, but some areas are still under private ownership. Its development and/or conservation has been the subject of considerable public debate in recent years. From a recreational value viewpoint it is obviously a strategically important area and any ultimate decision regarding its usage must be made within this context.

A small amount of tourist accommodation is available immediately adjacent to the Lake Foreshore. The Cams Wharf area is currently under pressure for this type of development. Demand for this type of tourist development could increase if more yachts from outside the Lake area were attracted to special events such as an annual Pittwater to Lake Macquarie race (pers comm, Michael Ridely). Additionally the economic benefits to the Lake if the channel was permanently navigable by ocean going yachts and cruisers is not known but it would be beneficial to gain an understanding of these broader economic implications.

SUMMARY

While some conflicts will always occur between different users of Lake Macquarie, there seems to be no major conflicts. This conclusion is also supported by the relatively minor responses on recreational conflict concerns from the community consultation workshops (see Appendix A).

Recreational concerns raised were more related to maintaining and improving the quality of the Lake (eg. water quality) and improving access (eg. creek siltation, foreshore erosion), thus providing a more pleasant recreational environment.

APPENDIX E: VISUAL QUALITY ANALYSIS FOR LAKE MACQUARIE

INTRODUCTION

This visual quality analysis is derived from the Draft Clouston Visual Quality Study (1994) for Lake Macquarie.

The objectives of the study are:

- to identify the characteristics and range of visual landscape resources of the City;
- to ascertain the relative value of this resource to the City;
- to ascertain the visibility or accessibility of the landscape; and
- to provide a basis for formulation of a landscape structure policy and the planning and management of the visual resources of the City in conjunction with other considerations for open space and recreation planning.

The Study methodology builds on the methods adopted by the Victorian Forests Commissions, which is derived from the United States Forest Service.

Views are classified into landscape setting units by attributing a scenic quality value. A scale of low, moderate, high is applied based on an assessment of its relative contribution of visual physical characteristics of the landscapes to its perceived scenic value. Scenic quality objectives are ascribed to each scenic quality level.

Additionally, a measure of scenic accessibility is determined by the visibility of the landscape and its distance from the viewer from more frequented view points and routes. Combining the assessment of scenic quality and scenic accessibility results in development of scenic management zones which provide the basis for a planning and management framework.

NATURAL LANDSCAPE STRUCTURE

Within a city wide context four landscape structures prevail with significant components of high scenic quality, recreation potential and residential amenity. These are:

- The Ranges
- The Lake
- The Coast
- The Hinterland

While this analysis focuses on The Lake, it is essentially the summation of the landscape viewed at a particular time and place which produces the visual character or overall scenic quality.

LANDSCAPE SETTING

The Lake comprises distinct landscape settings of geographic and topographic features combining to present a particular landscape character which comprises:

Lake Shore - cultural landscape of residential and park lands

Lake Shore - rocky forested lake and waters edge

Wetlands - small lakes

Ridge lines - hillsides

The shoreline of the Lake extends from the shallow waters and bay edges where jetties are built and boats moored to the line of development along the shore, or the rise in slope to a hillside.

SCENIC QUALITY ASSESSMENT

The following characteristics of the landscape is the criteria from which scenic quality is measured:

- Naturalness
- The presence and character of water
- The built form and identity
- The shoreline character and diversity
- Landform contrast and diversity, and
- Vegetation contrast and diversity

There are differing sets of characteristics for each level of scenic quality assessment.

Landscape setting units were derived by ground level observations and interpolation of topographic maps and aerial photos. Units were assessed in relation to local scenic characteristics and views available in areas of distinct landscape character and visual containment.

The following Table lists the scenic quality assessment for the Lakeshore unit.

Location within Lakeshore	Scenic Quality Rating
Nords Wharf	High
Point Morisset	High
Swansea West Shore	Moderate
Lake Entrance	Moderate
Belmont Bay	Moderate
Belmont North	Moderate
Green Point	High
Croudace Bay	Moderate
Warners Bay	Moderate
Cockle Bay	Moderate
Awaba Bay	Moderate
Kooroora Bay	High
Coal Point	High
Kilaben Bay	High
Wangi Bay	Moderate
Wangi South	High
Myuna Bay	Moderate
Lake Eraring	Moderate
Bonnells Bay	Moderate
Johnys Point	High
Bardens Bay	Moderate
Wyee Point	High
Pulbah North	High
Pulbah South	High

SCENIC ACCESSIBILITY ASSESSMENT

Vantage points of particular views of the landscape are assessed according to the number of users and frequency of use. The higher number and frequency, the higher the Viewing Level. These levels are important when considering management options and particularly the way in which uses and activities would affect them.

The following is the viewing levels determined for the various vantage points on and adjacent to Lake Macquarie;

Level 1 - High Viewing Level

Pacific Highway

Belmont Yacht Club and Lakeside Park

F3 Freeway

Toronto Lakeside

Warners Bay Road

Macquarie Drive, Esplanade (Belmont to Boolaroo)

Level 2 - Moderate Viewing Level

Lake Macquarie boating areas

Nords Wharf

Lake Entrance

Wangi Bay

Main Road and Wangi Road (Toronto to Morisset)

Wyee Road

Level 3 - Low Viewing Level

Lake Eraring

Bonnells Bay

Bardens Bay

Wyee Point

Johnys Point

Swansea West Shore

Morisset Peninsula

Coal Point

SCENIC MANAGEMENT ZONES

The foreground, middle ground and background of Viewing Levels are mapped as High, Moderate or Low Scenic Accessibility in relation to distance zones.

Combining the scenic quality and scenic accessibility maps results in scenic management zones. Four zones are recognised as A, B, C and D Zone.

Zone A comprises areas of highest scenic quality and accessibility and are of the most critical value to the overall scenic character of the Lake. The degree of scenic quality and accessibility and hence critical value diminishes from Zone A through to Zone D.

The Lake foreshore is regarded as being of high to critical value to maintaining the City's scenic character with evenly proportioned areas of Zone A and Zone B. There is a relatively small pocket of Zone C on the western Lake foreshore in the Myuna Bay area and south towards Morisset.

Scenic management planning objectives and guidelines are set out for each of the management zones which provide performance criteria for the management of the landscape and activities on the Lake, and development assessment and management of activities on the foreshore.

The following table presents the scenic management strategy for the shorelines in Zones A, B and C and provides a basis for formulating management options for the Lake Management Strategy.

	Scenic Management Objectives	**Strategic Guidelines**
Zone A	To protect the dominance of the natural character of shorelines in Management Zone A by ensuring visual impacts of development are minimal.	Lake Shore: Development along the shore shall be in character and scale with the existing development when seen in the foreground, mid ground or background of major views and not significantly extend the area and scale of development. Development in areas of natural shoreline shall be restricted to ensure protection of the scenic quality: • Vegetation removal to be a maximum of 10 % of existing canopy within 50 metres of the shore. • Council to prepare a concept shoreline strategy indicating long-term guidelines for boat access, boat sheds and jetties, vegetation character and vegetation rehabilitation and screening. Number and size of jetties and boat moorings to be limited to ensure a dominance of naturalness along the Lake shores. • Recreational facilities, including jetties, campgrounds, toilets, carparks, etc, on the water or shore to be presented for approval with a visual impact assessment demonstrating minimal change to the landscape character and degree of naturalness of the shoreline in the zone.
Zone B	To maintain the dominance of natural character in shoreline areas of Management Zone B whilst allowing some modification and rehabilitating areas of diminished scenic quality.	Council to prepare a concept shoreline strategy indicating long term policy and guidelines for boat access, boat sheds and jetties, vegetation character, rehabilitation and screening in public open space and private shoreline areas. Lake: Development in any open or semi-open grassland shoreline of this zone to be limited in location, size, scale and visual impact to comply with the shoreline strategy. Screening and vegetation restoration planting to be implemented along the shore to achieve a 50 % screening of any structure from views from the water's edge or Lake in 5 years time. Lake: Development in existing built areas to be limited to the existing character in scale and extent for small buildings, sheds and jetties, etc. Development on natural or predominantly treed sites shores to be restricted to ensure clearing of existing vegetation in the first 20 metres is limited to maintain a natural appearance along the waters edge. Development beyond this 20 m buffer zone to be restricted in scale, height and extent to maintain a dominant natural character and only partial visibility of buildings when viewed from the water and foreground and midground viewpoints. Height of structures not to extend above the tree canopy.
Zone C	To maintain the predominance of natural character of all shorelines where it exists in Management Zone C by ensuring developments do not exceed a moderate level of visual impact.	Lake: Development proposals along the shore to be allowed only to the extent there is maintained a natural shoreline along the majority of shore of any bay. • Development along the shoreline zone to be limited within the 20 metre zone from the water's edge and a landscape plan to be submitted to the Council demonstrating the vegetation retention, restoration and screening.

BOAT-BASED VISUAL SURVEY

The Clouston (1994) Study also undertook a visual survey from a boat during a two day trip on the Lake. This survey reinforces the land based analysis conclusions in relation to the Lake and its foreshore's scenic quality being regarded as high to critical value.

REFERENCES

Clouston, 1994 Draft Lake Macquarie Recreation and Open Space Plan - Visual Quality Study.

Pigram, J. 1983. Outdoor Recreation and Resource Management. St Martins Press, New York.

APPENDIX F: PUBLIC SUBMISSIONS ON LAKE MANAGEMENT ISSUES REPORT

No.	Organisation	Points Raised
1	Concerned Resident	Sedimentation, Seagrass, Lake Management/Single Lake Authority.
2	Concerned Resident	Foreshore erosion, Groynes, Belmont Bay.
3	NSW CFC	Marine Reserves (map).
4	CAG	Reduced Angler Catches, Purchase of Commercial fishing licences, Artificial reefs, Aquatic Reserves, Selenium and Heavy Metals.
5	Delta Electricity	Selenium Inputs/sources + Community concern, Ecology related Management Issues, Options concerning selenium, Thermal Discharges.
6	Concerned Resident	Overall Management Framework, Planning of residential development, Limits to population growth, Conservation area.
7	Director, Development Services, LMCC	Stormwater/runoff management, Effectiveness of pollution control devices, Council commitment, Costs of options, Disadvantages and costs of options to limit development, Seagrass and zoning, Seagrass maintenance, Yachts, Jet skis.
8	Concerned Residents	Weed in Fennell Bay.
9	Concerned Resident	Weed in Fennell Bay.
10	Concerned Resident	Weed in Fennell Bay.
11	Concerned Resident	Weed in Fennell Bay.
12	Concerned Residents	Weed in Fennell Bay, Dredge Fennell Bay.
13	Concerned Residents	Weeds in Edmunds Bay caused by Mudd Ck dredging.
14	Concerned Resident	Pelican Island in channel - need for cleanup of sand islands, Better co-ordinated management of Lake and sand islands.
15	Concerned Resident	Management - need for more coordination between authorities, Community attitudes (more than 1 community), Increase in tourism not positive, Data on yachts in channel not meaningful, Navigation in channel.
16	Concerned Resident	Seagrasses, Boat moorings, Swing moorings, Water tanks, Drop over.

17	Concerned Resident	Fish habitat silted over, Phase out nets, Undersized fish in Co-op, Fish catches dropping, Nets more sophisticated, Reduced recreational bag limits won't help, More fisheries inspectors would help. Foreshore erosion at Laycock St Carey Bay.
18	Concerned Resident (Joint submission with No.19)	Foreshore erosion - defer retaining walls, Seagrass removal, Degraded water quality - more silt traps required, Maintenance of GPTs etc, Toxic effects of Jutemesh, Facilities for discharge of boatwaste, Restore foreshore vegetation, artificial reefs, Single Lake Authority (SLA).
19	Concerned Resident	see No. 18.
20	Concerned Resident	Dredging, funding, siltation traps - plan of management, Tuggerah Lakes, Developers, Beach renourishment, Limiting development.
21	URGE	Comments & Strategies to address: Degraded water quality, Sedimentation, Community attitudes, Selenium/Heavy Metals, Seagrass, Wetlands, Thermal Discharges, Reduced Angler Catches, Haul Netting, Foreshore Erosion, Litter/Pet Faeces, Implementation of Plan.
22	Concerned Resident	Village Bay Siltation - Need for big dredging operation, Belmont Bay - Park to Cold Tea Creek (siltation, weed) - need for remediation.
23	Concerned Resident	Urbanisation, Implementation of Plan, Authorities, lack of LMCC funds, Need for Lake Macquarie Preservation Authority (ie SLA), business approach to running Lake Macquarie.
24	NSW, EPA	Diffuse sources of pollution/controls, Care with dredging, Acid sulfate soils, DUAP involvement in limiting urban growth, Quantify sources of nutrients in unsewered areas, Selenium in sediments, Thermal discharges, Artificial reefs.
25	LMCC - Strategic Program	Comments on content, structure, terminology, planning content, existing legal framework, development controls, scenic, tourism, ecology.
26	Lake Macquarie Yacht Club - Belmont	Numbers of yachts, yachts in channel, Navigation issues in channel, Report deals with environmental issues rather than recreational/economic and tourism.

27	Lake Macquarie Yacht Club - Cruising Division	Tourist potential of Lake, Channel a barrier, Argues against letting channel shoal up, Water circulation in Lake. Included a 500 signature petition.
28	CAG	Specific comments on fishing, water quality, development, ash dams and selenium, foreshore protection, fishery issues, haul netting, marine reserves, mine subsidence, recreation and tourism.
29	Department of Land and Water Conservation - Estuary Management Group, Sydney	Management aims (criticism of status quo, chlorophyll *a*, sediment and seagrass, dredging, heavy metals in sediment, tables 6.1C and 6.1A, reference to draft habitat protection plan No. 2 by NSW Fisheries, wetland education, seagrass.
30	Environment Protection Authority	Specific comments on Implementation of the Management Plan.
31	Cruiser/Business	Channel navigation, min 2.5m referred by Cnr Winning.
32	DLWC (Hunter)	statutory bodies should be listed, land management issues overlooked (Kilaben Bay/Baywater and weir at Marmong Lagoon), dredging spoil management, seagrass map from NSW Fisheries, more detail in domestic waterfront development, effluent discharge from vessels, optimum and sustainable levels of development.
33	HWC	TCM & EMC is way to go for Lake Management (not new authority), EPA should co-ordinate monitoring in the Lake, sewage overflow frequent and minor, updates since process study, stormwater greater load than sewage.
34	NSW Fishing Club	Fishing in Lake Macquarie is better in summer and the catch/hr is constant.
35	Economic Development, LMCC	Comments on reduced catches, seagrass protection, foreshore management.
36	Enfield	Sedimentation - Secret Bay should get high priority.
36a	Concerned Resident	Secret Bay concerns + entrance issues.
37	Concerned Resident	Cleaning of Marks Pt, Village Bay and Belmont Bay.
37a	Concerned Resident	Dredging in Village Bay and map.
38	CAG	Marine Reserve Petition.

APPENDIX G: LAKE MACQUARIE ESTUARY AND COASTAL MANAGEMENT COMMITTEE MEMBERS

The Lake Macquarie Estuary & Coastal Management Committee is a committee formed by Lake Macquarie City Council to oversee the preparation of Management Plans for the Lake and City's coastline. This Committee has overseen the preparation of the Coastline and Estuary Management Studies and has broad representation from government departments as well as community groups. This Committee is now supervising the formulation of Management Plans for the Lake Macquarie Estuary and Coast. The membership of the Committee is as follows:

Lake Macquarie City Councillors:
Cr Greg Piper - ***Chairman***
Cr Chris Coburn
Cr John Jenkins
Cr Milton Orkopoulos

Lake Macquarie City Council Staff:
John Parkes
Director Environmental Services

Jeff Jansson
Manager Environment
Environmental Services Division

Neale Farmer
Lake & Catchment Management Officer
Environmental Services Division

Robbie Economos-Shaw
Environmental Planner
Planning and Development Division

Ian Broadfoot/Greg Weir
Manager Asset & Policy Development, Community & Cultural Services Division

Michael Ridley
Tourism Manager

Bob Gardiner
Deputy Chairman
Lake Macquarie Catchment Management Committee

Glenn Sharrock
Environment Manager
Delta Electricity
Vales Point/Munmorah Power Station

Jack Shield
United Residents Group for the Environment (URGE) of Lake Macquarie

Terry St George
Public Lands Management Coordinator
Department of Land & Water Conservation, Maitland Office

Ric Slatter
Resource Improvement Works and Services
Department of Land and Water Conservation (former NSW Public Works)

Lionel Jones
Lake Macquarie Concerned Anglers Group Inc.

Don Cameron
Commercial Fishing Sector Newcastle Fishing Co-op

Warren Winter/John Holliday/Con Martschenko
NSW Fisheries

Dr Ron Kidd
University of Newcastle
Chairman of the Lake Macquarie Catchment Management Committee

Anna Ferguson
Co-ordinator
Lake Macquarie Catchment Management Committee (DLAWC)

Pam Dean-Jones
Head Regional Programs EPA

John Fisher
Manager Hunter/Central West
Waterway Authority

Pat Daley
Community Member

Ken Hoff
Community Member

Observer Status:

Michael Osborne
Hunter Water Corporation

Danny Roberts
Wyong Shire Council