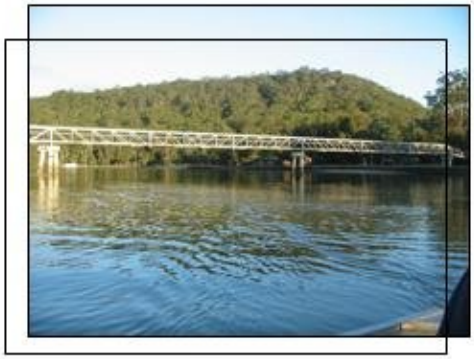
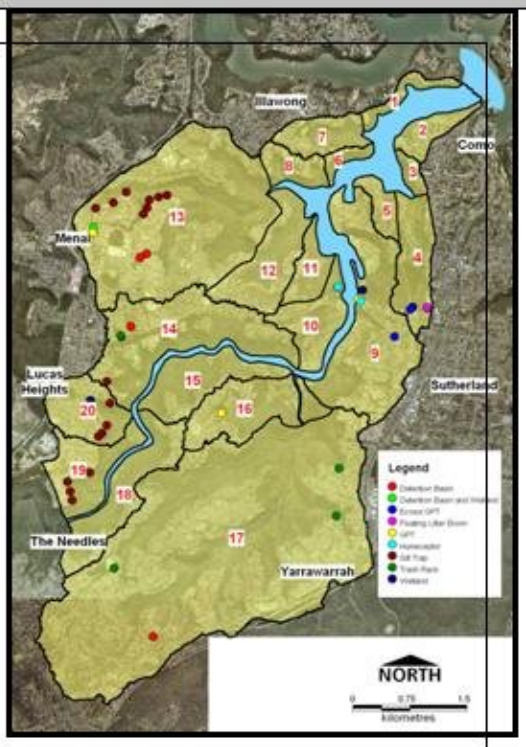
WBM

Woronora River Estuary Management Study and Plan

Final

February 2008





SUTHERLAND SHIRE COUNCIL

Department of Environment & Climate Change NSW

Woronora Estuary Management Study and Plan

Prepared For:	Sutherland Shire Council
Prepared By:	WBM Pty Ltd (Member of the BMT group of companies)

Offices

Brisbane
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DOCUMENT CONTROL SHEET

WBM Pty Ltd

Newcastle Office:

126 Belford Street
BROADMEADOW NSW 2292
Australia

PO Box 266
Broadmeadow NSW 2292

Telephone (02) 4940 8882
Facsimile (02) 4940 8887
www.wbmpl.com.au

ABN 54 010 830 421 003

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Project Manager :	Philip Haines
Client :	Sutherland Shire Council
Client Contact:	Gwyn Cleeves
Client Reference	

Title :	Woronora Estuary Management Plan
Author :	David Wainwright/Michelle Fletcher
Synopsis :	This document has been prepared in accordance with the NSW Estuary Management Manual. It outlines the management process that is to be followed in order to achieve long-term sustainability of the Woronora Estuary with regard to ecological, economic and social values. The Plan is intended to be used by Council to guide future works programs and policy changes.

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1 PREAMBLE

1.1 Introduction

This Estuary Management Study report is the third in a set of documents that have been produced to establish a long term management plan for the Woronora Estuary. Preceding this report have been a Data Compilation Study (WBM, 2004), wherein all relevant data regarding the Woronora River was compiled and reviewed, and an Estuary Processes Study (WBM, 2006), which describes various physical, chemical and biological processes within the Woronora River Estuary and the impacts of human activities on these processes.

Using the information from the previous studies, this Estuary Management Study identifies the essential features and the current uses of the estuary and details objectives for long term management of the Woronora River and recommends a series of future management strategies to meet these objectives. The report has been prepared with considerable input from the local community and its contents reflect the close relationship between the community and the estuary.

This project is being carried out under the state governments Estuary Management Program. The steps in the program are described in Figure 1-3. The next and final stage in the process will be the preparation of the Woronora Estuary Management Plan. This document will detail prioritised and costed strategies and actions to be undertaken by Council and other organisations as agreed. Most works and actions included in the Estuary Management Plan will be eligible to receive dollar for dollar funding from the state government through the Estuary Management Program.

The report has been prepared by environmental consultants *WBM Pty Ltd* on behalf of Sutherland Shire Council and the NSW Department of Environment and Climate Change.

1.2 Study Setting

The Woronora Estuary drains a steep and mostly forested catchment and forms the largest tributary to the Georges River, 10km upstream from its entrance to Botany Bay.

The catchment is characterised by steep slopes on the eastern and western sides of the Woronora Valley. The lower catchment has narrow river flats, which are occupied by residential and urban development. The tidal limit of the estuary is a few hundred metres upstream of an area known as “The Needles”, on the downstream side of the causeway and rocky falls near the Pass of Sabugal. The causeway is around 10 km upstream of the confluence with the Georges River. Upstream of the tidal limit, the river becomes narrow and incised within a steep bedrock valley. Figure 1-1 shows the main features of the Woronora Estuary and its catchment.

Figure 1-1 Features of the Woronora Estuary and its Catchment

The Woronora Dam is an important feature of the overall catchment, which is located about 20km upstream of the tidal limit. The construction of Woronora Dam was completed in 1942 (with two stages of construction between 1927-1931 and 1935-1941). The Dam's capacity is 71,790 ML, with a maximum depth of 60m. The catchment area of the Dam is 78.2 km^2 which is 45% of the overall catchment of the Woronora River (ACER, 1995). The Dam is operated by The Sydney Catchment Authority, which supplies water to the Sydney Water Corporation for the provision of potable water to some parts of the Sydney metropolitan area.

The Woronora Estuary contains a variety of habitats including intertidal shoals, seagrass, saltmarsh and mangroves, which are utilised by a range of species of conservation and fisheries significance. While most of the catchment and foreshore vegetation has been retained, reclamation activities, bank

erosion and foreshore protection works have caused some degree of physical disturbance. The wider catchment supports a mix of vegetation communities dominated by Gully Forest and Sandstone Ridge top Woodland.

For the purposes of the estuary management process, the Woronora Estuary includes the waterway (between the Georges River and the tidal limit), foreshores, and adjacent lands (riparian zone) of the Woronora River. The riparian zone has been broadly classified as the area 100 m either side of the waterway, although in some cases, it may be appropriate to vary this depending on the local conditions and issues of concern. The entire catchment is also considered as part of this Estuary Management Study insofar as it influences the condition of the estuary.

1.3 The NSW Government Estuary Management Framework

In 1992, the NSW State Government introduced an *Estuary Management Policy*, aimed at managing the growing pressures on estuarine ecosystems. The policy is implemented through an Estuary Management Program, which is co-ordinated by the Department of Environment and Climate Change (DECC) in co-operation with local government and the community.

The process of managing an estuary, in accordance with this Policy, is initiated by the establishment of an Estuary Management Committee. This Committee is responsible for the development of an Estuary Processes Study, followed by an Estuary Management Study and Estuary Management Plan (refer Figure 1-3). Once the Plan has been accepted by Council, the Community and the relevant Government departments, the Plan can be implemented through planning controls, works programs, monitoring programs, and education services.

1.4 Structure of this Report

This document provides the basis for selection of strategic management actions that will be incorporated into the Woronora Estuary Management Plan. As such, the document contains an array of information regarding the physical and biological processes, the community values, and the planning framework of the Woronora Estuary. This document comprises both the Estuary Management Study (Chapters 2 through 6) and the Estuary Management Plan (Chapter 7).

In arriving at the strategic management actions, a process was followed to determine which actions, should be included in the Estuary Management Plan. The various steps of this process are documented in this Estuary Management Study report as described in Figure 1-2.

Presented below is a basic outline of the contents of each chapter of this report, as they relate to the overall process of establishing long-term management strategies for the Woronora Estuary.

Chapter 2 presents a **summary of background information** including the **Estuary Processes Study** and the results of **community consultation** carried out for this project. The Estuary Processes Study outlines all of the fundamental physical, chemical and biological processes that currently occur within the Woronora Estuary, and how these processes need to be considered and managed in the future. The results of the community consultation details issues the community consider are most important to the Woronora Estuary, the ways in which they currently use the Woronora Estuary, and some suggested options for sustainable future management.

Chapter 3 summarises the **values and issues** of the Woronora Estuary, including consideration of present levels and types of use and development and any identified conflicts. Chapter 3 also details the **key management issues** that need to be addressed in order to maintain a healthy and sustainable estuarine environment in the future.

Chapter 4 provides an overview of the **planning context** that is currently applicable to the Woronora Estuary. This includes all relevant local, regional, state and federal legislation.

Chapter 5 defines **overarching goal and specific management objectives** that need to be addressed. The objectives have been based on specific details relating to each of the Key Management Issues.

Chapter 6 outlines the **development, assessment and prioritisation of potential management options** that could be employed to address the management objectives. A description of short listed management options is also presented.

Chapter 7 presents **details for implementation of the Woronora Estuary Management Plan**. These details include specific actions, responsibilities, costs, priorities and timeframes for each management strategy. The Estuary Management Plan (Chapter 7) will also provide a mechanism for monitoring and evaluation of the Plan, to ensure that it remains current and effective in the future.

Additional information is provided in the Appendices to this document, where necessary.

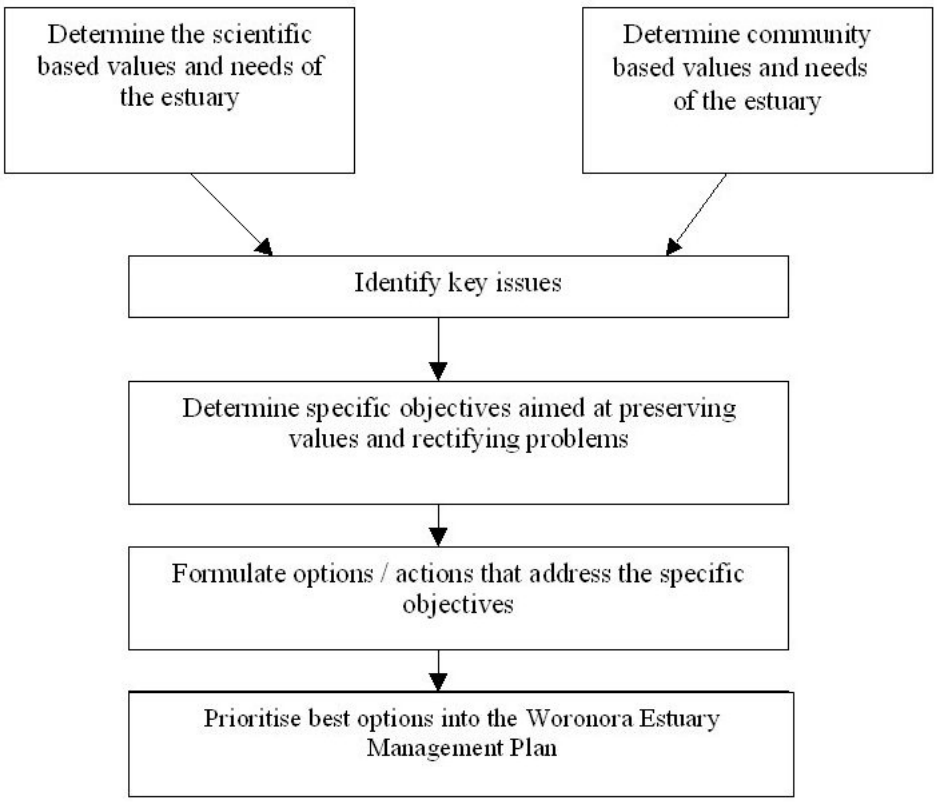

Figure 1-2 Schematic outline of process for developing management strategies

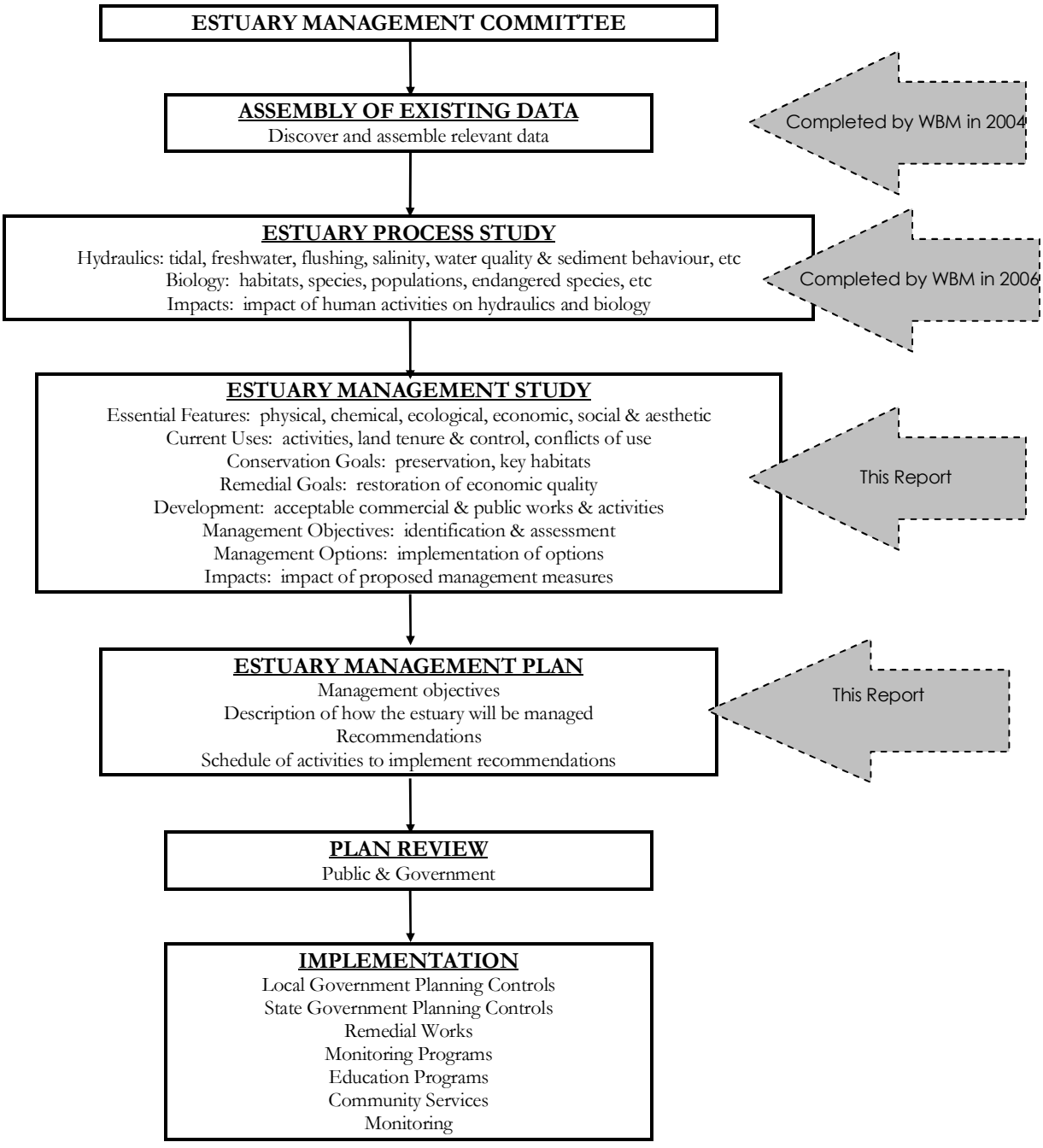

Figure 1-3 NSW Government's Estuary Management Process

1.5 Membership of the Woronora Estuary Management Committee

The Woronora Estuary Management Committee, as established by Sutherland Shire Council, contains representatives from Council, various Government agencies and the community (refer Table 1-1). Other Government agencies are periodically invited to attend Committee meetings depending on the nature of meeting agenda.

Table 1-1 Members of the Woronora Estuary Managment Committee (as of Dec. 2006)

Member	Stakeholder represented
Cr Steve Simpson	Sutherland Shire Council (Chairperson)
Cr Ken McDonnell	Sutherland Shire Council (Deputy Chairperson)
Mike Fursland	Sutherland Shire Council
Gwyn Cleeves	Sutherland Shire Council
Tim Cooney	Department of Environment and Climate Change
Paul Frank	Department of Primary Industries (Fisheries)
Lesley Diver	Department of Primary Industries (Fisheries)
Simon Annabel	NSW Maritime Authority
Tim Gilbert	Department of Environment and Conservation
Simon Heemstra	Community Representative
Doug Patterson	Community Representative
Robyn Davis	Community Representative
Colin Storey	Community Representative
James Higgins	Community Representative

2 PREVIOUS INVESTIGATIONS

The Woronora Estuary Management Plan aims to mitigate existing and future threats to the key values of the Woronora Estuary. Two parallel and related approaches have been undertaken to identify these values and their corresponding threats. First, a scientific approach to understanding the physical, chemical and biological status of the estuary has been undertaken. This has focussed on the existing available information, along with additional scientific investigations (refer Section 2.1). Secondly, a program of community and stakeholder consultation (including government agencies) has been undertaken to identify the existing human uses and demands on the Woronora Estuary (refer to Section 2.2). A synthesis of overall estuary values and threats is provided in Chapter 3.

2.1 Previous scientific investigations

The Woronora Estuary Data Compilation Study (WBM, 2004), compiled, documents and reviewed the existing data, reports and information relevant to the Woronora Estuary. Where relevant, information outside the immediate study area that relates to the Estuary was also considered.

Subsequent to the Data Compilation Study, an Estuary Processes Study was undertaken (WBM, 2006). An overview of the Estuary Processes Study is presented below.

2.1.1 The catchment

Approximately 81% of the Woronora River catchment, including areas upstream of the estuary, remains largely undeveloped and forested. This high proportion of undeveloped bushland may be partially attributed to the steep topography of the incised river valley. The eastern and western sides of the upper Woronora Valley are particularly steep, while the lower catchment (middle to lower estuary) contains narrow river flats that are occupied by residential and urban development. The tidal limit of the estuary is just upstream of 'The Needles', approximately 10 km upstream of the Woronora's confluence with the Georges River.

The Woronora Dam is located approximately 20 km upstream of the tidal limit. The Dam impedes small and medium flood events from reaching the estuary. A reduction in freshwater inflow to the estuary caused by the Dam has resulted in the upper section of the estuary becoming typically more saline.

2.1.2 Tides

The tidal range at the most upstream extent of the Woronora Estuary (Pass of Sabugal) is approximately the same as the tidal range at the downstream end of the Woronora Estuary. An average of 1,600ML of water flows in and out of the Woronora with each tide (occurring twice daily). This volume is significantly greater than the estimated average freshwater flows of approximately 30ML/day. Consequently, the Woronora Estuary is primarily influenced by marine waters, except during times of significant flood. Marine dominance decreases with distance upstream as tidal flushing times increase, and freshwater inflows are more comparable to tidal exchange volumes. The average lag at high tide between the ocean and Woronora Bridge, located in the middle reaches of the estuary, is approximately one hour.

2.1.3 Freshwater flows

An average freshwater flow of about 34,000 m^3/day (or 34ML/day) enters the estuary over a concrete weir at the Pass of Sabugal, Engadine, just upstream of the tidal limit. Highest rainfall in the Woronora catchment typically occurs in February and March, while the driest months occur during late winter and early spring.

Major flood events tend to result in significant elevation of the water levels in the upper reaches of the estuary, with significant water surface gradients between the tidal limit and Forbes Creek (middle reaches) during large events. Downstream of Forbes Creek, the flood waters are able to flow out of the incised river valley and onto adjacent floodplains which contain some residential development (e.g. the suburb of Woronora). River flooding is an issue, particularly where floodplains have been filled to accommodate residential development (such as in the river reaches immediately upstream of the Woronora Bridge and at Bonnet Bay).

After flood events, deeper holes on the outside of river bends in the upper reaches of the estuary may become stratified, with the warmer, fresh catchment waters overlying the colder and more saline marine waters. At other times, the estuary is generally well mixed.

2.1.4 Waves

The narrow, incised and sinuous nature of the Woronora Estuary does not allow significant wind-generated waves to form. Only during an extreme wind condition in the downstream parts of the Estuary would a wave of over 0.5 m in height be expected. Waves of significant size can, however, be generated by boat wash, and are considered to have contributed to current foreshore erosion in some reaches (particularly within the existing 8 knot speed limit zone).

2.1.5 Water quality considerations

The key inputs of nutrients, organics, bacteria and other pollutants to the Woronora Estuary are primarily derived from local catchment runoff following rainfall. Overflows from Sydney Water's sewerage network, particularly during wet weather, may also discharge pollutants to the estuary from time to time.

The quality of the water within the estuary is the resultant of the magnitude of inputs and the in-stream assimilation by biological and chemical processes. Recent monitoring data for the estuary is sparse, and the development of a targeted and holistic water quality and ecological health monitoring program is recommended by this Estuary Management Study.

Water quality data available for the Woronora estuary and catchment (including Council's SWAMP Storm Water Monitoring Program) is biased towards areas of poor water quality, as these locations are targeted for monitoring (e.g. major stormwater outlets). The most recent water quality data is more than 4 years old and may no longer reflect present day conditions. An assessment of the data collected over a 10 year period suggest that water quality is improving, with the majority of sites showing decreasing concentrations of selected parameters (including nutrients, bacterial indicators, BOD and heavy metals). Varying meteorological conditions over this same period (e.g. reducing rainfall) may have convoluted the results, however.

At times, locations within the estuary are not suitable for human contact (particularly in the vicinity of stormwater outlets). Bacterial indicators of risk to human health (enterococci and faecal coliforms) frequently exceeded recreational guidelines in tributaries to the Woronora Estuary.

Nutrient concentrations were also typically elevated, however, but somewhat typical of urban stormwater where the data has been primarily collected.

2.1.6 Sediment properties

The Woronora catchment is characterised by highly erodible sandy soils. Sediment from the catchment is carried into the river during large rainfall events and is redistributed by floods and tides, depositing and reforming shoals.

Overall, the sediments of the Woronora Estuary are relatively clean. This may be attributed to the lack of industrial activity in the catchment and the low fines content of the quartzose sand bed material, which has a low capacity to adsorb contaminants. Acid sulphate soils (ASS) are not a significant issue for the Woronora Estuary due to the mostly incised nature of the system (WBM, 2007).

2.1.7 Dredging

In response to concerns about navigation, approximately 400,000 m^3 of sediment was dredged in the late 1960's and early 1970's from the middle reaches of the Estuary between Forbes Creek and Bonnet Bay. This area has been subject to deposition over the last 35 years and continues to infill at a reducing rate. Dredged sediment was used for filling low lying areas adjacent to the River.

2.1.8 Sediment transport

The Woronora Estuary between the tidal limit and the Georges River confluence is considered to be a 'mature' estuary, meaning that the gross infilling process is basically complete and the amount of sediment that enters the Estuary from the catchment will roughly balance the amount leaving it, when averaged over the long term. Within this dynamic equilibrium, sand continues to move in a dominantly downstream direction, under the influence of intermittently occurring floods.

Issues with navigation associated with variable shoals and sedimentation may be attributed to the natural movement of sediment in response to the dominant hydrological and tidal processes, and increased loads of sediment being delivered to the estuary due to land clearing and catchment development. The Forbes Creek catchment is considered to have contributed a significant sediment load to the estuary over the past 30 years, as a result of urban development during this time.

Given the present rate of sand export from the catchment, periodic dredging may be necessary to maintain navigation within the Estuary. Reducing the sediment load could also be achieved through the installation and maintenance of appropriate stormwater quality improvement devices in the catchment.

2.1.9 Bank condition

Overall, boat wash is considered to be the dominant cause of bank erosion in the Woronora River. This is exacerbated in the downstream reaches of the estuary, where larger and more frequent boat traffic is present, including the vicinity of Janalli Reserve (where previous attempts at foreshore protection have been outflanked by erosion), between Janalli Reserve and the Bonnet Bay Boat Ramp (where mangroves are being substantially undermined) and Lakewood City Reserve at Bonnet Bay.

Boat wash is contributing to erosion as far upstream as Deepwater Estate. Beyond this, however, the main cause of bank erosion is likely to be attributed to rare flood events eroding foreshores that comprise loose sandy material.

Foreshore structures associated with residential development are present throughout the estuary. Overall, the foreshore structures tend to be in a reasonable condition, although there are examples of quite severe dilapidation (e.g. at Illawong, and in the upper reaches near Shackels Estate). In some instances, structures are poorly sited, such as in areas of Bonnet Bay, where inadequate depth is present and floating pontoons sit on the bed at low tide.

2.1.10 Ecology

The Woronora Estuary contains a range of high quality habitats and species of conservation and fisheries significance. While most of the catchment and foreshore vegetation has been retained, reclamation activities, bank erosion and foreshore protection works have caused some degree of physical disturbance.

There have been major changes in saltmarsh and mangrove distribution over the past 70 years (WBM, 2007). One aspect of this is the landward expansion of mangroves into saltmarsh areas. Seaward expansion of mangroves into new habitat due to localised sedimentation is also believed to be an issue in some areas (e.g. Mangrove Island).

Seagrass species belonging to the family Zosteracea (eelgrass) was recorded during field inspections. It is possible that a second genus *Halophila,* occurs in the estuary from time to time. *Halophila Ovalis* is a highly ephemeral species, and is commonly found in association with Zosteraceae in eastern Australia estuaries. In general, seagrass beds were recorded on several shoals within the main channel of the fluvial delta and riverine channel zones and within Forbes Creek. Beds are generally small and highly fragmented, albeit with dense cover (50-90%). Comparisons of marine vegetation maps produced at various times showed that there are major differences in seagrass bed distribution and extent, although it is difficult to determine whether this reflects actual temporal changes or differences in mapping methodology.

While commercial fishing (other than the taking of lobsters and abalone in accordance with share management plans) is banned within the Woronora Estuary, recreational fishing is very popular. Commonly caught species include yellowfin bream, Australian Bass, mullet, dusky flathead and luderick. The barrier to fish passage imposed by the weir at the Pass of Sabugal (upstream of tidal limit) is likely to be an issue for fish that migrate between fresh and marine waters such as the nationally protected Australian Grayling and Australian Bass. At the time of writing, a fishway is planned for construction at the pass of Sabugal.

The relatively close proximity of the Ramsar listed Towra Point wetlands and the existence of intertidal habitats suggest that the Woronora Estuary may be an important site for migratory and resident wader birds.

Benthic macroinvertebrate sampling undertaken for the Estuary Processes Study suggests possible nutrient enrichment of sediments within Forbes Creek, given high densities of Capitellidae worms.

Future monitoring of the Woronora Estuary should include biological indicators, such as macroinvertebrate assemblages, estuarine vegetation condition and distribution, and local fish stocks, to provide a more holistic assessment of overall estuary health.

2.1.11 Human Uses

Passive recreational activities such as canoeing, swimming and picnicking are most common in the Woronora Estuary. Some residents in suburbs such as Deepwater and Shackles Estate do not have road access and utilise the estuary on a daily basis to commute to parked vehicles. Commercial activities are very low key and include the Woronora Caravan Park, boat hire facilities and a number of small eateries.

More detail on Human Use is presented in Section 3.4

2.1.12 Heritage

The Aboriginal Heritage value of the Woronora River Estuary and its catchment is significant. This is reflected in the number of sites listed in the Aboriginal Heritage Inventory Management System (AHIMS) Register and the inclusion of one site on the Register of the National Estate. While the location of these sites is considered too sensitive for public release, their protection remains an important consideration for future management.

The Woronora Estuary also has heritage value from a European perspective. More detail on Heritage Issues is presented in Section 3.4.

2.2 Community and Stakeholder Consultation

The development of the Woronora Estuary Management Plan has involved significant community and stakeholder consultation in order to obtain data, listen to concerns and evaluate ideas.

This consultation has included the development of a customised, project-specific website which was established and launched in June 2005. The website provides background information on the study and access to relevant information. The site functionality also allows visitors to register for the project consultation database and to contact the study team.

The web address for the project website is www.woronora-ems.com.au

A variety of future Management Options were canvassed by the community and stakeholders during all phases of the community consultation and those have been integrated into our analysis of potential management options as outlined in Section 6.

2.2.1 Newsletter 1 and Questionnaire

The first community newsletter (refer Appendix B1), which was distributed during the Estuary Processes Study, provided a brief outline of the project and a questionnaire form. The questionnaire was targeted at obtaining any relevant information from the community including photos, flood marks and historical data along with information about their current usage of the waterway, what they like/dislike about the waterway, and suggested options for the future management of the estuary.

The distribution list for this document included around 1037 ratepayers and residents and ten community and stakeholder groups. The community groups contacted were:

- Woronora Precinct Residents Association;
- Woronora River Residents Environmental Action Committee;
- Woronora Life Saving and River Patrol Club;
- Sydney Catchment Authority;
- Woronora River Public School;
- Gandagara Local Aboriginal Land Council;
- National Parks & Wildlife Service;
- DIPNR;
- DPI Fisheries ; and
- NSW Maritime.

179 responses were received. This represents a 17% response rate, which is comparable to the response rate of similar studies.

The results of this consultation have been considered during the development of the Estuary Management Plan.

2.2.1.1 Results of Questionnaire

Activities

The first question asked respondents to indicate which of the listed activities they undertake within the estuary and surrounding lands. It also asked respondents to indicate how frequently they undertake these activities. Their results are presented in Figure 2-1.

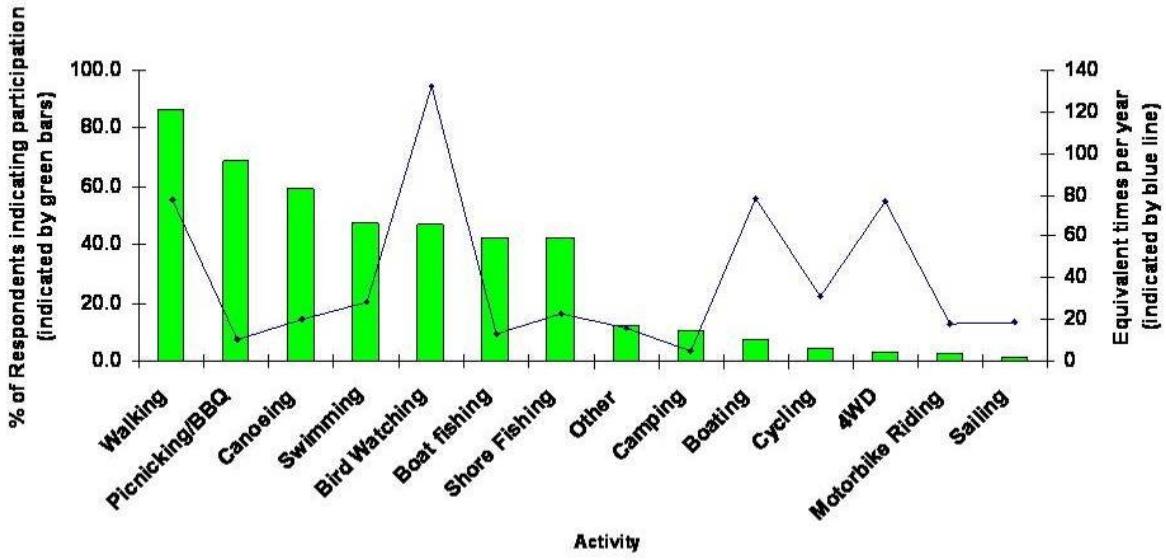

Figure 2-1 Activities undertaken on the estuary by respondents

The questionnaire also provided space for "other" activities to be included. In this section, respondents included activities such as bush regeneration, wildflower spotting and simply "enjoying" the estuary.

Values

The next question asked respondents to rank the degree to which they valued a selection of listed aspects of the Woronora Estuary as high, medium or low. The results of this are presented in Figure 2-2.

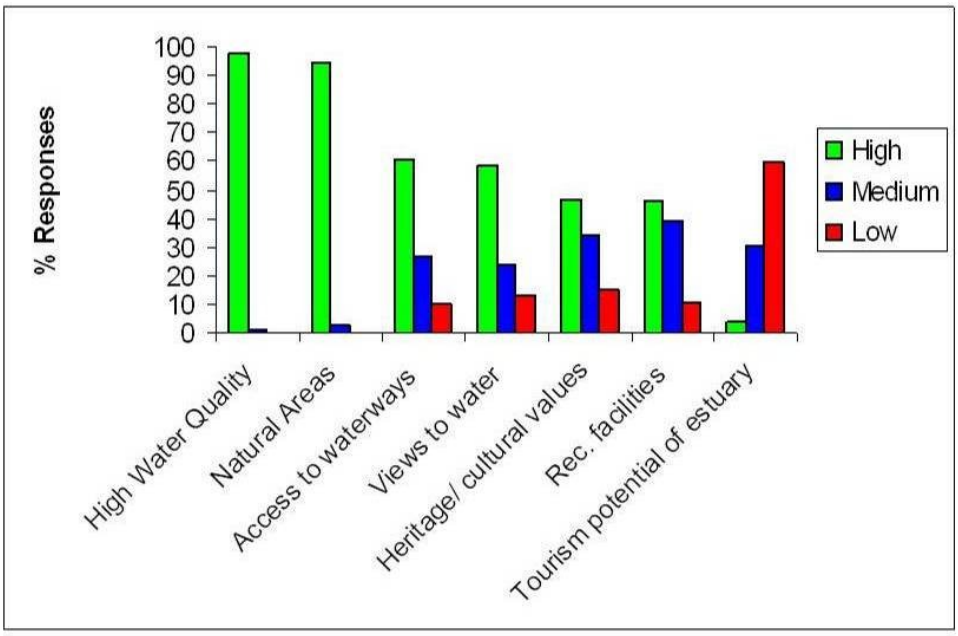

Figure 2-2 Ranking of selected estuary values by respondents

Issues of concern

A list of possible issues was also provided for respondents to rank as high, medium or low. The results of this are presented in Figure 2-3.

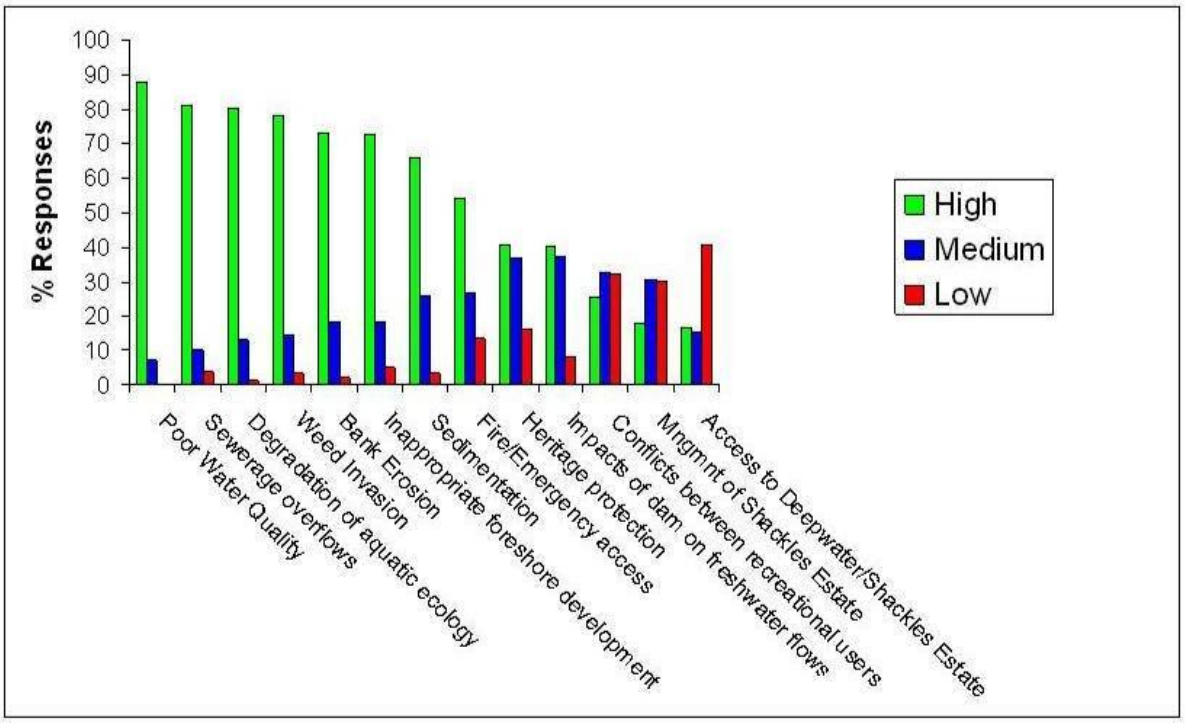

Figure 2-3 Ranking of issues by respondents

Furthermore, some respondents also suggested additional issues, including:

- Opening of the fire trail;
- Boats exceeding speed limits;
- Boat wash and noise;
- Vandalism;
- Rubbish removal regularly;
- Lack of bins;
- Risk of being in flood zone.

2.2.2 Stakeholder consultation

During the preparation of this Estuary Management Study, a letter was issued to stakeholder organisations asking for a response regarding the following:

- Comments on a draft list of values and issues;
- Suggestions for future management of the Woronora Estuary and;
- Any other matters requiring consideration.

The organisations contacted were:

- Internal Sutherland Shire Council (SSC) departments;
- NSW Maritime;
- Department of Environment and Climate Change;
- NSW Fisheries; and
- Department of Lands.

This letter is reproduced in Appendix B3.

2.2.3 Newsletter 2

A second newsletter was sent to community members who had previously indicated an interest in additional consultation. In total, the second newsletter was sent to 136 individuals and organisations. The newsletter was issued during the preparation of the Estuary Management Study, and provided a summary of the findings from the Estuary Processes Study. The newsletter also requested initial feedback on a set of draft management objectives for the Woronora Estuary. The second newsletter is reproduced in Appendix B4.

3 VALUES AND ISSUES FOR FUTURE MANAGEMENT

3.1 Introduction

The Estuary Management Plan is a strategic document aimed at securing long-term sustainability of the estuary with respect to ecological, social and economic values. To develop an effective management plan it is necessary to determine the important 'values' and 'issues' associated with the Estuary.

Values represent those features of the estuary that warrant conservation and/or recognition. The values have been determined from an appreciation of the scientific processes of the estuary, as well as community and stakeholder consultation described in Section 2.2

Issues represent problems with the estuary that need to be resolved in the future. These issues have also been determined through the scientific assessment and the information provided through community and stakeholder consultation.

The values and issues associated with the Woronora Estuary are documented in this Chapter. Many issues have evolved through poor estuary and land management practices in the past, while others relate to the potential impact of catchment practices in the future.

3.2 National, state and regional significance of the Estuary

Regional Significance

The Woronora Estuary is home to at least 87 species of fish, crustacean and mollusc, with 37 species (42% of species) and 64% of total catch comprised of species of direct commercial or recreational fisheries value (Williams and Louden, 2004),

State Significance

The Woronora Estuary catchment contains the following vegetation communities that are listed as Endangered Ecological Communities under the NSW *Threatened Species Conservation Act* 1995:

- Turpentine-Ironbark Margin Forest;
- Paperbark Communities;
- Coastal Saltmarsh.

National Significance

The Register of the National Estate is a listing of places of natural, historic and indigenous significance compiled by the Australian Heritage Commission since 1976. Within the estuary and immediate surrounds, the following items are included:

- an indigenous place in Woronora, (specific details withheld); and
- Como Rail Bridge.

There are also further items of interest to this study that have the status of an "indicative place" on the register. This means that they have been nominated but not yet assessed and registered, or dismissed. These items include the Como Tidal Pool, Como Pleasure Grounds and Prince Edward Park.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) protected matters database lists threatened species and communities of national conservation significance. One fish species of conservation significance, namely, the Australian Grayling (*Prototroctes maraena*) potentially occurs in the wider Woronora estuary. The Woronora River estuary itself is recognised in the EPBC protected database as an area likely to contain habitat for two species of migratory wader birds, namely: Japanese Snipe (*Gallinago hardwickii*) and the Painted Snipe (*Rostratula benghalensis* s. lat.).

3.3 Values of the Estuary

3.3.1 Introduction

The aspects of the Woronora Estuary most valued by the local community, in priority order, are:

- High water quality;
- Natural areas;
- Access to waterways;
- Views to water;
- Heritage and cultural value; and
- Recreational facilities.

(Source: community consultation, refer to Section 2.2).

3.3.2 Threats to estuary values

Compared with other similar estuaries within NSW, and particularly the Greater Metropolitan Region, very few threats to estuary values were identified for the Woronora Estuary. This may be attributed to:

- The large portion of the greater catchment that is "locked up" as either National Park or the catchment area of Woronora Dam;
- The steep topography which limits future development potential; and
- The low key nature of existing foreshore development.

As such, the focus of the Estuary Management Plan will be on proactive strategies to protect existing values.

3.4 Present uses and conflicts

3.4.1 Land use

Catchment land use determines the general quality of the water that runs off the catchment and into the Estuary. Catchment runoff from forested areas tends to have the best water quality, whereas urban runoff is typically characterised by elevated nutrients, sediments and some heavy metals.

During times of intense bushfire, the loss of vegetative ground cover from forested areas exposes the soil to increased runoff, resulting in higher sediment and nutrient loads. Urban areas are also characterised by faster, more concentrated flows from the catchment, which have a greater erosive potential.

3.4.1.1 Historical and present land use

Historical use of the Estuary is discussed in detail in the Estuary Processes Study. Use of the Woronora Estuary by Aboriginal people would have been extensive, as illustrated by the richness of indigenous heritage sites found in the area.

Historical European land use was also analysed using GIS as part of the Estuary Processes Study. On the basis of aerial photography (1930, 1984) and the present zoning of the catchment, it was found that the proportion of impervious land directly draining to the estuary had varied from 6% in 1930, to 13% in 1984 to 28% at present.

The present zoning of the Woronora Catchment, under Sutherland Shire Council's Local Environmental Plan, is discussed in Section 4.3.2. Some areas in the upper extents of the catchment are located within the Wollongong City Council and Campbelltown City Council Local Government Areas.

A large amount of the entire Woronora catchment (~80% - including areas upstream of Woronora Dam) remains in a natural condition (i.e. remnant bushland), while other areas have been developed primarily for residential and associated commercial land uses, with a very small proportion of the catchment currently being used for industrial purposes.

3.4.1.2 Road access

There are two estuary foreshore subdivisions without formal road access. These are Deepwater and Shackels Estates.

Deepwater Estate is an area of houses built very close to the estuary, just upstream of the township of Woronora. The only access to Deepwater Estate is via boat or pedestrian access along a waterfront path. Opposite Deepwater Estate, and extending further upstream, is Shackels Estate. The houses in Shackels Estate tend to be built higher above the waterway than those at Deepwater Estate and have pedestrian and/or vehicular access from unofficial ridgeline roads.

A Fire Trail, closed to public vehicular access, links the suburb of Woronora to Woronora Heights, which is perched on the plateau above the River to the south of Woronora, and north of the suburb of Engadine and is theoretically used for emergency access only. The fire trail cuts through the

ecological corridor linking Heathcote National Park and Loftus, via Woronora to Bonnet Bay, Como, Sutherland and Jannali. A very contentious issue among the local community has been the proposed conversion of the fire trail to a bus link between Bundanoon Road, Woronora Heights, and The Crescent, Woronora. Many residents of Woronora are concerned about the potential for significant future traffic increases through their generally quiet suburb, whereas some residents of Woronora Heights and North Engadine desire the considerable reduction in travel times when heading north that would be gained from construction of the link road. At present, Woronora Heights residents need to travel some distance south before gaining access to the Princes Highway in order to travel northwards to Sutherland and beyond. In 2006, the NSW State Government intervened and rezoned the fire trail, precluding its use for either public or general transport.

While emergency access was considered to be a significant issue for future management among respondents to the community questionnaire, access to Deepwater and Shackels Estate was ranked as the least significant issue of those listed.

3.4.1.3 Shackels Estate Acquisition Program

Shackels Estate was first developed in 1916, on the northern foreshore of the Woronora River between Woronora and The Needles. The area is not serviced by Council roads. The Shackels Estate Acquisition Program was introduced in 1973, with the aim of returning the site to natural bushland.

The acquisition program was reportedly quite rapid in its early stages, with state government providing funds to purchase properties at full market price and Council taking responsibility for decommissioning of existing infrastructure. In more recent times there has been significant opposition to the acquisition program and it was short listed as an important issue in the Woronora Estuary Data Compilation (WBM 2004). By 1997, 291 properties had been acquired through the program and only 23 remained. Consultation with Sutherland Shire Council Planning Department confirms that this remains the case and that three of the remaining properties are heritage listed and therefore will not be removed (Mike Fursland SSC, pers. com. 2006).

The Shackels estate foreshore subject to the acquisition program is shown in Figure 3-1.

The physical removal of buildings and vegetation from properties purchased as part of the program has not been without problems. In many locations, remnants of demolished building materials can be readily found close to the foreshore. The potential that harmful materials such as asbestos still remain on site needs to be considered. Furthermore, the existence of hardy exotic vegetation and land that has been disturbed has resulted in the proliferation of exotic weeds along some areas of foreshore.

Based on the results of the community consultation, management of Shackels Estate does not appear to be a significant concern for future management of the Woronora Estuary to the broader community. Nevertheless, the broader issues of weed invasion and riparian vegetation management are of importance to the community. These are issues that need to be addressed at Shackels Estate.

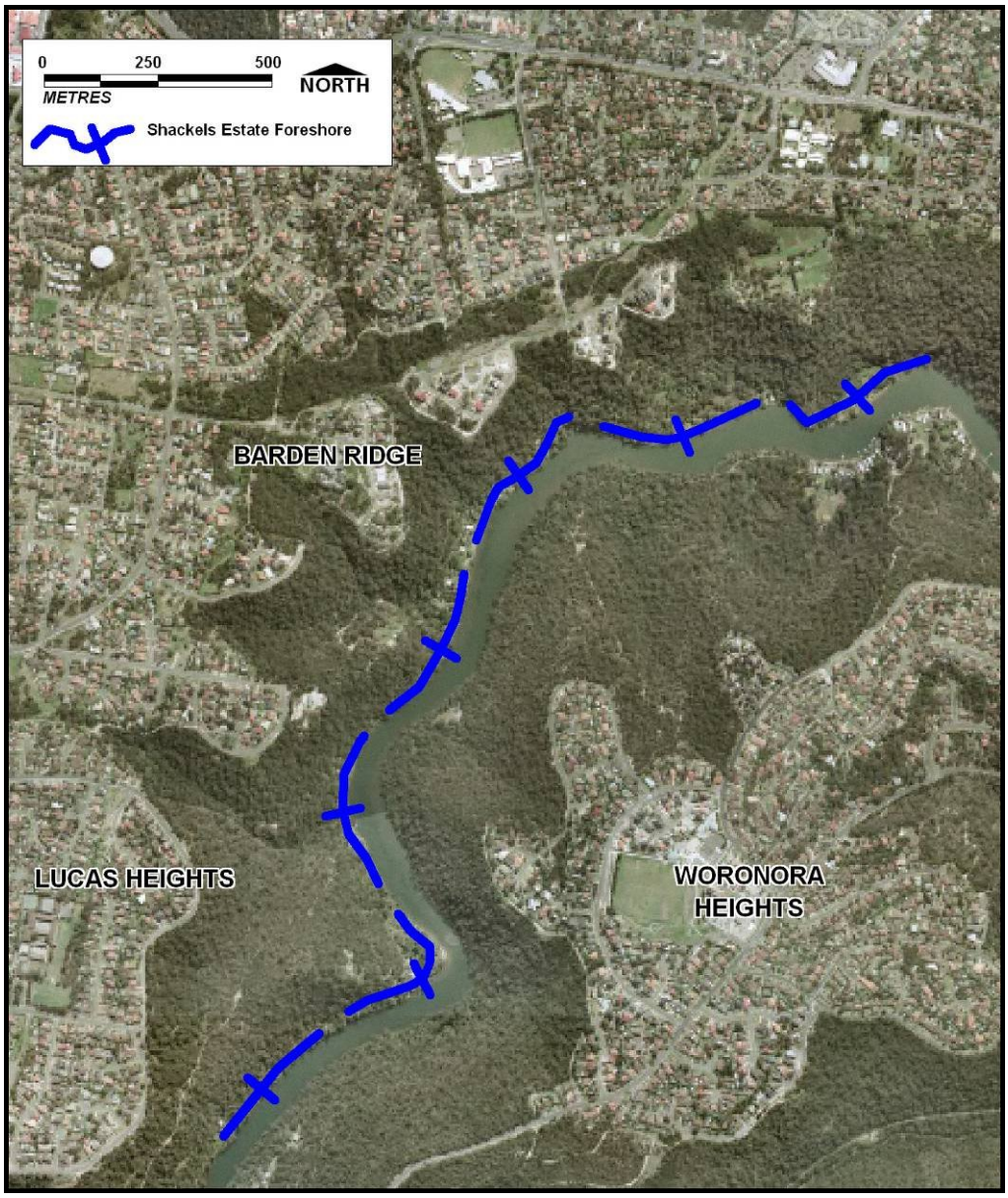

Figure 3-1 Location of Shackels Estate

3.4.1.4 Waterway and Foreshore Usage

Recreational Uses

As discussed in Section 2.2.1.1 passive recreational uses are relatively common in the Woronora Estuary. The most popular recreation activities were identified as picnicking, canoeing, bushwalking along the estuary, bird watching and swimming.

A potential issue for recreational use of the Woronora Estuary may be poor water quality. The Estuary Processes Study has found that bacterial quality of the water in some locations may not be suitable for primary or secondary recreational contact, during certain periods.

Boating is a popular activity on the Woronora Estuary from a recreational and commuting perspective. Public boat launching facilities are located at Bonnet Bay, the Woronora Bridge (Burnum Burnum Sanctuary) and Prince Edward Park. In addition, many private boat launching facilities front properties along the estuary. This includes a boat launching facility fronting the Rural Fire Service (RFS) station, on the western foreshore, between the two bridges. Adequacy of existing infrastructure was not identified as a significant community issue; however, numerous respondents to the questionnaire were concerned about the erosion impacts of boating.

Redevelopment of Prince Edward Park Wharf

Prince Edward Park Wharf is primarily used by residents of Deepwater Estate. Works are presently being undertaken to improve safety standards for use by small commuter craft.

Recreational Fishing

Recreational fishing is a popular activity on the Woronora Estuary, as highlighted by respondents of the community questionnaire (refer to Figure 2-1). Specific data on recreational fishing has not been identified.

The Great Kai'mia Way Project

The aim of the Great Kai'mia Way project is to create a network of walking trails linking river foreshores, parks, bushland reserves, public transport and other facilities in the Georges River region. Opportunities to link management options with this project have been investigated during the development of the Estuary Management Study.

Commercial Interests

Most of the Woronora Estuary has maintained an undeveloped atmosphere, with the few commercial interests. These interests are unlikely to be having a significant impact on the estuary.

Commercial fishing

The Woronora River upstream of the Old Woronora Rd Bridge is closed to all nets. Species of commercial interest are found in the estuary.

Commercial oyster industry

Commercial oyster farming is no longer undertaken in the Woronora Estuary. The oyster industry has been in decline throughout NSW with the peak production of the 1970s of nearly 150,000 bags dropping to about 78,000 bags by the mid 1990s (HRC, 2003). This decline may be caused by a number of influences including decline in water quality, virus scares and the onset of "QX" disease.

QX was first recorded as an issue in the Georges River in 1994 and has lead to the total collapse of the oyster industry in the Woronora Estuary (and Georges River). QX disease is a parasitic infection to the Sydney Rock Oyster caused by a protozoan parasite, *Marteilia sydneyi*. The life cycle of the organism is not well understood. The latest research indicates that QX is present in a dormant state in several oyster growing estuaries. However, what triggers it to go from a dormant state to an outbreak is still unknown. QX is believed to enter the body of the oysters, which are filter feeders, via the gills and lodge in the lining of the gut. Once there, QX can multiply in the stomach of the oyster,

eventually starving it to death (DPI Fisheries, 2004). DPI Fisheries advise that there are some remaining oyster leases in the Woronora Estuary, which are thought to have some heritage value (Tim Gippel, DPI, pers. comm., 2006). The community and stakeholder consultation did not indicate that derelict oyster leases were considered to be an issue for the Estuary.

Tourism

Tourism facilities are limited to the Woronora Caravan Park on Menai Road, the Star Boat Shed (including a Café and boat hire facilities) on Forbes Creek, and a takeaway shop and restaurant to the south of the Old Woronora Bridge. There is also an old scout camp opposite Woronora, upstream of Forbes Creek where camping is allowed for a fee, although this is a very low scale operation.

Holiday rentals are also common within the vicinity of the Woronora Estuary. Specific information regarding the numbers of this style of accommodation and the flow on impacts these may have on seasonal population and associated infrastructure are not available.

Social significance

The Woronora Estuary has significant social value within the local and wider community. The response to the community consultation indicated that for many people the estuary was a key reason for living in the area. The Woronora River RSL, Woronora River Primary School and the scout hall are located very close to the Estuary, with some locals choosing to commute by boat.

There are a number of estuary side reserves that are of significance from a recreational and social perspective. Details of these reserves are given in Table 3-1.

Table 3-1 Estuary side Reserves and facilities (Source: modified from SSEC, 2003)

Reserve	Details	
The Glen and Koolangarra Reserves, Bonnet Bay	• 326m of river frontage • 20ha bushland • zoned *7(b) Environmental Protection Bushland* under 2000 LEP (*Deferred Matter in 2006 LEP*) • Fire Trails/Sydney Water sewer maintenance track	• The Glen Reserve Bushcare Group and Koolangarra Bushcare Group both since 1992 • Passive recreation - bushwalking • Part of SSC Greenweb/endangered ecological community
Arthur Place Reserve, Bonnet Bay	• Council owned • 50m of river frontage • 1ha bushland • zoned Public Open Space (zone 13)	• Arthur Place Bushcare Group since 1997 and Nixon Place Bushcare Group since 1993 • Passive recreation - bushwalking, swimming, fishing • Part of SSC Greenweb
Burnum Burnum Sanctuary (Jannali Reserve)/ Bonnet Bay Reserve, Jannalli	• Crown Land managed by SSC • 1,500m of river frontage • 65ha bushland • zoned 7(b) and 6(a) under 2000 LEP, *Environmental Protection Waterway, Public Open Space Bushland, Public Open Space,* and *Deferred Matter* und 2006 LEP. • Boat ramp facilities • Car park • Baseball field • Playground and picnic facilities	• Pedestrian link with adjacent Glen Reserve • Streamwatch monitoring in stormwater pond • Jannali Reserve Bushcare Group since 1993, Jannali Reserve (Tyler Place) Bushcare Group since 1999 and Jannali Reserve Boat Ramp Bushcare Group since 2000 • Passive recreation - bushwalking, swimming, fishing, playground • Part of SSC Greenweb
Prince Edward Park	• Crown land managed by SSC • 600m of river frontage	• soccer, rugby and cricket fields • boat ramp, parking facilities

Reserve	Details	
	• 800m Forbes Creek frontage • 45ha bushland and open space • zoned Public Open Space (bushland) • Known Koala habitat • BBQ facilities • Walking track system linking Sutherland and Woronora • Prince Edward Park Bushcare Group since 1993 • Passive recreation - bushwalking, swimming, fishing • Part of SSC Greenweb	• public toilets • pedestrian bridge over Woronora River • Scout Club • Royal Lifesaving Club • Playground
Lakewood City Reserve, Bonnet Bay	• Council owned • 735m of river frontage • 2.8ha bushland • zoned Public Open Space	• sports oval • tennis courts • car park • passive recreation - picnicking, fishing, swimming
Forbes Creek Woronora to Engadine	• Crown land managed by SSC • 1000m Forbes Creek • >60ha bushland • zoned 7(b) under 2000 LEP, Deferred Matter under 2006 LEP	• Forbes Creek Woronora Bushcare Group since 1996, Upper Forbes Creek Bushcare Group since 1996, Forbes Creek South Bushcare Group since 2002, Croston Road Bushcare Group since 2002 • Part of SSC Greenweb
Woronora River Reserve, Woronora	• Crown land managed by SSC • 860m of river frontage • 22ha bushland	• zoned 6(a) • Passive recreation - fishing, boating, bushwalking • Part of SSC Greenweb
Prices Circuit, Woronora	• Crown land managed by SSC • 400m of river frontage • 1.5ha public open space • zoned as *Public Open Space* • seawall	• car park • BBQ facilities • Playground • Picnicking • Passive recreation - fishing, swimming
Prices Circuit Reserve, Woronora	• Crown land managed by SSC • 1,000m of river frontage • 25ha bushland • Zoned as *Public Open Space Bushland* • part of SSC Greenweb - known Powerful Owl habitat, Endangered Ecological Community	• Fire Trails • Woronora Public School Bushcare Group • Passive recreation - boat landing, fishing, swimming, picnicking
River Road Public Jetty, Woronora	• Council owned • 12m of river frontage • public jetty • Boating access to Deepwater Estate properties	• Car park • Public toilet facilities • Passive recreation - fishing, swimming
Shackels Estate Reserve	• Council owned • 100m of river frontage	passive recreation - boat landing canoeing, fishing, swimming

The Woronora community has an isolated village atmosphere, despite the townships proximity to metropolitan Sydney. The construction of the high level bridge has effectively removed much of the traffic from suburban streets, adding to the village feel.

3.4.2 Human impacts and conflicts

Human activities have had some impact on all environmental processes associated with the Woronora Estuary. Table 3-2 presents a brief summary of key human impacts. Note that this summary is limited to the current understanding of estuarine processes, which is restricted by available data and scientific knowledge.

Table 3-2 Identified impacts of human activities on estuarine processes

Process	Key Human Impacts
Water Quality	Catchment inputs (including runoff and sewerage overflows) contributing to high nutrients, high bacterial contamination and elevation of some heavy metals in the water column
	Tidal intrusion from the Georges River contributing to high nutrients, high bacterial contamination and elevation of some heavy metals in the water column
	Woronora Dam – reduced freshwater flows increasing salinity in upstream reaches of estuary
Hydrodynamics	Dam regulation of freshwater flows – small to medium floods no longer reaching the estuary
	Dredging of entrance sand spit – increased tidal prism
	Possible contamination of groundwater from industrial leachate – unconfirmed
	Filling of floodplains to allow residential development- altered flood patterns
	Construction of Woronora Bridge-localised increase in flood levels of 0.03 m
Ecology	Dam construction – reduced connectivity between fresh and estuarine areas
	Reclamation loss of shallow sandy shoal, and wetland habitat (e.g. Bonnet Bay)
	Increased tidal prism due to removal of sand shoal and sedimentation due to catchment development contributing to mangrove encroachment upon saltmarsh areas
	Declining water quality impacting on resident ecology
	Sabugal Pass Weir interrupting fish passage
	Edge effects of development
	Potential impacts of recreational fishing on fish stocks
	Foreshore protection works replacing natural habitats
Sediment and Erosion Processes	Catchment development – increase in sediment loads
	Boat wake causing erosion of the banks
	Reclamation and associated vegetation removal weakening banks and increasing sedimentation

3.5 Management Issues

A brief description of the key management issues for the Woronora Estuary, based on the scientific investigations and consultation described in Section 2, is provided below. Nine key issues have been identified.

3.5.1 Water quality

3.5.1.1 Issue A: Unsuitable water quality conditions

At times, locations within the estuary experience a decline in water quality that is not compatible with human recreation or good environmental health requirements. Bacterial indicators of risk to human health (enterococci and faecal coliforms) frequently exceed recreational guidelines in tributaries to the Woronora Estuary. This can be attributed to overflow of the sewerage system and stormwater runoff. Nutrient inputs may also be contributing to nuisance algal growth. Unlike many other estuaries, where clean ocean tidal waters have a key role in flushing pollutants from upstream areas, tidal exchange from the Georges River may actually be supplying pollutant loads to the Woronora Estuary, and may not always be beneficial to improving water quality within the estuary.

3.5.2 Ecology

3.5.2.1 Issue B: Decline in saltmarsh and seagrass

There has been a decline in saltmarsh as a result of foreshore reclamation, foreshore structures and mangrove encroachment. Processes that may be contributing to the loss of seagrass for the Woronora Estuary include water quality degradation and disturbance by boat wake and disturbance by propellers. Current and historical mapping of seagrass areas are not available, making it difficult to assess the extent of this issue.

3.5.2.2 Issue C: Interruptions to fish passage

The Sabugal Pass Weir barrier to fish passage is considered an issue for fish that migrate between fresh and marine waters such as the Australian Bass and the nationally protected Australian Grayling. There is already some work being undertaken to address this issue by DPI Fisheries and Sutherland Shire Council. The site was identified by the DPI as the sixth highest priority in the Sydney area for removal. An assessment of the site has been undertaken by DPI and a remediation response proposed. The aim of the proposal is to increase the frequency of events that allow fish to pass the site by reducing the height of the barrier.

3.5.2.3 Issue D: Potential decline in wader bird species and numbers

The proximity of the estuary to the Towra Point Ramsar listed wetlands and the existence of intertidal habitats suggest that the Woronora may be an important site for migratory and resident wader birds. However, there is limited data available on this aspect.

3.5.2.4 Issue E: Weed invasion of riparian areas

Displacement of native plant species and alteration of habitat values for native fauna is an issue along the banks of the Woronora Estuary. An area of particular concern is the Shackels Estate Area.

3.5.3 Sedimentation

3.5.3.1 Issue F: Bank Erosion

Boat wake is considered to be the major cause of bank erosion in the Woronora Estuary. This is particularly a problem in the 8 knot speed limited zones. Erosion hotspots are most pronounced in the downstream reaches of the estuary, where larger and more frequent boat traffic is present, including in the vicinity of Janalli Reserve (where inadequate foreshore protection has been outflanked), between Janalli Reserve and the Bonnet Bay Boat Ramp (where mangroves are being substantially undermined) and Lakewood City Reserve at Bonnet Bay.

3.5.3.2 Issue G: Unfavourable conditions for Navigation

The naturally shoaled nature of the Woronora Estuary makes navigation an issue for boat users. The expectation for a navigable estuary has been created through extensive dredging operations in the 1960's and 1970's. While the Woronora Estuary is extensively filled in sediment terms, sandy sediments from the catchment continue to be transported to the estuary and move slowly through the estuary in response to floods. Navigation issues reportedly restrict emergency bushfire management access to isolated areas.

3.5.4 Information gaps

3.5.4.1 Issue H: Gaps in existing knowledge

A key barrier to managing the ecological resources of the Woronora River Estuary is the absence of recent and historical information on estuarine habitat and fauna assemblages.

Similarly there is an absence of recent and relevant water quality monitoring data indicating 'typical' water quality conditions in the estuary, as well as targeted monitoring during and immediately following catchment runoff events to measure the estuary's response to catchment-derived pollutant inputs.

4 PLANNING AND CONSENT REQUIREMENTS

4.1 Relevant NSW Parliamentary Acts

There are a number of NSW Parliamentary Acts that are relevant to the development of an Estuary Management Plan for the Woronora Estuary. These are:

- *Environmental Planning and Assessment Act 1979;*
- *Coastal Protection Act 1979;*
- *Rivers and Foreshores Improvement Act 1948;*
- *Water Management Act 2000;*
- *Catchment Management Authorities Act 2003;*
- *Natural Resource Commission Act 2003;*
- *Local Government Act 1993;*
- *Fisheries Management Act 1994;*
- *Threatened Species Conservation Act 1995;*
- *Protection of the Environment Operations Act 1999;*
- *National Parks and Wildlife Act 1974;*
- *Crown Lands Act, 1979.*

The significance of these Acts to the future management of the Woronora Estuary is detailed in Table 4-1.

A number of Environmental Planning Instruments are made under the provisions of the *Environmental Planning and Assessment Act 1979*, including:

- State Environmental Planning Policies (SEPPs);
- Regional Environmental Plans (REPs);
- Local Environmental Plans (LEPs); and
- Development Control Plans (DCPs).

These documents are discussed further later in this Chapter.

Table 4-1 Implications of NSW Legislation for the development of management options for the Worornora Estuary

Legislation or planning document	Relevant to the study site	Implications for the development of management options
Environmental Planning and Assessment Act 1979	Yes	• Is development consent required for management option? • If yes is it designated development? • Where development consent not required assess if significant impact on environment (Part 5) • Consider contributions plans
SEPP 71 (Coastal Protection)	Yes	• Would option be classified as State Significant Development, Significant Coastal Development or Development in Sensitive Coastal Locations?
SEPP 14 (Coastal Wetlands)	No SEPP 14 wetlands in the area	No action
SEPP 26 (Littoral Rainforest)	No SEPP 26 Rainforest in the area	No action
SEPP 35 (Maintenance Dredging of Tidal Waterways)	Yes	• The Policy enables public authorities to undertake maintenance dredging of waterways without the need to obtain development consent. Maintenance dredging means the winning or removal and the disposal of extractive material from the bed of a tidal waterway to enable the waterway to continue to function as a tidal waterway, or to resume its function as a tidal waterway.
SEPP 44 (Koala Habitat Protection)	High quality koala habitat adjoins upper reaches of the estuary	• Unlikely to be a major consideration for estuary management options • Is option likely to impact on Koala habitat?
Rivers and Foreshore Improvement Act 1948	Applicable at time of writing- due to be repealed and replaced by water management act at some unspecified future date	If management options involve: • Excavation on, in or under protected land, or • Removal of material from protected land, or • Obstruct, or detrimentally affect, the flow of protected waters. A part 3a permit may be required.

Legislation or planning document	Relevant to the study site	Implications for the development of management options
Water Management Act 2000	Provisions for approvals of controlled activities not in force at time of writing but due to replace the Rivers and Foreshores Improvement Act permits at an unspecified future date	• Determine if management options would be controlled activities
Sydney Regional Coastal Management Strategy	Relevant to Sutherland LGA	• Implementation Plan should be reviewed for potential management options • Ensure management options are consistent
Coastal Protection Act 1979	Yes	• Part 3 of the Act includes a requirement for public authorities (if notified under section 38) to gain concurrence from the Minister for Environment and Climate Change before any development is carried out or consent is given for the use, occupation or development of the coastal zone. It also provides for general supervision of development within the coastal zone that is not otherwise subject to the provisions of an environmental planning instrument (other than a State Environmental Planning Policy). This will be an important aspect for management options that involve development applications within the coastal zone
Local Government Act	Yes	• Investigate funding options and orders and enforcement to work in with management options
Fisheries Management Act	Yes	• Consider fish habitat protection plans in developing management options • Assess need for permit for dredging/reclamation or damage to marine vegetation
Threatened Species Conservation Act 1995	Yes	• Assess management options potential to harm any animal or plant that is a threatened species, population or ecological community
Crown Lands Act	Yes	• Is management option to be carried out on Crown land (including the bed of the estuary)? • If yes, a Crown lands licence may be required. This would need to be preceded by a Land Assessment to determine appropriate usage of the Crown land parcel. • Any works carried out on Crown land that require development consent will need to be supported by Department of Lands via formal landowner consent.

4.2 Commonwealth legislation

The key piece of commonwealth legislation relevant to the development of an Estuary Management Plan for the Woronora Estuary is the Environment Protection and Biodiversity Conservation Act 1999 (EPBC). Environmental impact assessments for certain activities are required under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) (*EPBC Act*).

4.3 Other important planning documents, policies and initiatives

4.3.1 Georges River Regional Environmental Plan

The Georges River Regional Environmental Plan (REP) influences the land use, environmental planning and management decisions taken when land within the wider Georges River catchment is affected. Development undertaken within the catchment that is likely to affect the environment is subject to the provisions of the Plan.

The broad aims of the REP are:

- Maintain and improve water quality and river flows in the Georges River and its tributaries;
- Protect and enhance the environmental quality of the Catchment for the benefit of all users; and
- Ensure consistency in the delivery of Ecologically Sustainable development when assessing development.

More specifically, the REP notes the following objectives:

- Preserve and protect significant environments (including mangroves, saltmarsh and seagrass), bushland and open space corridors, identifying environmentally sensitive area sand providing for appropriate land use and development controls;
- To preserve, enhance and protect estuarine ecosystems;
- To ensure development is consistent with the aims of the REP;
- To identify land uses with potentially adverse environmental impacts;
- To conserve, manage and improve the aquatic environment by providing controls to reduce pollution entering the watercourses; and
- To protect the safety and well being of the local and regional community by improving water quality and river flows for health and recreation.

Planning principles are highlighted that aim to:

- Avoid or minimise disturbance of acid sulphate soils;
- Protect banks and foreshores from degradation;
- Avoid land degradation including, erosion and sedimentation; loss of native vegetation; deterioration of soils; pollution of ground or surface waters and adversely impacting sensitive natural environments;

- Provision of public access;
- Proper management of on-site sewerage systems;
- Management of Sewer Overflows through appropriate planning and management of development within the catchment;
- Minimisation of stormwater runoff impacts;
- Provision of appropriate buffer widths retained to improve surface runoff;
- Improvement of water quality and river flows;
- Protection of Wetlands.

The REP places controls on extractive industries and maintenance dredging, works associated with stormwater management and sewer works, and development in vegetated buffer areas adjacent to river foreshores.

4.3.2 Sutherland Shire Council Local Environmental Plan, 2006

4.3.2.1 Zoning

The Local Environmental Plan (LEP) provides the broad strategic framework for environmental planning and development control at a local government level. The LEP deals with local issues such as land use controls, approval criteria, urban structure, heritage conservation, protection of environmentally sensitive land and reservation of land for public purposes such as roads and open space. The land use zonings applicable to the Woronora Estuary are defined by the Sutherland Shire LEP 2006 (SSLEP2006). This instrument came into effect on 29 November, 2006. Present landuse zonings around the Woronora Estuary are shown on Figure 4-1.

Residential zonings include the following:

- Zone 1: Environmental Housing (Sensitive Land): which encourages residential development that is sympathetic to the character of and sensitive to the natural environment? This applies to development along the waterfront;
- Zone 3: Environmental Housing (Bushland): which encourages minimisation of risk (primarily from bushfires) and development that is sympathetic to the natural bushland environment. This applies to development along ridge tops and adjacent to bushland areas in the catchment; and
- Zone 4: Local housing: Allowing for low density urban residential development.

Other areas of particular note, adjacent to the waterway include:

- Zone 14: Public Open Space (bushland): which aims to protect public open space areas of environmental significance and bushland in general. This is typically located upstream of the Woronora road bridges;
- Zone 16: Environmental Protection (waterways): This provides for maintaining recreational use and access and protecting aquatic environments.
- Zone 17: Environmental Protection (low impact rural): This enables low impact rural and agricultural development on land not suitable for urban development while aiming to protect the natural environment. This area covers the hillsides below Lucas Heights and Barden Ridge.

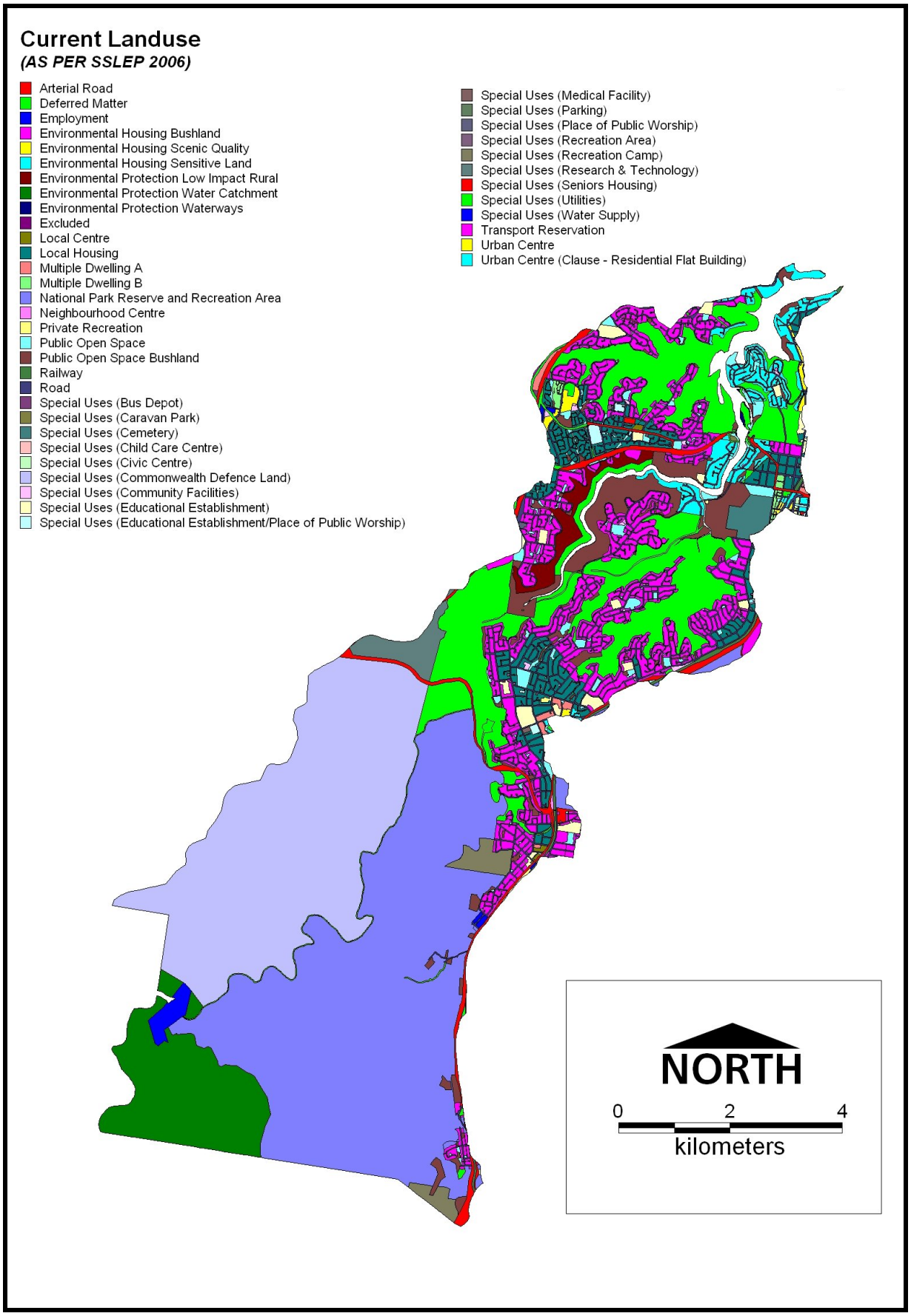

Figure 4-1 Present catchment landuse zonings

A significant amount of land, including Shackels Estate and large parts of the Forbes, Loftus and Still Creek corridors are presently classified as "Deferred Matter" meaning that a decision on final zoning is pending. In this case, reference needs to be made to the zonings of the previous Sutherland Shire Local Environment Plan (2000).

In addition to the major zonings noted above, Lakewood City Reserve and Prince Edward Park are zoned as Public Open Space and there are a mixture of other zones including arterial private recreation, roads (including arterial roads) and special uses.

The bed of the Woronora Estuary is zoned Environmental Protection Waterways (Zone 16) under the LEP. The objectives of this zone, as set out in the development control table, are:

- to recognise the importance of the waterways of Sutherland Shire as an environmental and recreational asset;
- to ensure development is carried out in a way that protects the ecology, scenic value or navigability of the waterways;
- to ensure aquatic environments are not adversely affected by the recreational use of the waterways;
- to allow private development only where it does not reduce or hinder the use of public beaches, intertidal areas or the waterways;
- to provide for viable aquaculture in the waterways.

Development permitted without consent in this zone includes:

- beach and foreshore protection works by or on behalf of the Council (if authorised by a plan of management under the Local Government Act (1993), moorings.
- Development by or on behalf of (or authorised by) the Maritime Authority of NSW for the purpose of maintenance dredging of navigation channels or access channels that provide water access to a lawful commercial, recreational or public facility, navigation aids.

Development requiring consent in this zone includes:

- aquaculture, beach and foreshore protection works (if carried out by a public authority and authorised by a plan of management under the Local Government Act, 1993, berthing areas, ferry operations, marinas, passenger transport facilities, public pedestrian access to facilitate recreational use of the waterway, scientific research associated with native habitats, utility installations (except for gas holders or generating works), watercraft facilities, wildlife refuges. Demolition not provided for in development allowed without consent.

4.3.2.2 Development potential

Further development of the Woronora catchment is restricted by zoning and topography. By comparing the existing zoning and latest air photos it is evident that there are presently four parcels of undeveloped bushland zoned for residential development. The largest of these, zoned as Environmental Housing (Sensitive Land), is located south of the low level Woronora Bridge on the western side of the Estuary in the vicinity of Price's Circuit.

There are also about 150 hectares of land zoned as bushland. As well as zoning, the development potential of the catchment is also a function of land capability (including topography). The parcel of rural land is particularly steep with typical slopes in the order of 1V:2H (i.e. 30 degrees).

4.3.3 Development Control Plans

4.3.3.1 Sutherland Shire Environmental Site Management DCP

This DCP applies to any works that may disturb the ground surface and/or affect public safety. The DCP explains that an Environmental Site Management Plan is required for all Development Applications.

Section 9 of the DCP outlines Environmental Site Management Standards. This includes general requirements related to sediment and erosion control and the following list of general requirements:

- Compliance with the Protection of the Environment Operations Act (PEOA);
- Compliance with Council's Specifications for site management works;
- Installation of erosion and sediment control measures prior to commencement of any activity;
- Maintenance of all erosion and sediment control measures;
- Hay bales are not to be used as sediment control devices; and
- Any sediment deposited on the public way is to be removed immediately.

The Environmental Site Management DCP is a good resource for planners and the public on how to protect the waterways of the Woronora Estuary from erosion and sediment issues associated with developments requiring a formal development application. The detailed guidelines, however, are not statutory and their presence alone will not protect the Estuary. In order for the DCP to be successful, it would need to be supported by site audits and regulatory actions. In this case, the penalties described in the Regulatory Provisions of the DCP may not be severe enough to deter potential breaches of the recommendations made in the DCP.

4.3.3.2 Sutherland Shire Dredging Waterways DCP (SSC, 2002)

The purpose of the Sutherland Shire Council Dredging Waterways Development Control Plan is

"*To make the remedial dredging of identified sites within the 7(a) Environmental Protection (Waterways) zone permissible with development consent, in order to achieve the stated outcomes as listed in the Schedule of this DCP*"

The entire waterway within the estuary is zoned Environmental Protection Waterways. There are two distinctive parts of the DCP. Part 1 provides an introduction to the plan and its application. Part 2 is titled "Controls" and comprises the main body of the DCP. This part provides:

- An outline of the information that is required to be submitted with an application to dredge a waterway,
- A description of the required consultation to ensure that all likely environmental impacts of the dredging of a site are identified and appropriately assessed through consultation with relevant stakeholders prior to determination, and

- A description of the requirement for an *Acid Sulphate Soils Management Plan* to accompany certain dredging development applications.

Management strategies designed in the current document are consistent with the dredging waterways DCP.

4.3.3.3 Sutherland Shire Waterfront Development DCP (SSC, 2002)

The Waterfront Development DCP applies to all development within the Sutherland Shire that is below the Foreshore Building Line and/or along the waterfront, above, on, or below Mean High Water Mark (M.H.W.M). The DCP seeks to allow development that is in harmony with the natural surroundings, which minimises the impact on the natural environment and acknowledges the importance of the waterways as a natural public resource. The DCP outlines a number of objectives and standards that Council must consider in determining development applications. Council can consider a variation of a standard where it is satisfied that despite the non-compliance, the objectives of the DCP are still achieved.

The DCP also provides advice on lodging applications with other government agencies for "integrated development". Integrated development is development that requires an approval, licence or permit from a government agency other than the Council. For waterfront development in the Sutherland Shire Council area this would include:

- A permit from DPI (Fisheries) for aquaculture, dredging or reclamation and removal or damage to marine vegetation;
- A permit from DECC to excavate or remove material from within 40m of the waterway;
- Owners consent from the Department of Lands for structures and works (including dredging) below MHWM; and
- Comments from the NSW Maritime Authority on proposals likely to impact on navigation.

The DCP also outlines the details that need to be included with a development application for lands covered by this DCP in the form of a site analysis.

Watercraft facilities, including jetties, ramps and pontoons are a permissible form of development below MHWM under the Sutherland Shire Council LEP. Controls that apply to these structures are listed in the DCP. These relate to lengths, widths, applicable standards, stabilisation, colours and pedestrian access. Controls for berthing areas and sliprails are similarly defined.

Development allowed below the foreshore building line and above MHWM includes:

- Boatsheds;
- Watercraft facilities;
- In ground swimming pools, no higher than 300mm above ground level at any point;
- Works, including mechanical work, to enable pedestrian access; and
- Landscaping and barbeques.

Controls for each of these are set out in Part 11 of the DCP. Figure 4-2 shows the key steps in applying to undertake a development below MHWM. Note that the old acronym DLWC is used in the figure. This role would now be undertaken by DECC, with owners consent from the Department of Lands.

Development which is prohibited below MHWM includes dwellings, reclamations and boatsheds. Existing dwellings or boatsheds that are below MHWM are intended to be phased out, unless they have heritage significance.

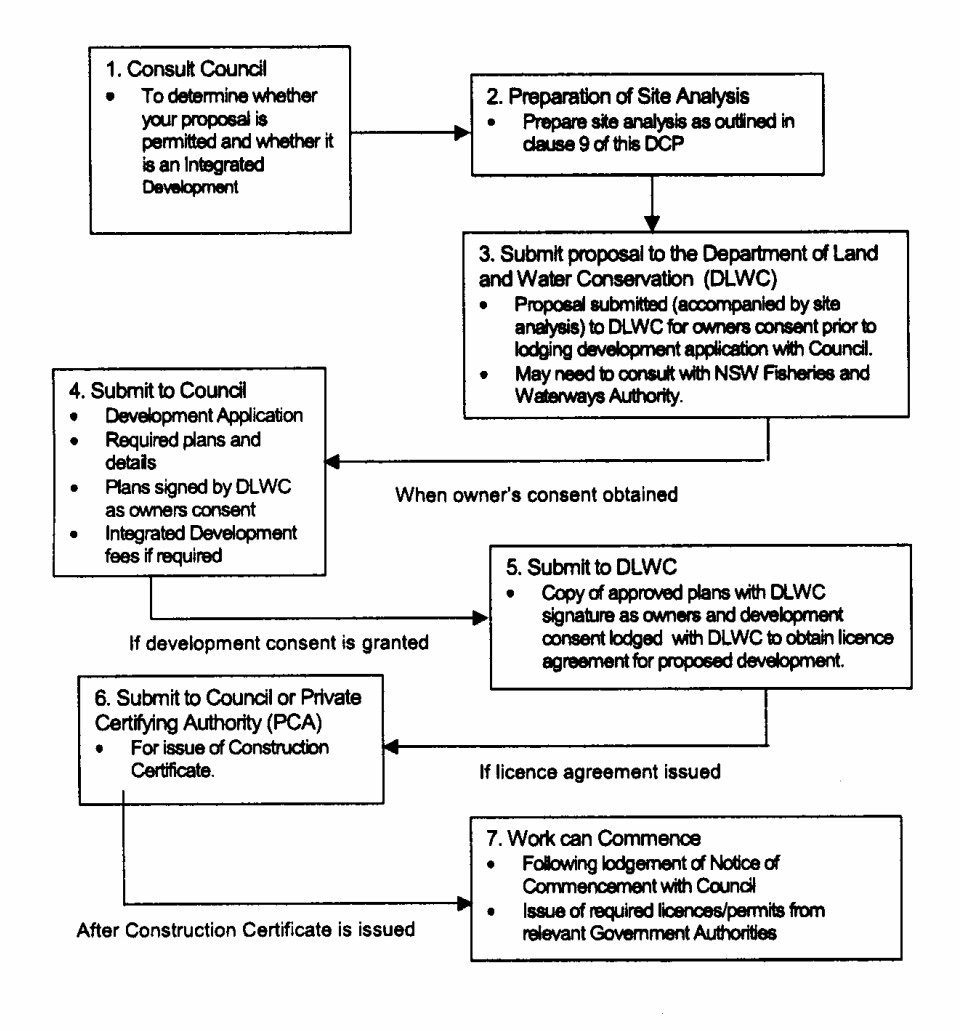

Figure 4-2 The process involved in applying for development consent below MHWM for the Worornora Estuary (Source: Sutherand Shire Council, 2002)

4.3.4 Catchment Action Plan

The Woronora Estuary is within the boundary of the Sydney Metro Catchment Management Authority (CMA). This CMA has not yet developed a draft Catchment Action Plan (CAP). The now outdated catchment Blueprint which covered the Woronora Estuary included an action for the development and implementation of Estuary Management Plans in accordance with NSW Government requirements as the 49th of 90 priorities.

While a CAP has not yet been developed, a series of Draft Catchment and Management Targets, which will ultimately form the basis for the CAP were released in May 2006. Briefly, the targets deal with the following (date of implementation is 2016):

- **Community:** education, better involvement and communication with communities (including indigenous communities) and stakeholders. Ongoing monitoring and evaluation of key natural resource indicators.
- **Biodiversity:** a net increase in the coverage of native terrestrial vegetation in the catchment, including improved condition and connectivity. Better preservation of threatened species and a decrease in the number, distribution and impact of invasive weeds and pest animals.
- **Water:** Improvements in the health of waterways and an increase in the net extent of wetlands. Water quality indicators are to be within the relevant guidelines (i.e. ANZECC) and objectives. There is to be an improvement in the quality and use of groundwater resources and progress is to be made towards achieving an NSW river flow objective.
- **Estuary, Coastal and Marine**: There is to be an overall improvement in the condition of estuaries.
- **Land and Development:** This section deals with the overall prevention of land degradation, including the minimisation of sediment loads to bushland and waterways identification of natural resource land use constraints.

Although the management targets were in draft form at the time of writing this management study, they have been considered in the development of management objectives and options to ensure the best chance of compatibility with the Catchment Action Plan when it is released.

4.3.5 Healthy Rivers Commission Independent Inquiry

The Healthy Rivers Commission (HRC) was established to undertake an independent public inquiry on river systems selected by the government. The Woronora River was one of the original rivers identified for an independent inquiry and due to the connection with the Georges River; the scope was subsequently increased to consider the Georges River as well.

Based on an assessment of the state of the system, the Commission recommended strategies including the following of relevance to the Woronora:

- Increase fish passage;
- Integrated local stormwater management and adoption of water sensitive urban design principles;
- Maintaining public ownership and access to foreshore land;
- Control excessive erosion and sedimentation;
- Replace non-native with native riverbank vegetation;
- Adoption of water quality objectives based initially on the ANZECC guideline trigger values;
- Collection of river health data;
- Establishing a flow regime that will sustain the river's current ecological condition (an initial flow regime was recommended for the Woronora);

- Protection of natural corridor lands in the vicinity of the Woronora Estuary;
- Reducing the impact of sewage and stormwater on the water quality of the river; and
- Reducing the extent and pace of urban weed infestation in the catchment.

The strategies and objectives outlined by the Healthy Rivers Commission have been considered in the development of appropriate objectives and management studies.

The Healthy Rivers Commission (HRC) was discontinued in 2004, with the responsibility for ensuring that the outstanding recommendations of the HRC be implemented passing to the Natural Resources Commission (NRC). The NRC will audit the Catchment Action Plans produced by the various Catchment Management Authorities for adequacy in achieving those objectives. Accordingly, the body that should be consulted with regard to achieving the HRC objectives for the Woronora is the Sydney Metropolitan CMA.

5 GOALS AND OBJECTIVES FOR FUTURE MANAGEMENT

Four (4) overarching goals have been defined for the future management of the Woronora Estuary. These goals define the aspirations of the community and future direction for management with respect to the environmental, social, recreational and economic sustainability and viability of the estuary.

For each goal, a set of well-targeted management objectives has been formulated based on the values of the estuary and the issues/problems facing the estuary, as presented in the previous chapters.

The objectives aim to preserve and enhance the estuary's inherent values while rectifying the problems facing the estuary.

5.1 Water quality objectives

GOAL1: Water quality of the Woronora Estuary should be suitable for a range of environmental and recreational uses

Objective 1 *Reduce the level of pollutant and sediment loads entering the Woronora Estuary from catchment runoff*

Objective 2 *Reduce pollutant and bacterial loads from on-site sewerage systems*

Objective 3 *Reduce pollutant and bacterial loads from sewerage overflows*

Objective 4 *Ensure future activities and development within the catchment do not adversely impact on the estuary*

Objective 5 *Minimise incidences of illegal dumping of waste into the estuary*

5.2 Ecology objectives

GOAL2: Habitats of the Woronora River Estuary should support a diversity of estuarine species

Objective 6 *Ensure upstream flows are adequate to support ecological function of the estuary*

Objective 7 *Identify, protect and enhance key habitat areas*

Objective 8 *Increase fish passage opportunities to allow migration between estuarine and freshwater reaches of the Woronora River*

Objective 9 *Identify and minimise impacts of recreational activities on estuarine habitats and species*

Objective 10 *Remove weeds from bushland areas around the estuary*

5.3 Waterway and foreshore use objectives

GOAL3: Appropriate use of the waterway and foreshores without compromising natural and cultural values of the Woronora Estuary

Objective 11 *Stabilise eroding foreshores, where necessary, to protect assets or infrastructure*

Objective 12 *Minimise bank erosion impacts of recreational and commuter boating*

Objective 13 *Improve and maintain amenity of foreshore reserves, where appropriate*

Objective 14 *Recognise Aboriginal and early European cultural significance of Woronora River Estuary and environs*

Objective 15 *Provide appropriate navigation access along the Woronora River Estuary*

5.4 Monitoring and evaluation objectives

GOAL4: Acquire appropriate knowledge to continually improve management of the Woronora River Estuary

Objective 16 *Water quality monitoring and analysis to establish ongoing suitability of estuary for environmental and recreational uses*

Objective 17 *Ecological monitoring to determine existing and future habitat extents, conditions and community structure*

Objective 18 *Ongoing channel monitoring to identify any compromise in agreed navigational requirements*

Objective 19 *Periodic review and reconsideration of estuary management goals, objectives and strategies to adapt to changing environmental conditions, community expectations, best practice environmental management and government policy*

5.5 Prioritisation of management objectives

The above objectives were provided to members of the Woronora Estuary Management Committee, and a request made to rank the objectives from 1 through to 19. In total, five completed rankings were returned and have been analysed.

Each submission was given equal weighting. The resultant scores were tabulated and added to determine a final prioritisation of management objectives. The final prioritisation of management objectives is provided in Table 5-1.

Table 5-1 Prioritised ranking of Management Objectives

Objective	Priority Rank (1 is most important)
OBJECTIVE 1: Reduce the level of pollutant and sediment loads entering the Woronora Estuary from catchment runoff	1
OBJECTIVE 2: Reduce pollutant and bacterial loads from on-site sewerage systems	8
OBJECTIVE 3: Reduce pollutant and bacterial loads from sewerage overflows	2
OBJECTIVE 4: Ensure future activities and development within the catchment do not adversely impact on the estuary	4
OBJECTIVE 5: Minimise incidences of illegal dumping of waste into the estuary	11
OBJECTIVE 6: Ensure upstream flows are adequate to support ecological function of the estuary	10
OBJECTIVE 7: Identify, protect and enhance key habitat areas	7
OBJECTIVE 8: Increase fish passage opportunities to allow migration between estuarine and freshwater reaches of the Woronora River	15
OBJECTIVE 9: Identify and minimise impacts of recreational activities on estuarine habitats and species	14
OBJECTIVE 10: Remove weeds from bushland areas around the estuary	5
OBJECTIVE 11: Stabilise eroding foreshores, where necessary, to protect assets or infrastructure	6
OBJECTIVE 12: Minimise bank erosion impacts of recreational and commuter boating	9
OBJECTIVE 13: Improve and maintain amenity of foreshore reserves, where appropriate	12
OBJECTIVE 14: Recognise Aboriginal and early European cultural significance of Woronora Estuary and environs	18
OBJECTIVE 15: Provide appropriate navigation access along the Woronora Estuary	3
OBJECTIVE 16: Water quality monitoring and analysis to establish ongoing suitability of estuary for environmental and recreational uses	17
OBJECTIVE 17: Ecological monitoring to determine existing and future habitat extents, conditions and community structure	19
OBJECTIVE 18: Ongoing channel depth monitoring to identify any compromise in agreed amenity	16
OBJECTIVE 19: Periodic review and reconsideration of estuary management goals, objectives and strategies to adapt to changing environmental conditions, community expectations, best practice environmental management and government policy	13

6 DEVELOPMENT, ASSESSMENT AND PRIORITISATION OF POSSIBLE MANAGEMENT OPTIONS/STRATEGIES

6.1 Formulation of Management Options / Strategies

A total of 45 potential management options were formulated and considered to address the 19 management objectives described in Section 5. The management options were developed in consultation with the Woronora Estuary Management Committee and in response to community and stakeholder consultation.

The potential management options are presented below under the same categories as the management objectives: i.e. Water Quality, Ecology, Waterway and Foreshore; and Monitoring and Evaluation.

6.1.1 Strategies addressing Water Quality Objectives (Objectives 1 to 5)

WQ-1 Emergency Plan for Illegal Dumping. This would include the provision of appropriate clean up infrastructure at various locations along the River.

WQ-2 End of Pipe Treatment for Stormwater Outlets. Suggestions include provision of 'meshes' or 'grates' at outlet locations. This would primarily be to trap rubbish.

WQ-3 Restrict Waterfront and Ridge Top Development. The restriction of these types of development could help prevent the exacerbation of any sediment (silt/sand) load coming off the catchment.

WQ-4 Ongoing upgrade and modifications to stormwater system. This may include source control in catchment stormwater, the retrofitting of existing stormwater infrastructure with appropriate stormwater quality improvement devices and sediment traps to protect the river and minimise erosion by controlling runoff velocities.

WQ-5 Locate and monitor all on-site sewerage systems.

WQ-6 Education program including information dealing with the effect of unsealed surfaces.

WQ-7 More effective policing and penalties for people caught dumping waste illegally into the Estuary.

WQ-8 Assess and upgrade Sydney Water's sewerage system to minimise overflows.

WQ-9 Review and revise Council's stormwater policy. This would include reconsidering total water cycle, stormwater harvesting and water sensitive urban design, with particular emphasis on the high erodibility of soils in the catchment and sedimentation in the Woronora Estuary.

WQ-10 Don't open the fire trail. This option was initially considered as a proactive measure to prevent additional runoff from the road introducing pollutants and sediment into the River. This option has now been effectively implemented through rezoning.

6.1.2 Strategies addressing Ecological Objectives (Objectives 6 to 10)

Ecol-1 Construction of an effective fish passage at the Pass of Sabugal. This area is a priority barrier to fish migration for the Department of Primary Industries, and is being addressed at present, although the barrier is not being completely removed.

Ecol-2 Use Bushcare groups to revegetate areas close to and within ecologically sensitive areas.

Ecol-3 Ensure that management of the Woronora Estuary is considered when setting appropriate environmental flow levels. The Sydney Catchment Authority is responsible for managing environmental flow releases, which are licensed by the Department of Environment and Climate Change.

Ecol-4 Targeted bush regeneration at Shackels Estate. There is a proliferation of terrestrial weeds upon properties "bought back" during the Shackels Estate Acquisition Program. A logistical problem may be the presence of asbestos from demolished buildings which may hamper the use of Bushcare to undertake this work.

Ecol-5 Mark key habitat areas at recreational access points to the Estuary.

Ecol-6 Use Bushcare groups to revegetate a riparian buffer zone for the protection of aquatic ecosystems. Provide more protection to riparian zones.

Ecol-7 Mapping study of estuarine vegetation communities (mangrove, seagrass and saltmarsh). This can be analysed spatially to determine proximity to any threatening processes (e.g. stormwater or erosion).

Ecol-8 In developing planning instruments, include upstream buffer zones to allow upward migration of saltmarsh in response to future sea level rise.

Ecol-9 Foreshore structures designed to minimise impact on aquatic vegetation.

Ecol-10 Additional promotion of Green Web program to protect the important ecological corridor in the Forbes/Loftus Creek areas.

Ecol-11 Community Education Program on Ecology and Heritage.

6.1.3 Strategies addressing Waterway and Foreshores Objectives (Objectives 11 to 15)

W&F-1 Replace and/or improve speed limit signs. The aim is to ensure that waterway speed limits are obvious, as boat wake is almost definitely the main cause of foreshore erosion.

W&F-2 Moderate, targeted and ongoing dredging with regular monitoring and appropriate safeguards. Dredging is the most commonly recommended strategy from community respondents. The need for dredging has been earmarked at numerous locations along the entire Estuary, including: near Bonnet Bay, within Forbes Creek, areas upstream of Deepwater Estate (for fire access) and the entrance shoals.

W&F-3 Extensive Dredging. One community respondent has made particular reference to the loss of seawalls following extensive dredging during the 1970's and 1960's and this would need to be considered, along with the loss of seagrass. Some consider that major sedimentation has resulted from activities during construction of the new Woronora Bridge and that this needs to be addressed.

W&F-4 Education of boaters on speeding and the damage it does. This could include appropriate signs at points of access to the Estuary. Leaflets could be distributed at various commercial and retail establishments on the Estuary.

W&F-5 Change speed limit to 4 knots within the Estuary or review speed limits in the vicinity of eroding foreshores (introducing no-wake zones where appropriate).

W&F-6 Exclude large boats. Large boats are implicated in causing boat wake erosion. Of particular note is Council's waste barge.

W&F-7 More frequent and effective policing of waterway users.

W&F-8 Soft protection of eroding foreshores. This may be appropriate in more natural areas such as those fronting the scout camp or areas fronting mangroves stands.

W&F-9 Hard protection/repair of existing foreshore structures. Areas where this needs to be targeted include Janalli Reserve (Burnum Burnum Sanctuary) and Prince Edward Park, where tidal inundation during king tides is also an issue.

W&F-10 Community education program targeting sedimentary processes, enabling people to understand what causes sedimentation.

W&F-11 Upgrade PEP Wharf – After considerable effort, it appears that this project is now to go ahead, albeit at a much reduced scale than originally anticipated.

W&F-12 Upgrade public facilities in reserves, e.g. near public boat ramp at Prince Edward Park.

W&F-13 Prepare Council policy on erosion and sedimentation within Catchment (note that this could be included in a review of the stormwater policy see option WQ-9).

W&F-14 Clean up foreshores campaign to educate and encourage private land owners to take pride in their community and tidy up areas fronting their properties. This could be done in conjunction with Council assistance.

W&F-15 Restrict/prevent additional development of foreshores.

W&F-16 Ban wakeboarding.

W&F-17 Construct a right of way fronting all foreshore properties through a buy back scheme.

W&F-18 Construct groynes along southern bank of Forbes Creek near confluence with the Woronora and dredge to clean up creek and move flood flows away from residential properties.

6.1.4 Strategies addressing Monitoring and Evaluation Objectives (Objectives 16 to 19)

M&E-1 Undertake survey on recreational fishing.

M&E-2 Water quality monitoring program.

M&E-3 Ecological health monitoring program.

M&E-4 Hydrosurvey monitoring.

M&E-5 Monitor stormwater quality devices (perhaps to determine origin of any bacterial parameters).

M&E-6 Periodic review of Plan implementation progress.

6.2 Assessment and prioritisation of possible management options

As presented above, 45 possible management options have been considered to potentially address the objectives of the Estuary Management Plan. The greatest benefit to the estuary will be gained if the most effective options are implemented first. Consequently, in order to determine the most effective options, a multi criteria decision making process has been adopted to compare and prioritise the 45 management options.

Preferred management options have been determined considering the following criteria:

1. Effectiveness of the option in addressing specific management objectives;
2. Acceptance of the option by community and stakeholders;
3. Cost of the option;
4. Number and priority of objectives that the option meets;
5. Requirements for completion of other management options;
6. Options should include a range of different implementation approaches; and
7. Options should include a range of different implementation timeframes.

For criterion No. 6, 'different implementation approaches' include:

- Administration;
- Education;
- Investigation and Review;

- Planning and controls;
- On-ground Works; and
- Monitoring

For criteria No. 7, the different timeframes considered, include:

- Immediately (next 6 – 12 months);
- Short Term (1 – 3 years);
- Medium term (3-5 years); and
- Long term (5-10 years).

Most of the information used in the decision making process was obtained from the community and stakeholders groups via feedback from questionnaires and discussions, particularly regarding the first two criteria.

The preferred order of implementation is considered to represent the most effective approach to managing the estuary from an outcomes viewpoint.

6.2.1 Results of the multi criteria assessment

The result of the multi criteria assessment, including a more detailed description of the way in which the assessment was undertaken is provided in Appendix A. Figure 6-1 shows a graphical representation of the relative score for the 45 management strategies, from the highest scoring to the lowest scoring. These scores take into consideration the number of objectives addressed by each option, the relative importance (score) of each objective addressed (refer Section 5), the relative cost of implementation, and the relative effectiveness and acceptability of each option. From Figure 6-1 it can be seen that management strategy W&F-7, which involves more frequent policing of the waterway has been given the highest score. The top 10 options include revision of the stormwater policy and DCP to more directly address development and redevelopment within the Woronora catchment, the identification and mapping of sensitive habitats, targeted maintenance dredging of the waterway and other options to protect eroding foreshores.

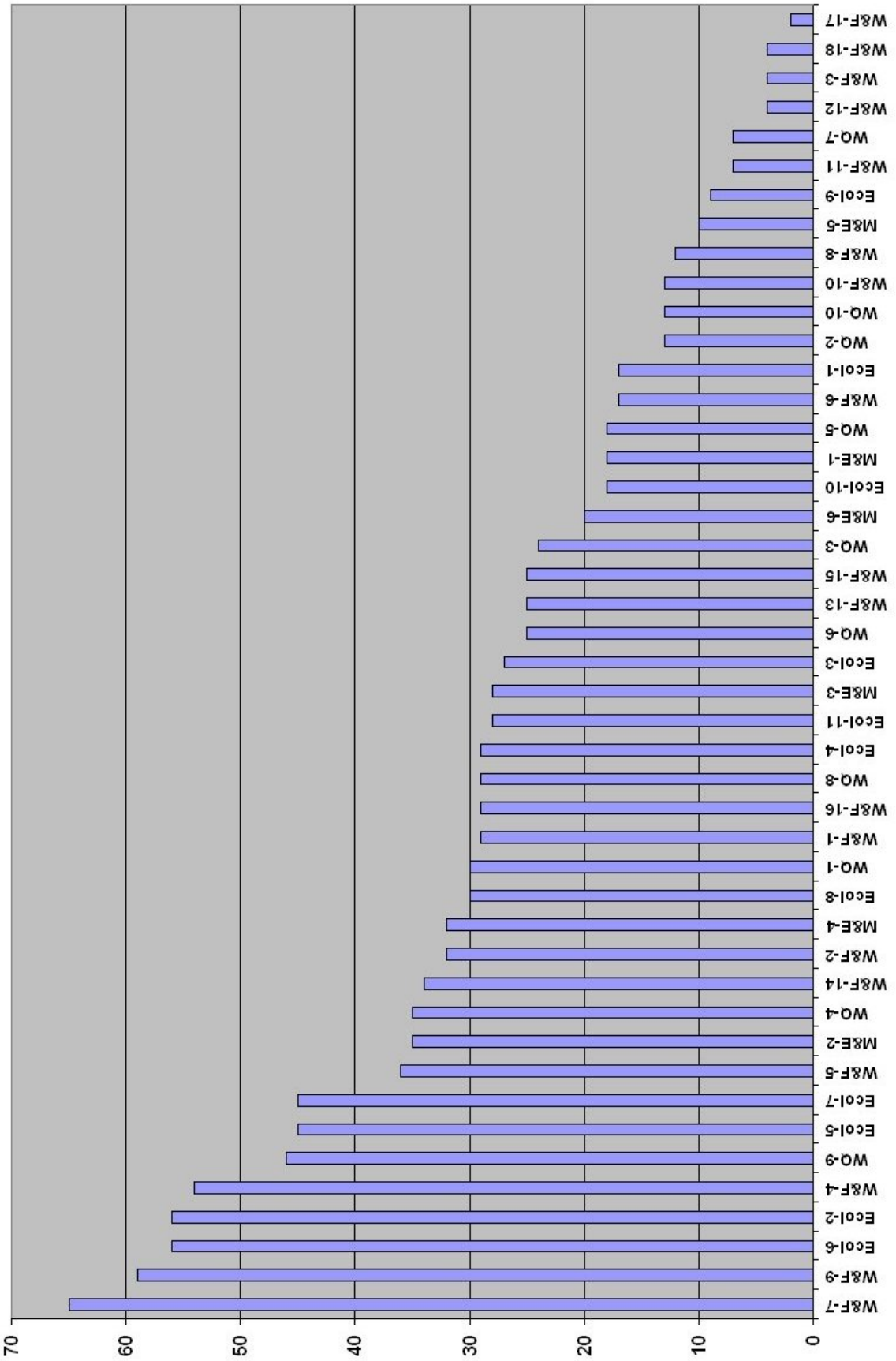

Figure 6-1 Relative Score for Possible Management Options

6.2.2 Short-list of preferred management options / strategies

A short list of twenty six (26) management options has been identified based on the results of the multi criteria assessment (refer Table 6-2). Twenty six options are considered a sensible number for inclusion in the Estuary Management Plan, when factoring anticipated funding and resource limitations.

The short-listed options represent those that have scored the highest in the assessment process, and also represent a range of implementation approaches and timeframes. A number of lower scoring options were also short-listed, to ensure that all the management objectives were addressed by at least one management option, or if a higher scoring option was dependent upon the prior completion of the lower-scoring option. Most options associated with monitoring have also been included to provide a mechanism for future assessment of the Estuary Management Plan. Where there was some overlap, aspects of some lower scoring options have been incorporated into the short listed options (e.g. policing illegal dumping into the River can be achieved at the same time as policing for speeding at minimal additional cost).

Nineteen (19) potential management options were not short-listed. These options should still be considered, however, as well as the non-completed short-listed strategies, during future reviews of the Estuary Management Plan. Reviews of the document will be very important to ensure that the Plan remains relevant, and is considerate of new technologies, approaches and methods for environmental management (i.e. adaptive management).

An options and objectives matrix is shown in Table 6-2. This matrix shows the connection between the defined management objectives and the short-listed management options, as outlined in Table 6-1. From Table 6-2 it can be seen that all objectives are addressed by at least one management option, while most objectives are addressed by multiple options (maximum of 10 options in respect of Objective 9). Most options address two or more objectives.

For comparison, the strategies that were eliminated are listed in Table 6-3. This table includes comments that further justify the exclusion of those strategies at this time.

Table 6-1 Short-List of Preferred Management Options / Strategies

Option No.	Option Description	Relative Score	Management Approach	Relative Timeframe
W&F-7	More frequent and effective policing of waterway users	65	Administration	Immediate
W&F-9	Hard Protection/Repair of Eroding Foreshores.	59	On-ground works	Short
Ecol-6	Revegetation / Protection of eroding foreshores using Bushcare Groups	56	On-ground Works	Immediate
Ecol-2	Bushcare Groups: Revegetate areas close near ecologically sensitive areas	56	On-ground Works	Short
W&F-4	Provide Education to Boaters on the Effects of Speeding	54	Education	Immediate
WQ-9	Prepare Best Practice / WSUD Policy for Catchment	46	Planning and Controls	Short
Ecol-5	Mark key habitat areas at access points to the estuary	45	Education	Short
Ecol-7	Mapping Study of Mangroves, Saltmarsh and Seagrass	45	Investigation and Review	Immediate
W&F-5	Limit Speed Limits in Estuary	36	Planning and Controls	Immediate
M&E-2	Water Quality Monitoring Program	35	Investigation and Review	Immediate
WQ-4	Catchment Source Control	35	On-ground Works	Medium
W&F-14	Community Campaign for Cleaning up Foreshores	34	Education	Short
W&F-2	Moderate, targeted and ongoing dredging with regular monitoring	32	On-ground works	Short
M&E-4	Hydrosurvey Monitoring.	32	Investigation and Review	Immediate
Ecol-8	Introduce Upstream Buffer Zones for Saltmarsh Migration	37	Planning and Controls	Immediate
WQ-1	Emergency Plan for Illegal Dumping.	30	Planning	Short
W&F-1	Replace and/or Improve Speed Limit Signs.	29	Education	Immediate
W&F-16	Ban Wakeboarding	29	Planning and Controls	Immediate
WQ-8	Assess and upgrade Sewerage System to minimise overflows	29	On-ground Works	Long
Ecol-4	Shackels Estate Bush Regeneration	29	On-ground Works	Short
Ecol-11	Community Education Program on Ecology and Heritage	28	Education	Short
M&E-3	Ecological Health Monitoring Program	28	Investigation and Review	Immediate
Ecol-3	DECC to ensure ongoing input to the Environmental Flow Process	27	Administration	Immediate
M&E-6	Periodic Review of Implementation Progress	20	Investigation and Review	Medium
M&E-1	Undertake survey on Recreational Fishing	18	Investigation and Review	Immediate
WQ-5	Locate and monitor all on site sewerage systems	18	Monitoring	Immediate

Table 6-2 Short-listed Management Options / Strategies and Objective Matrix

	Management Objectives																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
WQ-1					√				√										
WQ-4	√			√															
WQ-5		√																	
WQ-8	√		√																
WQ-9	√			√															
Ecol-2							√			√									
Ecol-3						√		√											
Ecol-4										√									
Ecol-5							√		√										
Ecol-6							√			√	√								
Ecol-7							√		√										
Ecol-8							√		√										
Ecol-11							√							√					
W&F-1									√			√							
W&F-2															√			√	
W&F-4									√			√	√						
W&F-5									√			√	√						
W&F-7					√				√			√							
W&F-9							√				√		√						
W&F-14										√			√						
W&F-16									√			√							
M&E-1									√										
M&E-2	√															√			
M&E-3							√										√		
M&E-4															√			√	
M&E-6																			√

Table 6-3 Eliminated Management Options / Strategies

Option No.	Option Description	Relative Score	Comment
WQ-2	End of Pipe Treatment for Stormwater Outlets	13	Has been rolled into a more holistic interpretation of WQ-4 – upgrade of stormwater system
WQ-3	Restrict Waterfront and Ridge Top Development	24	New Development opportunities are already limited
WQ-6	Community Education Program on Unsealed Surfaces and similar catchment pollution mechanisms	25	Probably of limited effectiveness
WQ-7	More effective policing and penalties for people dumping in the river	7	Included with waterway policing (W&F-7)
WQ-10	Don't open the fire trail (note: during completion of this plan, opening of the fire trail is no longer an issue due to rezoning)	13	May be some impact on estuary during construction & operation but consider that this needs to be adequately accounted for if the project goes ahead.
Ecol-1	Construct Fish Passage at the Pass of Sabugal	17	Already Planned
Ecol-9	Foreshore structure design to minimise impact on aquatic vegetation	9	Guidelines are proposed by the CMA draft targets – can be adopted when ready.
Ecol-10	Additional Promotion of the Green Web to Protect the Forbes/Loftus Creek Corridors	18	Expected to be of limited effectiveness.
W&F-3	Extensive Dredging	4	Considered excessive and unlikely to be acceptable to community
W&F-6	Prevent Large Boats	17	Limited depths already achieve this. 'No Wash' zones will address bank erosion
W&F-8	Soft protection of eroding foreshores	12	Not ecologically desirable. Much better to eliminate erosive process (boat wake)
W&F-10	Community Education Program on Sedimentary Processes	13	Community are already largely aware of these issues
W&F-11	Upgrade PEP Wharf	7	Already being done
W&F-12	Upgrade Public Facilities in Reserves	4	Of limited effectiveness in addressing objectives
W&F-13	Prepare Council Policy on Erosion and Sedimentation within the Catchment	25	Can be incorporated into review of Stormwater DCP
W&F-15	Restrict/Prevent additional development of Foreshores	25	New Development opportunities are already limited
W&F-17	Construct right of way fronting all waterfront properties	2	Likely to be cost prohibitive
W&F-18	Construct Groynes and dredge on Forbes Creek	4	Likely to be ineffective and expensive
M&E-5	Monitor Stormwater Quality Devices	10	Can be included in a more holistic WQ monitoring program (M&E 2)

7 WORONORA ESTUARY MANAGEMENT PLAN

7.1 Strategy Implementation Order

The short-listed and preferred management strategies outlined in Section 6.2.2 have been developed further in the preparation of the Woronora Estuary Management Plan, which is contained within this chapter. The strategies have been classified on the basis of their perceived importance (i.e. high, medium or low dependant upon the objective they are addressing) and the time frame within which they can be realistically achieved. This ranking has subsequently been used to develop a proposed order of implementation (refer Table 7-1) Furthermore, some of the initially short-listed items have been rationalised to occur in tandem as they deal with objectives in a similar or overlapping manner.

Table 7-1 Order of implementation for short-listed strategies / options

Strategies

		TIME FRAME		
		Immediate	**Short Term**	**Medium Term**
IMPORTANCE	**High**	Ecol-6 Ecol-0 M&E-4 M&E-2	Ecol-5 Ecol-11 Ecol-2 Ecol-4 W&F-9 WQ-9 W&F-14 W&F-2	WQ-4 WQ-8
	Medium	W&F-0 W&F-7 W&F-4 M&E-1 Ecol-3 Ecol-8 WQ-5	WQ-1	
	Low			M&E-6

Order of implementation

	Immediate	***Short Term***	***Medium Term***
High	***1***	***3***	***6***
Medium	***2***	***5***	***8***
Low	***4***	***7***	***9***

7.2 Implementation Schedules

A program for implementation of the Woronora River Estuary Management Plan has been developed with tasks spanning approximately 5 years. The implementation details for each separate estuary management strategy are provided in the following schedules.

The implementation details are presented in the form of 'schedules', and provide information on specific actions required to implement each strategy, as well as indicative costs, timeframes, maintenance requirements, responsibilities for implementation, and 'performance measures' to define the success of implementation. Comments are also provided for each strategy, which includes background information relevant to the implementation of the strategy and cross-references to other similar strategies.

The schedules are designed to provide the information in a 'quick reference' format to facilitate implementation and adoption by the responsible authorities.

Strategy M&E-6 is considered to be an integral part of the entire plan. Accordingly, it has not been included within the implementation tables but is discussed separately within Section 7.5.

HIGH PRIORITY STRATEGIES

7.2.1 Ecol-6: Revegetation / Protection of Eroding Foreshores

Priority: High

Description/Discussion:

Riparian vegetation is very important for the protection of key aquatic habitats by providing a buffer, and the strengthening of foreshores.

A number of strategies utilising the Bushcare resource and involving bush regeneration and revegetation are considered suitable for the Plan. This particular strategy, involves revegetation and/or other soft protection of eroding foreshores.

The community based Bushcare program has shown to be a successful strategy for weed removal and bush regeneration in the Sutherland Shire. The volunteer input by the community is supported by Council through guidance and supervision by paid Bushcare Officers, training and newsletters. The groups are entitled to apply for grant funding through initiatives such as the Natural Heritage Trust and Environmental Trust. The 2004/5 State of the Environment Report for Sutherland Council reports that the number of Bushcare volunteers in the area continues to grow. The current groups operating along the Woronora Estuary include:

- The Glen Reserve Bushcare Group;
- Arthur Place Bushcare Group; since 1997
- Jannali Reserve Bushcare Group; since 1993
- Jannali Reserve (Tyler Place) Bushcare Group; since 1999
- Jannali Reserve Boat Ramp Bushcare Group; since 2000
- Nixon Place Bushcare Group; since 1993
- Koolangarra Bushcare Group; both since 1992
- Forbes Creek Woronora Bushcare Group; since 1996,
- Upper Forbes Creek Bushcare Group; since 1996,
- Forbes Creek South Bushcare Group; since 2002,
- Croston Road Bushcare Group; since 2002,
- Azalea Walk Bushcare Group; since 2006.

This strategy requires continued support for the Bushcare program with a focus on sites along the Woronora.

The strategy will also take opportunities to work with Council's Greenweb project where appropriate.

The locations of foreshore erosion identified during the Estuary Processes Study are shown on Figure 7-1 and Figure 7-2. The priority areas are located in the northern part of the Estuary (Locations 1, 2, 3 and 4). In addition, Location 7 in the southern Estuary is also a priority area. Strategies would include soft bank remediation methods as appropriate and progressive revegetation with indigenous species.

At present, the walking routes identified as part of the Great Kai'mia Way Project do not incorporate the foreshores in question. Nevertheless, with additional linking trails, there are opportunities to integrate rehabilitation works with this project.

The Woronora Estuary Management Plan should recognise the importance of riparian zones. Accordingly, where possible, changes to existing planning instruments should be made to protect riparian vegetation where it still exists.

Timeframe: Immediately (6-12 Months)

Responsibility: Sutherland Shire Council

Cost: Say $50,000 per year for 5 years

Performance Measure: Length of eroded foreshore (particularly priority foreshore) that is remediated through soft bank treatment and revegetation.

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-6-1	Remediate eroding foreshore at Lakewood City Reserve	☐	☐
Ecol-6-2	Remediate eroding foreshore opposite Bonnet Bay Boat Ramp	☐	☐
Ecol-6-3	Remediate eroding foreshore at Bonnet Bay Boat Ramp	☐	☐
Ecol-6-4	Remediate eroding foreshore at Scout Camp, Opposite Burnum Burnum Sanctuary	☐	☐
Ecol-6-5	Remediate eroding foreshore at Scout Camp, West of Deepwater Estate	☐	☐

See Also: W&F-1, W&F-7, Ecol-2, Ecol-4

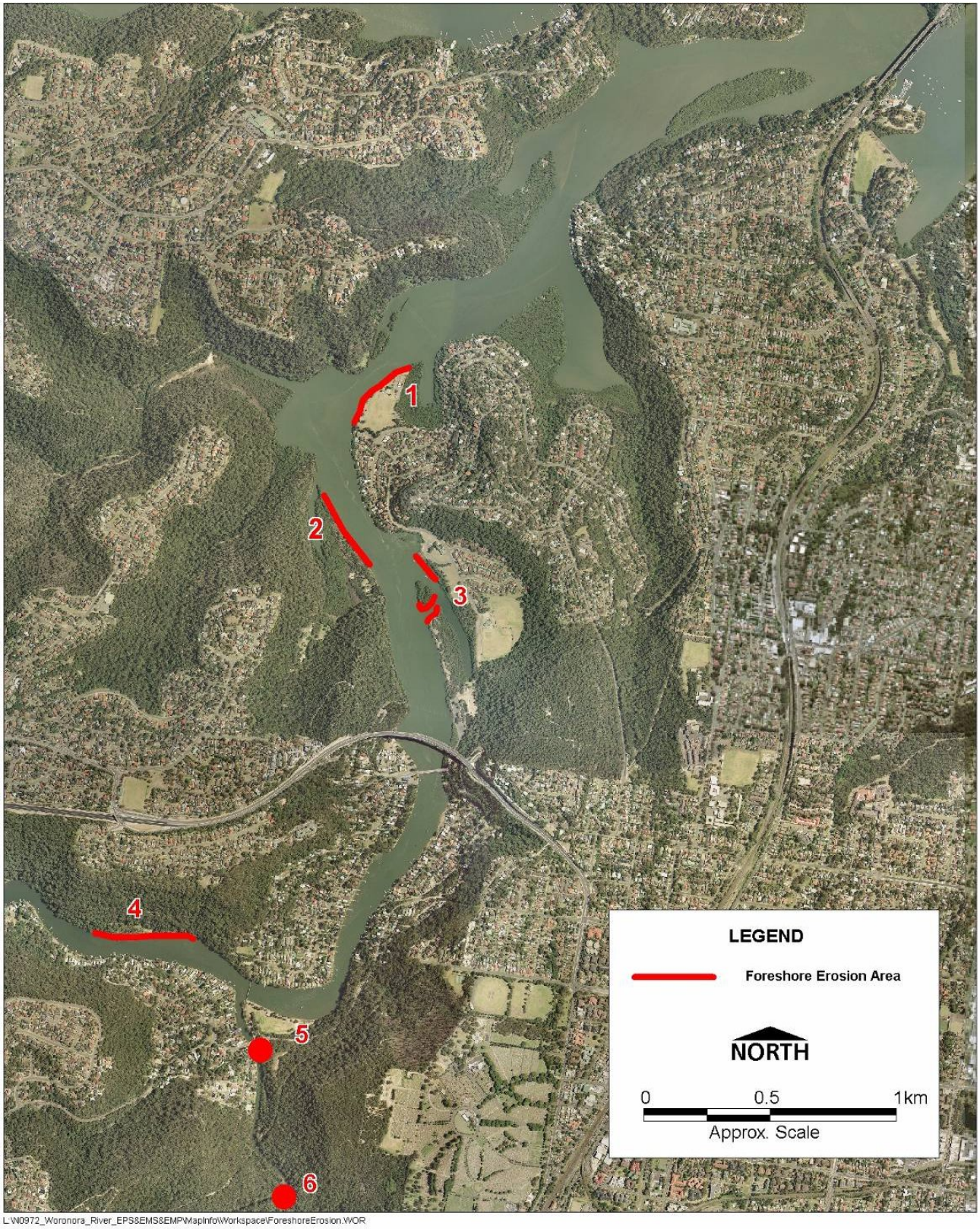

Figure 7-1 Foreshore Erosion Areas: Northern Woronora Estuary

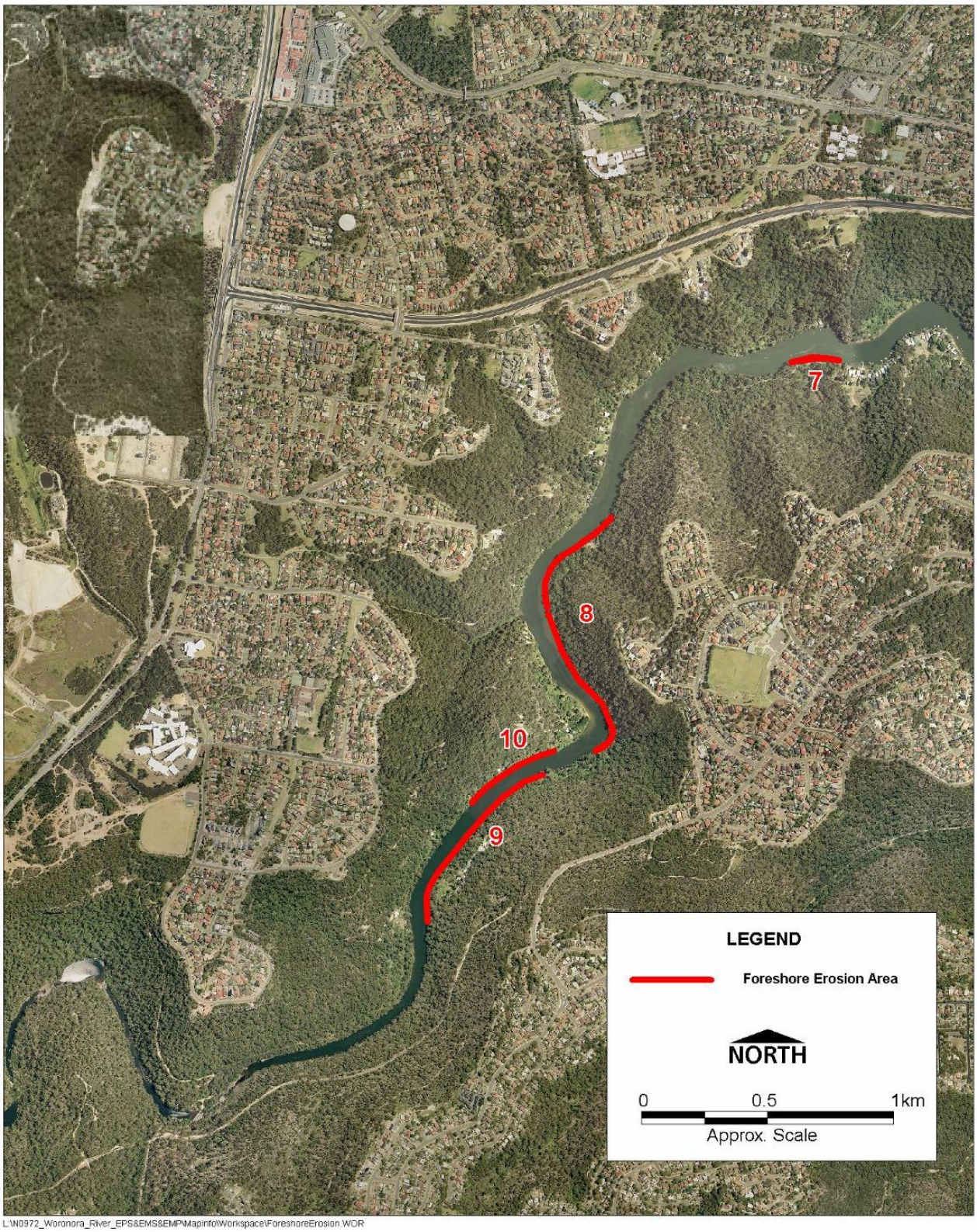

Figure 7-2 Foreshore Erosion Areas: Southern Woronora Estuary

7.2.2 Ecol-0: Mapping and monitoring of ecological communities

Priority: High

Description/Discussion:

This strategy incorporates strategies **Ecol-8:** *Mapping Study of Mangroves, Saltmarsh and Seagrass* and **M&E-3:** *Ecological Health Monitoring Program* from the Estuary Management Study (see Chapter 6).

The two complementary strategies aim to improve the data set relating to ecological communities.

The Estuary Processes Study provided maps of saltmarsh and mangroves (based on fieldwork undertaken during the study and previous research (Pickthall et al, 2004)). These are reproduced as Figure 7-3 and Figure 7-4.

Future monitoring of the Woronora Estuary should include biological indicators, such as macroinvertebrate assemblages and the distribution and health of estuarine vegetation. The distribution and health can be affected by seasonal factors such as wind and turbidity or physical disturbance through sedimentation or boating.

In particular, the following need to be recognised:

- Seagrasses are productive marine flowering plants that stabilise sediments, and provide habitat, food and shelter for many species of fish and invertebrates including those of economic importance.
- Broad scale changes in seagrass over time need to be assessed more rigorously than is possible with existing data. For example, it is difficult to determine whether changes between existing data sets reflect actual changes or differences in mapping methods and effort.
- Estuarine wetlands provide habitats for a wide range of biota including species of fisheries value and conservation significance. Estuarine wetlands also play an important role in bed/bank stabilisation. Estuarine wetlands are highly productive and are important in the cycling of nutrients.
- There is a need to identify and map the existence of threats to estuarine wetland vegetation, including boat wake erosion, proximity to stormwater outlets, clearing activities, reclamation and foreshore structures, the encroachment of mangroves onto saltmarsh areas and weed invasion to identify areas of valuable vegetation that are at risk.
- Coastal Saltmarsh is an endangered ecological community listed on Schedule 1 of the Threatened Species Conservation Act.
- Invertebrates are important ecosystem components, particularly from the perspective of nutrient cycling and transfer of energy through the food web. Invertebrates also form important food resources for many bird and fish species. Macroinvertebrates control nutrient fluxes, which affect benthos community structure and local nutrient concentrations.

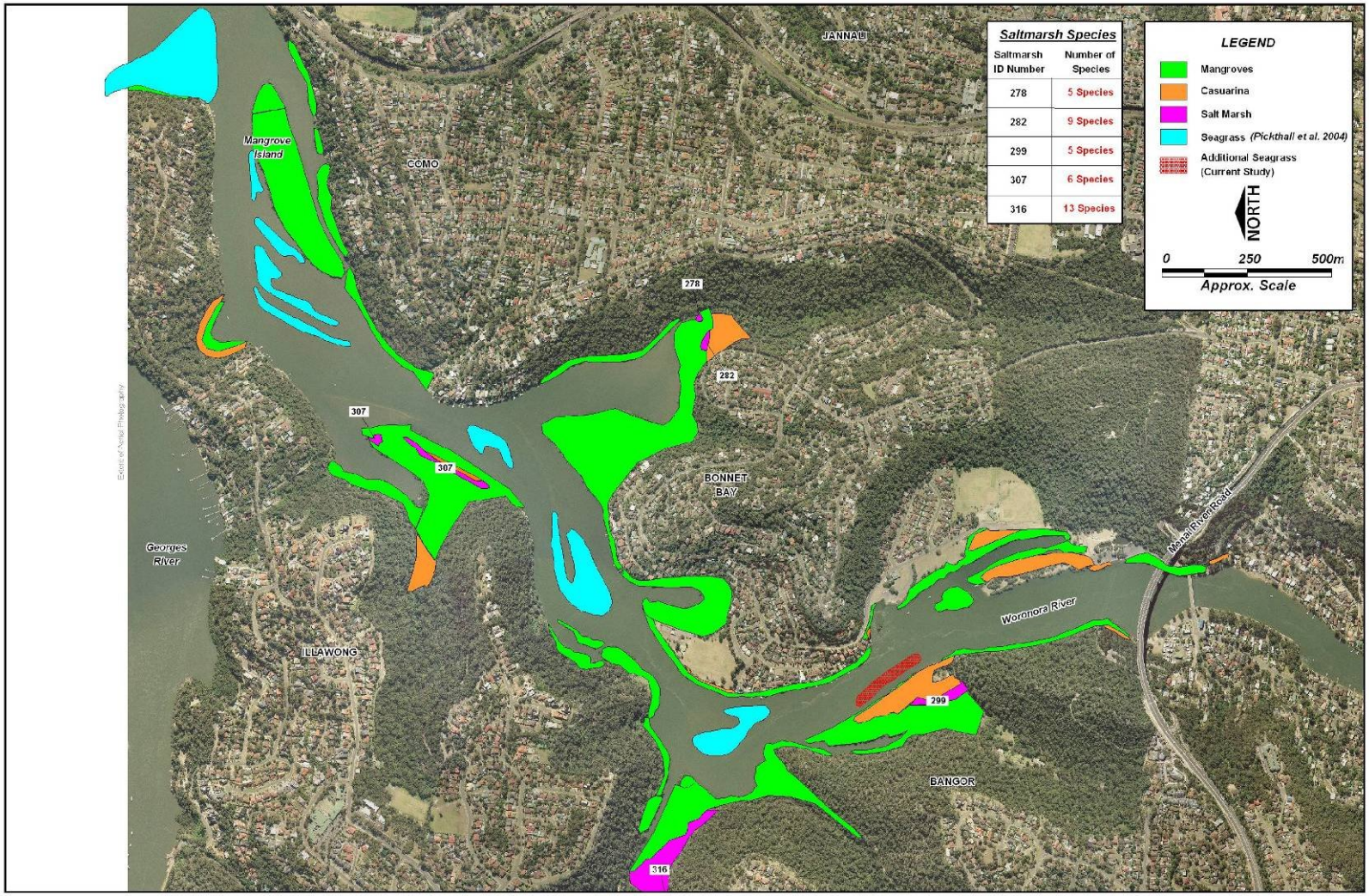

Figure 7-3 Distribution of estuarine vegetation in the fluvial delta geomorphologic zone, Woronora Estuary

Sources: Pickthall *et al.* 2004 (saltmarsh and *Casuarina*), WBM (mangroves) current study

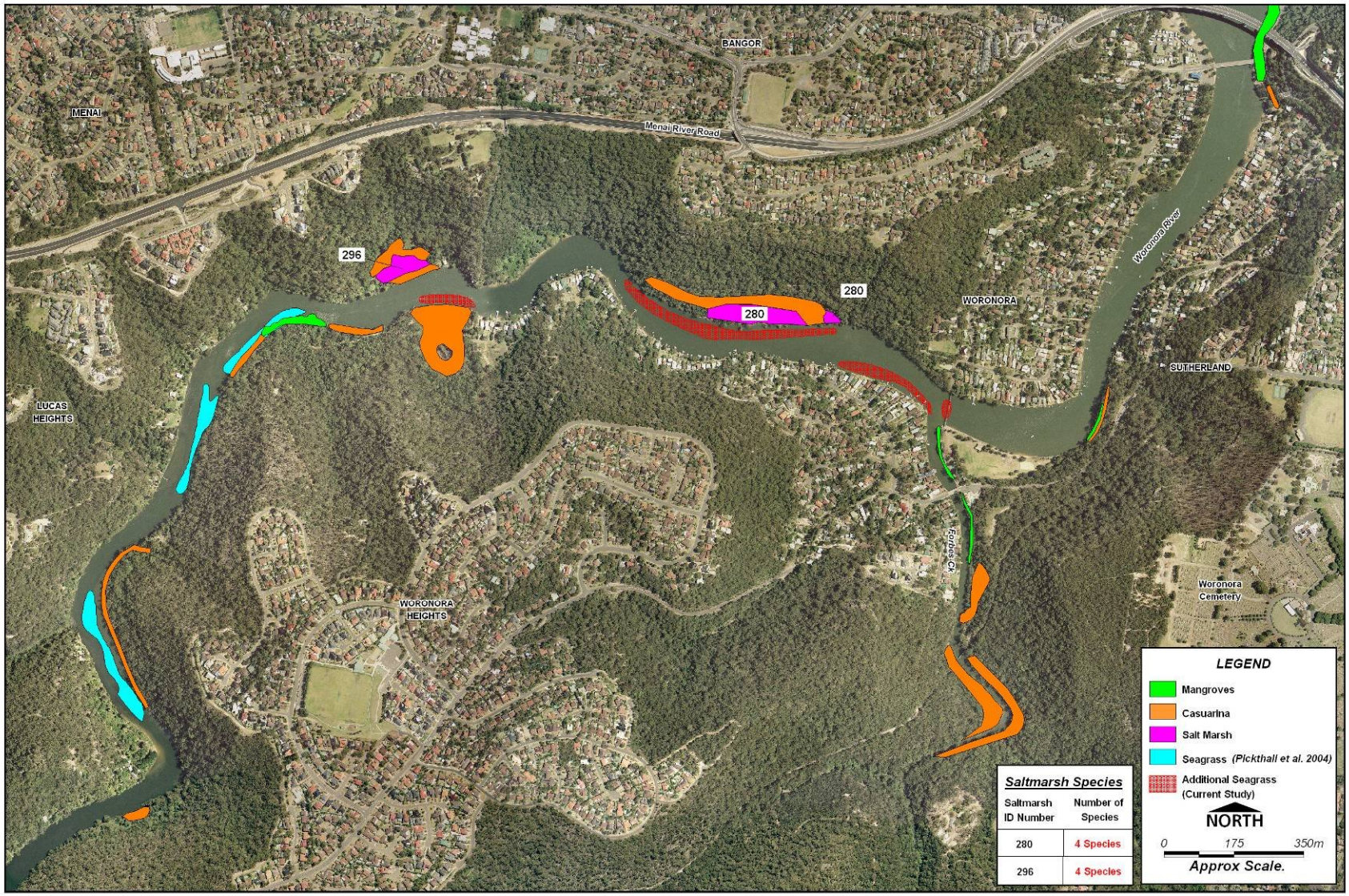

Figure 7-4 Distribution of estuarine vegetation in the riverine and channel geomorphologic zone, Woronora Estuary Sources: Pickthall *et al.* 2004 (saltmarsh and *Casuarina*), WBM (mangroves) current study

- The Woronora River estuary is situated within 10 kilometres of Towra Point Nature Reserve, a *Ramsar* listed wetland and the Woronora River estuary itself is recognised in the EPBC protected database as an area likely to contain habitat for two species of migratory wader birds, namely: Japanese Snipe (*Gallinago hardwickii*) and; the Painted Snipe (*Rostratula benghalensis* s. lat.).
- The shoals at the river mouth, Mangrove Island, and Bonnet Bay could all represent locally important roost and feeding sites for wader birds. This requires further investigation.

Key areas requiring consideration during ecological monitoring include:

- Consideration of water quality monitoring results (refer Strategy M&E 2) to determine possible influences on estuarine community functioning. This should include not only physio-chemical parameters, but also monitoring of biological indicators such as Capitellidae worm densities (to assess potential effects on nutrient enrichment), and seagrass depth range assessments (to assess turbidity and nutrient impacts);
- Monitoring of estuarine wetland condition and extent. There is currently little information of long-term historical changes in these communities, and there is currently no program in place to assess future changes. Given the importance of these habitats for fisheries, and possible reductions in saltmarsh extent in the wider region, this should be a priority issue; and
- Assessment of wader bird habitats and populations in the study area, and development of management strategies for these communities. In particular, the impact of disturbance by boating traffic and pedestrians needs to be considered.

The Woronora Estuary Management Plan should recognise the importance of key habitats to the overall functioning of the estuary. Accordingly, changes to existing planning instruments should be made to protect the key aquatic habitats identified by the mapping study. This would also include protection of riparian buffer zones.

Timeframe: Immediate (6-12 months), Ongoing as required

Responsibility: DPI Fisheries/Sutherland Shire Council

Cost: Say $30,000 per year 5 years

Performance Measure: Reports describing results of ecological monitoring programs.

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-0-1	Undertake seasonal estuarine vegetation mapping	☐	☐
Ecol-0-2	Undertake periodic macro invertebrate monitoring	☐	☐
Ecol-0-3	Undertake periodic seagrass health monitoring	☐	☐
Ecol-0-4	Undertake periodic wader bird surveying	☐	☐
Ecol-0-5	Undertake threat identification, including water quality analysis	☐	☐

See Also: M&E-1, M&E-2, Ecol-5

7.2.3 M&E-4: Hydrosurvey monitoring

Priority: High

Description/Discussion:

Lack of depth in a number of locations throughout the estuary is an issue of significant concern to many community members. Particular areas include:

- Upstream reaches (primarily an access issue for fire fighting) notably an area known as "Kings Flats";
- In the vicinity of Prince Edward Park Wharf;
- Forbes Creek, particularly at the entrance and downstream of the Prince Edward Park Road Bridge;
- Bonnet Bay; and
- Downstream of the bridge generally.

Hydrosurvey monitoring is recommended to be undertaken as an identifier of the need for, and as a precursor to, any maintenance dredging works that may be required (Strategy W&F-2).

A two tiered hydrosurvey program is recommended as follows:

1. Informal hydrosurvey with an echo sounder, to generally monitor and provide feedback on areas that may need dredging in the future;

2. Following identification of a potential need to dredge, more formal and accurate survey of any areas of concern, to confirm the need for dredging and the extent of work required.

It is envisaged that the informal survey may be undertaken through the expanded River Keeper program, as described under Strategy W&F-1. While level 1 survey would be undertaken on a relatively frequent basis (say, monthly), there would also be scope for the local community to identify particular areas that are of concern. A fairly simple arrangement utilising an echo sounder, GPS and a network of permanent tide boards to establish water level at any given time is considered appropriate for this type of survey.

Following identification of a potential issue, more formal and accurate survey would be undertaken to identify the spatial extent of the problem. The extent would be determined on the basis of an agreed depth requirement for navigation.

The local community needs to be consulted regarding the draft requirements of existing vessels to determine an appropriate navigable depth. However, it is considered that, as a minimum, the vessels of the Rural Fire Service should be adopted for design to ensure an appropriate level of emergency access. The present trend for increasing vessel size is not suitable for the Woronora due to its naturally shallow geomorphology.

Work on these tasks has been ongoing during the preparation of this plan. It is envisaged that, following adoption of the Plan, these works will be undertaken as part of overall management of the Estuary.

Responsibility: Sutherland Shire Council and River Keeper Programme

Timeframe: Immediate (6-12 Months) and Ongoing

Cost: Minimal for informal hydrosurveys, $10,000 per survey for more detailed hydrosurveys.

Performance Measure: Record of informal surveys, and survey reports for detailed hydrosurveys.

Actions:

Action Ref No.	Action description	Underway	Complete
M&E-0-1	Undertake consultation regarding vessel draft requirements	☐	☐
M&E-0-2	Undertake informal monitoring survey	☑	☐
M&E-0-3	Undertake detailed hydrosurvey, if required	☑	☐

See Also: W&F-2

7.2.4 M&E-2: Water Quality Monitoring

Priority: High

Description/Discussion:

The availability of ongoing and appropriately targeted estuarine water quality data for the Woronora is an issue of concern. Existing water quality data is biased towards areas of known poor water quality. This is because the primary source of monitoring data for the estuary is from the Sutherland Shire Council Strategic Water Quality Monitoring Program (SWAMP), which specifically focussed on sampling stormwater outlets. The latest data from this program is now at least 4 years old and may not reflect present day conditions. An assessment of the data collected over 10 years indicated that water quality in the Woronora Estuary is improving, with the majority of sites showing decreasing concentrations of selected parameters (including nutrients, bacterial indicators, BOD and heavy metals) (WBM, 2006).

An ongoing receiving water quality monitoring program, specifically designed to inform management activities and on-ground works that effectively target sources of nutrients, sediments and faecal contamination to the Woronora Estuary is to be developed. The monitoring program has two main aims:

- To develop an understanding of background water quality conditions in the estuary;
- To inform and assess the effectiveness of management strategies.

The program should integrate with the reinstatement of the SWAMP program (expected to restart in late 2006) and should also consider inclusion of any data collected by the Sydney Catchment Authority at the point where freshwater flows into the River (at their station known as “The Needles”, which is actually upstream of the Pass of Sabugal). The water quality monitoring program should include event based measurements, designed to capture the response of important parameters to rainfall events. It should also include monitoring the impact of flow on environmental processes, such as nuisance algal growth and sediment accumulation.

Parameters that should be measured routinely to derive background data include:

- Nutrients;
- Dissolved Oxygen;
- pH;
- Temperature;
- Heavy Metals;
- Chlorophyll-a;
- Turbidity; and
- Salinity.

Furthermore, all parameters should be monitored intensively during and following rainfall to gain an understanding of the estuary’s response to rainfall/runoff events in the catchment.

Objective setting is an important aspect of a successful monitoring program. This will determine the parameters tested, sampling locations and frequency. As improvement in ecological health is an objective of this Estuary Management Plan, consideration should be given to monitoring ecological responses to declining water quality such as growth of nuisance algae (for example, in the vicinity of Deepwater Estate). This may assist in identifying nutrient loads to the waterway. This is important as increases in nutrient loads may not initially be reflected in background water quality monitoring, due to increased biological uptake.

Given the high concentrations of bacterial indicators in stormwater and the potential for sewage overflows in the catchment, consideration should be given to using a more robust indicator (such as faecal sterols or delta Carbon 15) to differentiate between human and other animal sources. This would provide greater assistance in targeting management options.

In addition, consideration should be given to acquiring some time series data in order to attain a better understanding of the oxygen balance of the Woronora Estuary. Time series data collected over diurnal and seasonal timescales at a number of locations would be necessary. It is suggested that a suitable location for a water quality logging instrument would be in the vicinity of the existing water level recorder at Woronora Bridge. Water quality readings from this instrument could be made available on-line. The conditions at the permanent logging instrument should be supplemented by temporary installations at additional locations.

The Water Quality Monitoring Program will be an important consideration when reviewing the effectiveness of management strategies aimed at improving water quality within the estuary.

Collected data should be stored in a suitably structured database that makes it easy to compare and analyse results.

Timeframe: Immediate (6-12 months) and ongoing

Responsibility: Sutherland Shire Council

Cost: Say $30,000 per year for 5 years

Performance Measure: Reports outlining the results of water quality monitoring.

Actions:

Action Ref No.	Action description	Underway	Complete
M&E-2-1	Install permanent, telemetered Water Quality Instrument (for background WQ Assessments)	☐	☐
M&E-2-2	Design and implement program for temporary water quality instrument installations	☐	☐
M&E-2-3	Undertake event based water quality monitoring	☐	☐
M&E-2-4	Design database and store data.	☐	☐
M&E-2-5	Undertake background data analysis and reporting	☐	☐

See Also: M&E-3, WQ-5, WQ-9, WQ-4, WQ-8

7.2.5 Ecol-5: Mark key habitat areas on signs at recreational access points and with marker buoys

Priority: High

Description/Discussion:

Following determination of the extent of ecological vegetation and key habitat areas, considering the full range of seasonal variation and results from environmental health monitoring discussed in previous strategies, the key sensitive habitat areas are to be indicated at the main recreational access points to the Estuary. These areas would include shoals utilised by wader birds.

At present, NSW Maritime's boating charts provide a note indicating that seagrass beds can be damaged by anchoring and through propeller wash, and that these areas should be avoided by the general boating public. Significant habitat areas are to also be identified in the field by markers/buoys. This strategy also includes provision of DPI Fisheries information on seagrass areas, their significance and the regulations that protect them on informative signs at the recreational access points.

At this stage, the opportunity should be taken to upgrade and/or replace signs and brochures developed as part of Strategy W&F-4.

Timeframe: Short Term

Responsibility: Sutherland Shire Council / NSW Maritime

Cost: $10,000

Performance Measure: Signage and marker buoys in place indicating sensitive habitats.

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-5-1	Develop and install informative signs at relevant recreational access points to Estuary	☐	☐
Ecol-5-2	Install marker buoys around sensitive habitat areas	☐	☐

See Also: Ecol-8, W&F-4, Ecol-11

7.2.6 Ecol-11: Community education program on ecology and heritage

Priority: High

Description/Discussion:

The results of community consultation activities have highlighted that appreciation of the ecological and heritage values of the Woronora Estuary is low in the community.

Following the study and mapping of significant ecological areas, a program for educating the local community should be developed in order to gain a better understanding of the natural variability of these communities and the threats to them (Strategy Ecol-8).

Furthermore, the Woronora Estuary has been identified as being rich in heritage value and this is an aspect of the local environment that is not well recognised by the local community. The significance of the area to indigenous Australians should be highlighted; however this needs to be done sensitively to ensure that Aboriginal sites are not placed at risk.

The program will focus primarily on the local community, attempting to foster a sense of custodianship over the estuary. Specific strategies will include:

- Publication of a small booklet outlining both European and Aboriginal Heritage of the Woronora, development patterns, resulting impacts upon ecological health, measures being undertaken to mitigate adverse impacts and the ways in which the community can assist to ensure that the objectives of the Estuary Management Plan are realised. The booklet should focus on the integrated nature of processes and issues, rather than focussing on specific individual issues. This booklet could be delivered to each household within the catchment;
- Organised boat excursions for interested community members to point out areas of interest, areas under threat and to explain the impact of various activities within the catchment on the Estuary. The locations targeted during the boat excursions should be consistent with the contents of the brochure outlined above. The boat excursions could be facilitated through an expanded River Keeper program as described in Section 7.2.1;
- Distribution of pamphlets containing a précis of the booklet described above for provision to visitors to the Estuary. This could be made available at the counter of the handful of commercial establishments that exist along the estuary.

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council / Riverkeeper Program

Cost: $30,000 for booklet preparation and distribution

Performance Measure: Publication of booklet and précis; number of residents in receipt of new information regarding the estuary.

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-11-1	Develop and distribute brochure and pamphlet on ecology and heritage within the Woronora Estuary	☐	☐
Ecol-11-2	Organise and undertake boat excursions through the River Keeper	☐	☐

See Also: Interacts with most other management strategies

7.2.7 Ecol-2: Bushcare Groups: Revegetate areas close to ecologically sensitive areas

Priority: High

Description/Discussion:

This strategy is closely linked to strategies Ecol-6 and Ecol-4, involving the activities of local Bushcare groups. Strategy Ecol-2 is scheduled to occur in the short term to ensure that prior information is gathered on the location of sensitive ecological areas (Strategy Ecol-8), and thus provide information of where this strategy is to be carried out.

In a number of locations, where building demolition has occurred it will be necessary to identify the extent and type of contamination of areas with cemented asbestos building materials (i.e. "fibro") to ensure that proper precautions can be taken during any rehabilitation activities.

Strategy Ecol-2 will focus on providing an effective buffer of indigenous vegetation between any sensitive estuarine ecological communities and the general public.

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council

Cost: Say $10,000 per year for 5 years

Performance Measure: Extent of area revegetated following identification of sensitive ecological areas.

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-2-1	Prioritise areas for protection and timetable revegetation/rehabilitation activities. Inspect to identify presence (or otherwise) of asbestos	☐	☑
Ecol-2-2	Undertake Bushcare revegetation and rehabilitation	☐	☐

See Also: Ecol-8, Ecol-4, Ecol-6, Eco-11

7.2.8 Ecol-4: Shackels Estate Bush Regeneration

Priority: High

Description/Discussion:

The notable presence of exotic weed infestation along the foreshores of Shackels Estate requires remediation to prevent the ongoing spread of these introduced species into adjacent bushland.

This strategy is closely linked to strategies Ecol-2 and Ecol-4, involving the activities of local Bushcare groups. Strategy Ecol-6 is scheduled to occur in the short term due to the potential difficulties in managing asbestos that remains from the demolition of properties during the Shackels Estate re-acquisition program.

Strategy Ecol-4 will aim to regenerate bushland in the vicinity of Shackels Estate and will therefore require ongoing vigilance and repeated weed removal efforts to enable the effective reestablishment of a healthy indigenous riparian ecosystem. Regeneration works should aim to provide strength or protection to any lengths of foreshore that are eroding, using “soft” methods that achieve a natural appearance.

In conjunction with these efforts, it will be necessary to make contact with the remaining residents of Shackels Estate to discuss vegetation on their properties and offer incentives to replace potentially invasive species. Particular attention needs to be paid to any noxious weeds that are present in the first instance.

Additional work will be required where remnant structures at risk of collapse require removal prior to regeneration activities.

In a number of locations, where building demolition has occurred it will be necessary to identify the extent and type of contamination of areas with cemented asbestos building materials (i.e. “fibro”) to ensure that proper precautions can be taken during any regeneration activities.

At the time of writing, this activity is already being undertaken

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council/Riverkeeper Program

Cost: $5,000 per year for 5 years

Performance Measure: Extent of land regenerated around Shackels Estate

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-4-1	Inspection and progressive removal of remaining asbestos containing building materials	☑	☐
Ecol-4-2	Inspection and progressive removal of remnant structures at risk of collapse	☑	☐
Ecol-4-3	Progressive bush regeneration along Shackels Estate foreshore	☑	☐
Ecol-4-4	Make contact and discuss project with remaining residents. Develop strategies to minimise introduction of weeds into native bushland	☐	☐

See Also: Ecol-8, Ecol-2, Ecol-6, Eco-11

7.2.9 W&F-9: Hard protection/repair of eroding foreshores (private and public)

Priority: High

Description/Discussion:

The protective structures fronting Burnum Burnum Sanctuary (Janalli Reserve) and Prince Edward Park have been identified as requiring repair. Also, the foreshore stairways fronting the reserve immediately upstream of the low level bridge (western side) require either repair or replacement.

There is the potential to target all three locations at the same time, using the services of appropriately qualified maritime structural engineers.

The first stage of the process would involve an assessment of the extent of repair required and development of an appropriate conceptual design. This would be closely followed by detailed design and subsequent reconstruction. The following should be considered during the process:

- The use of environmentally sensitive methods for bank stabilisation, potentially providing new habitats for aquatic species;
- Enhancement of aquatic ecology and the dissipation of wave energy;
- The possibility of integrating the foreshore with wider landscaping of the parklands fronting the estuary, considering the expressed desire of the community to have facilities upgraded. This issue was directly considered as part of a preliminary option (W&F-12) but subsequently eliminated. It is considered that this may be achieved effectively in conjunction with the present management option. Of particular concern is the unsealed car park in Prince Edward Park, which is inundated by very high tides.
- It may also be expedient to demolish remnant structures at Shackels Estate during construction activities and in conjunction with Strategy Ecol-4.

Any structural design needs to minimise the impact on marine vegetation and should avoid sheltering seagrass areas. Any proposal that harms marine vegetation will require an appropriate approval from DPI Fisheries. An ideal design from the view point of DPI fisheries is a sloping rock rip-rap seawall and no mortaring. This type of design provides an improved aquatic habitat (when compared to vertical, mortared sea walls) and helps to absorb wave energy and reduce erosion. Any dredging or reclamation will require a permit under the Fisheries Management Act, 1994. DPI does not generally support groynes as a protection measure.

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council

Cost: Up to $100,000 per site

Performance Measure: Length of foreshore stabilised through formal foreshore protection works.

Actions:

Action Ref No.	Action description	Underway	Complete
W&F-9-1	Investigate, design and seek approvals for foreshore protection works at Prince Edward Park Reserve	☑	☐
W&F-9-2	Construct foreshore protection works at Prince Edward Park Reserve)	☐	☐
W&F-9-3	Investigate, design and seek approvals for foreshore protection works at Burnum Burnum Sanctuary	☐	☐
W&F-9-4	Construct foreshore protection works at Burnum Burnum Sanctuary	☐	☐
W&F-9-5	Investigate, design and seek approvals for foreshore protection works at Woronora Foreshore Reserve – Fronting Prices Circuit	☐	☐
W&F-9-6	Construct foreshore protection works at Woronora Foreshore Reserve – Fronting Prices Circuit	☐	☐

See Also: Ecol-6, Ecol-2, Ecol-4, W&F-14

7.2.10 WQ-9: Review/revise stormwater policy considering erodibility of soils within catchment

Priority: High

Description/Discussion:

To ensure that future development (including intensification of existing developed areas) has minimal impact on the condition of the estuary, Council's existing stormwater policies and Development Control Plans (DCP's) should be reviewed and revised, as appropriate, to consider the erodible character of the Woronora Catchment.

The present DCP includes implementation of Water Sensitive Urban Design and Integrated Water Cycle Management (including stormwater harvesting and reuse), which are aimed at reducing stormwater runoff flows and loads from urban areas by adopting a range of options including rainwater tanks (with reuse for garden and lawn watering, toilet flush, laundry, hot water services, etc) and infiltration systems. However, the existing DCP applies across the whole Sutherland Shire LGA. There are opportunities to include more stringent controls in the Woronora Estuary's catchment to further control the export of coarse sediment from the catchment.

Council could also encourage the adoption of WSUD and other on-site stormwater controls for existing developments through a range of financial incentives (including rainwater tank rebates, rate reductions etc), or other market-based incentives.

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council

Cost: Minimal for DCP review; dependent on extent and scope of incentives offered.

Performance Measure: Revised and adopted DCP for Woronora catchment to impose more stringent limits on coarse sediment export associated with development.

Actions:

Action Ref No.	Action description	Underway	Complete
WQ-9-1	Investigate potential for Woronora specific modifications to Council Development Control Plans	☐	☐
WQ-9-2	Implement changes to DCP as appropriate	☐	☐
WQ-9-3	Introduce a range of incentives for community to implement best practice water management within existing developments.	☐	☐

See Also: M&E-2, WQ-4

7.2.11 W&F-14: Community campaign for clean-up / restoration of foreshores

Priority: High

Description/Discussion:

In line with the overall desire for community custodianship of the Estuary (Strategy Ecol-11) a campaign should be launched to encourage and empower waterfront property owners to take responsibility for keeping the foreshores and waterway in the vicinity of their properties free of rubbish.

Care needs to be taken to ensure that residents are properly educated regarding what constitutes rubbish. The benefit of retaining seagrass and estuarine wetland vegetation should be stressed to prevent over zealous individuals from clearing valuable vegetation.

Specific events should be targeted, such as a community based effort during Clean-up Australia Day. Furthermore, Council's twice yearly household clean up service should be expanded to include a waterfront service whereby collected rubbish is removed via waterway access.

In addition, the efforts of other stakeholder organisations, such as NSW Maritime and the Rural Fire Service could, at the same time, concentrate upon the removal/relocation of snags from navigable areas of the waterway (having due consideration to ecological considerations). The expanded River Keeper program may provide a coordinating role for this strategy.

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council/Riverkeeper/Rural Fire Service

Cost: Council clean-up services, say $10,000 per year.

Performance Measure: Reduction in the amount of litter accumulated on the estuary foreshore.

Actions:

Action Ref No.	Action description	Underway	Complete
W&F-14-1	Designate appropriate locations along Woronora Estuary as Clean-Up Australia sites	☐	☐
W&F-14-2	Provide informative leaflet encouraging waterfront land owners to participate in coordinated community events	☐	☐
W&F-14-3	Introduce water front service for twice annual clean up	☐	☐

See Also: W&F-7, Ecol-5

7.2.12 W&F-2: Limited navigation dredging, as-required

Priority: High

Description/Discussion:

A review of the available historical information and community expectation for a navigable waterway highlights that the community's perception of what constitutes a natural situation for the Woronora Estuary has been influenced by historical dredging practices. There is limited hard evidence showing how the estuary may change in the short term, as a result of floods and tides.

The balance of hard evidence in the form of both aerial and ground based photography shows that the Woronora Estuary has always been prone to shallow depths and mobile shoals. Nevertheless, there has almost definitely been an acceleration of sediment exported from the catchment during urban development stages and there is a need for navigation along the Estuary, particularly for the purpose of commuting from upstream areas not serviced by roads and for access by the Rural Fire Services vessel.

This Strategy aims to maintain minimum navigable depth within the waterway, and requires input from Strategy M&E-4 which monitors the navigable depths. This strategy has been prioritised to occur during the short term to ensure that an adequate monitoring regime is established, and that realistic and achievable needs of the community relating to navigation are determined as part of Strategy M&E-4.

Undertaking substantial dredging immediately, as suggested by some community members, is not recommended given the following risks:

- The dredging may prove to be ineffective as the dynamics of the shoal development rates at different locations within the estuary are not fully understood; and
- The dredging may be excessive, resulting in a waste of funding and potentially unnecessary damage to foreshore structures and important estuarine habitats.

Generally, dredging is not seen as an effective management strategy in addressing problems within an Estuary. However, given enough evidence to inform a targeted, limited and cautious dredging strategy geared at addressing localised navigation requirements, it would appear to be a suitable measure in the Woronora Estuary.

Once the requirements for navigable depth are established and a need for dredging determined, an ongoing program of maintenance dredging could be implemented.

There are many competing values that need to be considered as part of any maintenance dredging program, namely:

- What is a reasonable navigable depth?;
- What permits are required and how can the approval process be streamlined? For example, a licence will be permit will be required from the NSW Lands Department under the Crown Lands Act, while a permit may also be required from DPI Fisheries if seagrass is to be harmed or removed;

- What is the potential impact on seagrasses? (this will not be known until the seasonal variation has been established under Strategy Ecol-8);
- What types of dredging plant are available? (small, flexible and environmentally friendly plant are preferred);
- Are there any issues relating to Acid Sulfate Soils?;
- How will the dredged spoil be handled and processed (is there available space)?; and
- What is the economic value of dredged spoil and can it be sold for profit to offset the cost of the program?

A feasibility study is required prior to the completion of any dredging works and this study can be initiated in conjunction with Strategy M&E-4. It must be realised that this is not the only way that sedimentation will be targeted. The source control measures described as part of Strategy WQ-4 are also important. Nevertheless, control of export from the surrounding urban catchment will not remove the need for ongoing maintenance dredging and navigation may still be impaired from time to time.

A responsive, flexible approach is required to manage navigation within areas that are known to become shallow from time to time. Overall, it is recommended that the scale of maintenance dredging be kept as small as practicably possible. Relatively major dredging may be required following any significant flood events, but the significance of individual floods is not yet fully understood.

At the time of writing, targeted dredging works are planned for navigation purposes within the Estuary. The aim of this strategy is to streamline this process and develop a framework for undertaking dredging in a systematic and responsive manner.

Timeframe: Short Term (1-3 years)

Responsibility: Sutherland Shire Council, NSW Maritime, Lands Department

Cost: Ranging between $100,000 and $500,000 depending on scope of works.

Performance Measure: Maintenance of a navigable waterway that enables access for key estuary users.

Actions:

Action Ref No.	Action description	Underway	Complete
W&F-2-1	Undertake feasibility study incorporating monitoring data available under strategy M&E-4 and considering logistics of the approval process, physical removal	☑	☐
W&F-2-2	Develop framework for responsive, targeted dredging	☐	☐
W&F-2-3	Undertake dredging as and when required (including necessary repeat approvals)	☐	☐

See Also: Ecol-8, M&E-4

7.2.13 WQ-4: Modifications to stormwater system including end-of-pipe treatment

Priority: High

Description/Discussion:

Development within the catchment has almost certainly increased the sediment load to the Estuary. As the areas dredged prior to the mid 1970's have progressively filled, the sediment transport processes have returned to a dynamic equilibrium whereby the amount of material entering the Estuary from the catchment is approximately balanced by the amount of material leaving the downstream end of the Estuary (WBM, 2007). Although the flux is balanced, the high sediment transport rates will continue to cause problems with shallowing in certain areas and unpredictable morphological changes, normally in response to significant catchment flooding events.

Based on the results of catchment modelling, recent patterns of development, and the patterns of erosion and accretion measured over the past 20 years, it would seem that the catchment of Forbes Creek and Loftus Creek contribute significantly to the sediment load delivered to the estuary, and could be targeted for remediation.

Although some treatment measures have been constructed within subcatchments draining to the Woronora Estuary, there are still many subcatchments that have no treatment measures in place to target the key pollutants affecting the health and water quality in the estuary. Stormwater treatment measures should be retrofitted to existing development to treat stormwater at both discharge points to the Estuary and at source. End-of-line treatment measures are recommended as a first call of action to provide a short-term solution to the improvement to stormwater within the lower Woronora catchment. Measures such as ponds, sedimentation basins, wetlands and bioretention basins can provide substantial improvements to water quality (especially the removal of nutrients) with minimal cost and maintenance required. End of line treatments should target locations where the discharge is close to key estuarine habitats (identified by Strategy Ecol-6). These end-of-line treatment measures would eventually become more of a backup treatment measure and provide a final polishing of stormwater before discharging to the downstream waterways, as source treatments are implemented.

In areas where end-of-line treatment is not possible or would fail to adequately treat stormwater from the local subcatchment, it is recommended to adopt a 'distributed approach' whereby treatment measures are constructed within vacant sites (e.g. Council owned land, land adjacent to riparian vegetation, public open spaces) providing treatment of stormwater for a number of smaller upstream areas. A variety of treatment measures may be adopted in such cases including vegetated swales, bioretention systems, infiltration systems and filter strips.

MUSIC modelling of the lower Woronora River catchment, carried out by WBM as part of the Estuary Processes Study, identified a number of areas that could be better managed to reduce the overall pollutants loads entering the Woronora River Estuary. Subcatchments 2, 5, 7, 10, 13, 14, 17 and 20 (refer to Figure 7-5) are more intensely developed than many of the other catchments and although some treatment measures (e.g. sedimentation basins, GPTs and silt traps) have been constructed there still remains a large proportion of untreated development in many subcatchments.

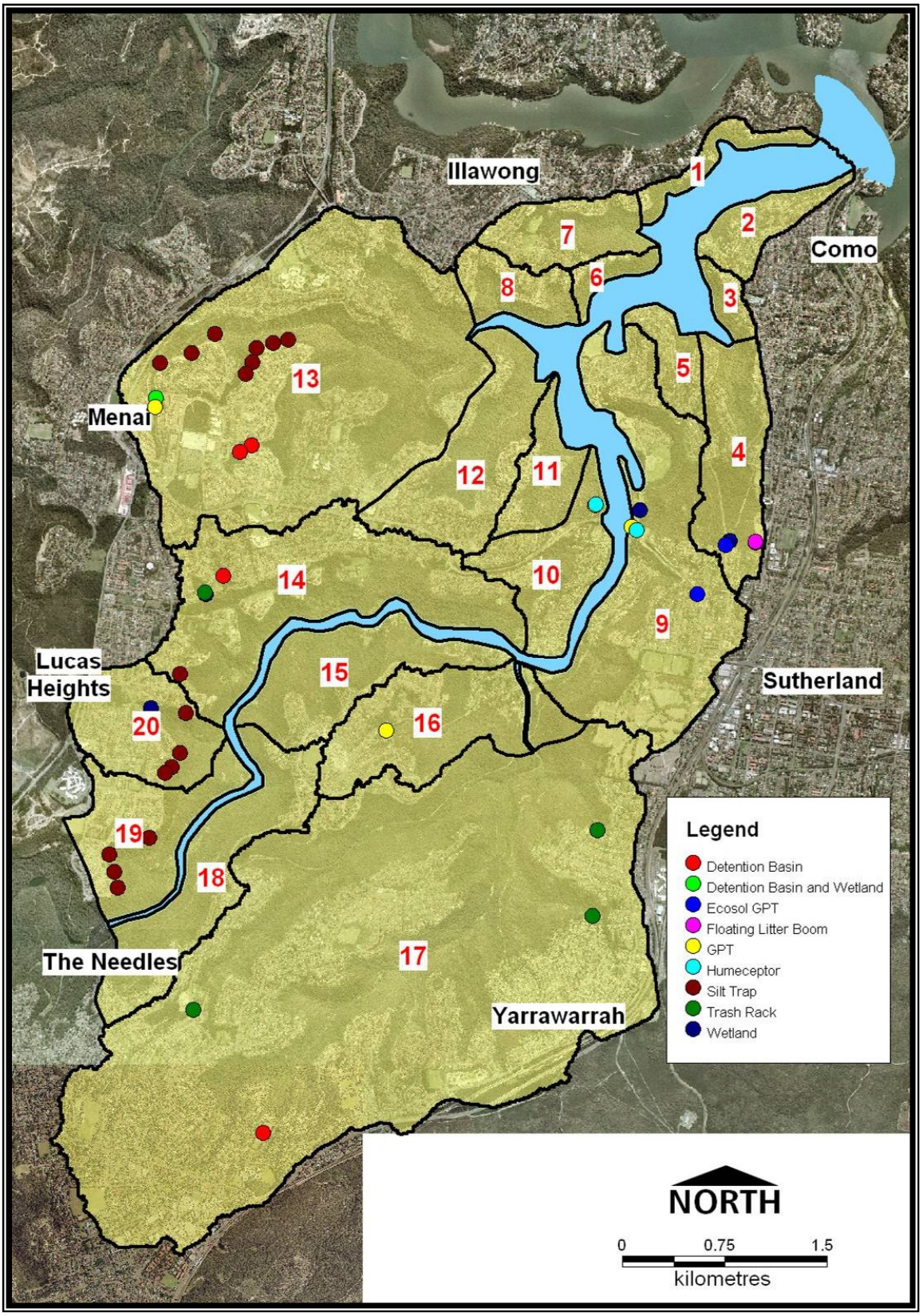

Figure 7-5 Sub-catchments and existing treatment devices for the Woronora River Estuary

All proposed measures should be subject to an appropriate maintenance and cleaning regime.

Timeframe: Medium Term (3- 5 years)

Responsibility: Sutherland Shire Council

Cost: In excess of $500,000 depending on number and type of treatment measures implemented.

Performance Measure: Amount of stormwater treated by additional water quality control measures within the catchment.

Actions:

Action Ref No.	Action description	Underway	Complete
WQ-4-1	Detailed assessment of stormwater system draining to Woronora Estuary (includes identification and assessment of any decommissioned ponds or basins)	☐	☐
WQ-4-2	Prioritise locations for end-of-pipe treatment	☐	☐
WQ-4-3	Prioritise locations for distributed treatments	☐	☐
WQ-4-4	Progressive design and construction of end-of-pipe treatments	☐	☐
WQ-4-5	Progressive design and construction of distributed treatments	☐	☐

See Also: M&E-2, M&E-4

7.2.14 WQ-8: Assess and upgrade sewerage system to minimise overflows

Priority: High

Description/Discussion:

The last publicly available document detailing the distribution and frequency of sewerage overflows was Sydney Water's Environmental Impact Statement for the Sewer Overflows Licensing Project in 1998. Since that time, the reporting of overflow frequencies and volumes by Sydney Water to the Environment Protection Authority (now Department of Environment and Conservation) has been limited to totals for the entire Cronulla Ocean Outfall Sewerage System of which the catchment of the Woronora Estuary contributes only a small part.

Information is not available that relates specifically to the Woronora Estuary's catchment from Sydney Water. In the absence of this information, it is not possible to provide a targeted response to the issue of sewer overflows within the catchment. Whilst Sydney Water has provided information to Sutherland Council on the location of sewerage infrastructure, this data could not be included specifically in this plan due to restrictions placed upon it by Sydney Water.

Accordingly, as an initial step in the determination of the contribution of sewer overflows to pollution within the estuary, it will be necessary to obtain the relevant information from Sydney Water. In addition, Sydney Water should be urged to participate with the Estuary Management Committee in an integrated manner to ensure that the objectives of the Estuary Management Plan are achieved.

An assessment of sewage overflows from the reticulated system and a corresponding risk assessment should be undertaken for the Woronora Estuary. Once risks have been quantified, actions should be implemented to reduce overflows. The required actions will be determined as more is understood regarding the source of pollution to the Estuary (as part of Strategy M&E-2) but may include:

- Undertaking works to increase the hydraulic capacity and/or reduce leakage from the network, and
- Developing response plans so that overflows are rapidly identified and managed.

Timeframe: Medium Term (3-5 years)

Responsibility: Woronora Estuary Management Committee / Sydney Water

Cost: Say $200,000, depending on the extent of infrastructure works required

Performance Measure: Reduction in the frequency and quantity of sewer overflows directed to the Woronora Estuary.

Actions:

Action Ref No.	Action description	Underway	Complete
WQ-8-1	Establish contact with Sydney Water and acquire necessary data.	☐	☐
WQ-8-2	Assess sewer system performance in light of water quality monitoring data	☐	☐
WQ-8-3	Identify sewer overflow 'hot spots' and assess/modify plan for response to overflow events	☐	☐
WQ-8-4	Establish targeted program for sewer system upgrade as necessary	☐	☐
WQ-8-5	Undertake works to abate sewer overflows	☐	☐

See Also: M&E-2

MEDIUM PRIORITY STRATEGIES

7.2.15 W&F-0: General boating restrictions

Priority: Medium

Description/Discussion:

This strategy incorporates the following strategies identified during the management study:

- **Strategy W&F-1**: Replace or Improve Speed Limit Signs;
- **Strategy W&F-5**: Limit Speeds in Estuary; and
- **W&F-16** Ban Wakeboarding.

All of the above options are aimed at reducing the amount of boat wash that impacts upon foreshores within the estuary. Both the community and government agencies are concerned about the impact that boat wake is having on eroding foreshores within the estuary.

The use of power boats moving at speed and generating large wake are seen as incompatible with aspects of the estuary that are held valuable by the community. Furthermore, in some areas, the impact of boat wake is directly undermining valuable ecological areas.

The dynamic nature of shoals within the Woronora Estuary is also a safety issue when shallow areas encroach upon navigation channels. Reduced speed would mitigate this safety issue.

An extract from the relevant current NSW Maritime Boating Chart (available from www.maritime.nsw.gov.au) is provided as Figure 7-6. The speed zones should be modified from those shown to comprise a no-wash zone throughout the entire estuary. The extension of the no wash area is consistent with the original recommendations of the Healthy Rivers Commission (1999). The proposed changes would cover all areas of erosion identified in the Estuary Processes Study (Appendix F). Initially, speed limits are to be maintained as they are at present, with a review being undertaken in future to determine whether the objectives of this strategy are being achieved. In the opinion of NSW Maritime, the shallow draught vessels which use the Woronora tend to create more wash at 4 knots than at 8 knots, meaning that a reduction in speed limits is likely to be detrimental in terms of reducing bank erosion.

In conjunction with the change to navigation restrictions, speed limit signs should be replaced as necessary, and their visibility, placement and spacing reviewed to ensure that restrictions are clear throughout the estuary. The introduction of a global no-wash zone will effectively exclude wake boarding from within the estuary.

Community acceptance of this strategy could be enhanced by the education initiatives proposed by Strategy W&F 4. Opposition may arise from the point of view of those using the river to commute from upstream, particularly if transit times are increased.

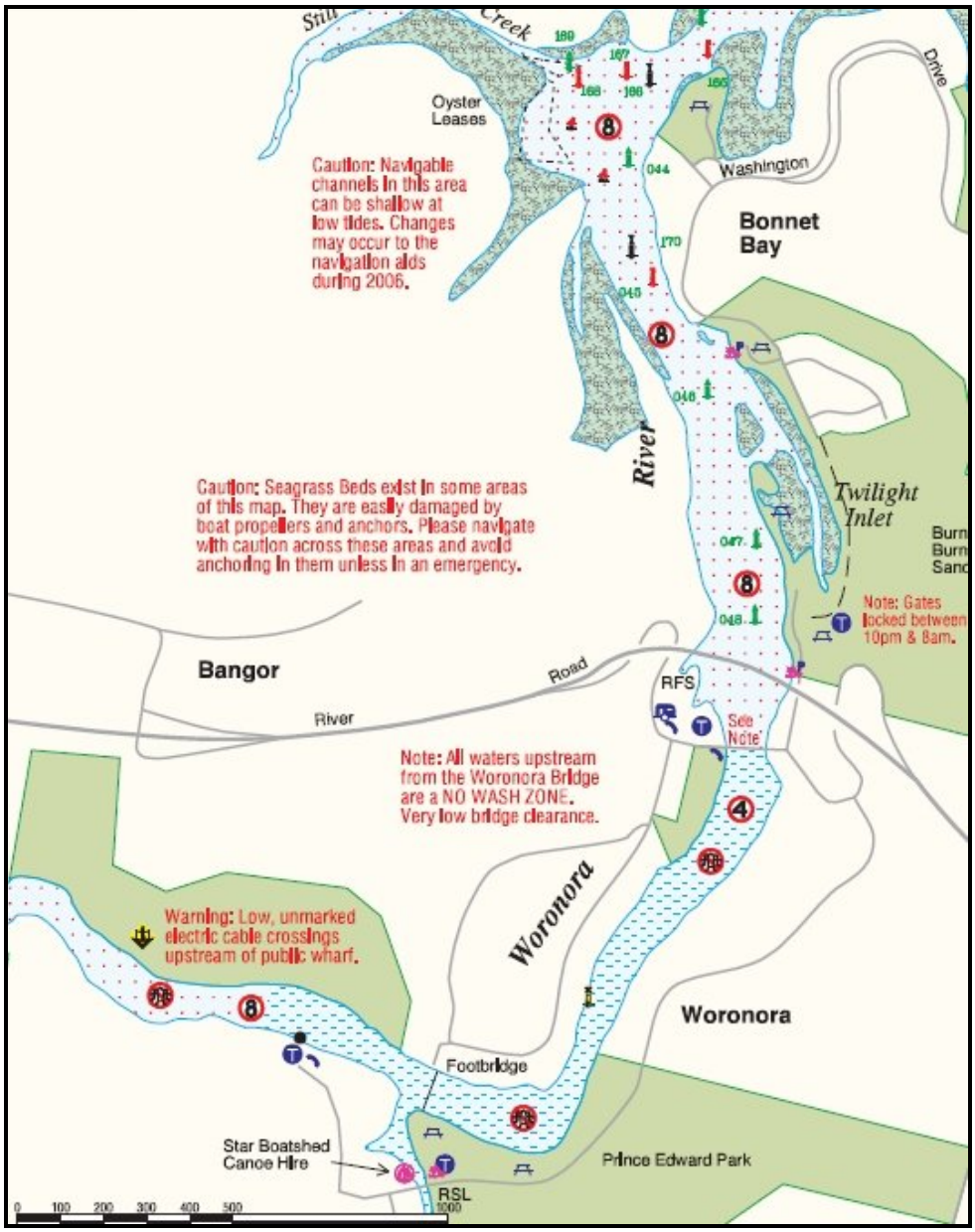

Figure 7-6 Extract from NSW Maritime Boating Map

Timeframe: Immediate (6-12 months)

Responsibility: NSW Maritime

Cost: Say $10,000 for new signage, maps/brochures and education.

Performance Measure: Reduction of boat wake within the estuary.

Actions:

Action Ref No.	Action description	Underway	Complete
W&F-0-1	Review and adjust navigation restriction signs, replacing dilapidated signs as necessary	☐	☐
W&F-0-2	Adjust boating maps to reflect changes to navigation restrictions	☐	☐

See Also: W&F-7, W&F-4, Ecol-5

7.2.16 W&F-7: More frequent and effective policing of waterway users

Priority: Medium

Description/Discussion:

An issue raised by a number of responses to the community consultation was the inability of present policing arrangements to respond quickly to complaints from residents with relation to speeding vessels.

In conjunction with the initiatives described in Strategy W&F-0, a strategy for more effective policing of the Woronora Estuary is proposed.

The Georges River "Riverkeeper" is funded by Hurstville, Sutherland, Rockdale, Kogarah and Bankstown Council (i.e. the Georges River Combined Council Committee, GRCCC) and the NSW Maritime Authority. Accordingly, the Riverkeeper is presently responsible for a much wider area than the Woronora Estuary, including Botany Bay, the Georges River and its tributaries.

NSW Maritime is responsible for monitoring compliance with speed restrictions on the navigable waters of the Woronora River. The Riverkeeper has delegated powers to act as a Compliance Officer for NSW Maritime in enforcing speed restrictions. This strategy requires use of the Riverkeeper to increase the frequency of compliance campaigns along the Woronora River, particularly in conjunction with other measures proposed as part of this Plan.

While the River Keeper program is responsible for facilitating environmental remediation and protective works, the role also overlaps with that of a normal Boating Services Officer of the Maritime Authority.

Extension of the Riverkeeper program to enable more of a focus on the Woronora Estuary is recommended and necessary for a number of strategies contained within the Woronora Estuary Management Plan. One of the areas that should be targeted is the policing of revised navigation restrictions for the Estuary, especially during its introductory stages. This needs to occur in conjunction with appropriate community education (W&F-4). Depending on the degree to which the River Keeper program can be feasibly extended, the River Keeper can provide additional assistance in the implementation of other strategies. The policing of illegal dumping, a management option that was eliminated by multi-criteria analysis undertaken as part of the estuary management study, could also be addressed by the River Keeper.

The effectiveness of this strategy would be difficult to measure. One way of gauging the effectiveness of this strategy would be to undertake community consultation to determine whether the strategy is considered useful and/or effective.

Timeframe: Immediate (6-12 months)

Responsibility: Sutherland Shire Council/ River Keeper / NSW Maritime

Cost: Depending on how additional policing can be achieved (e.g. modify tasks of existing personnel, or employ additional personnel).

Performance Measure: Improved compliance with various regulations covering the Estuary.

Actions:

Action Ref No.	Action description	Underway	Complete
W&F-0-1	Approach the River Keeper to determine the extent to which this strategy, along with others, can be incorporated into existing duties	☐	☐
W&F-0-2	Approach the Georges River Combined Council Committee (GRCCC) and NSW Maritime to examine feasibility and costs associated with additional focus of the River Keeper program on the Woronora Estuary	☐	☐
W&F-0-3	Increase frequency of compliance checking within the Estuary	☐	☐

See Also: W&F-1, W&F-5, W&F-16, W&F-7, Ecol-6 and (Ecol-5, M&E-2, WQ-1, Ecol-2. Ecol-4, W&F-4: dependant upon degree to which River Keeper program can be expanded)

7.2.17 W&F-4: Provide information on the effects of speeding

Priority: Medium

Description/Discussion:

In order to educate and gather community support for the initiatives proposed to reduce speed limits in the estuary, educational strategies are recommended to inform estuary users of the reasons for the change. The recommended approach uses two strategies:

- Publishing an informative brochure explaining the need for the changes;
- Erecting signs at strategic locations to provide information to boaters.

It is envisaged that signage will comprise constructed stands, within which changeable informative posters can be displayed.

The information contained within the brochure and on the signs would be similar. The following are considered appropriate:

- Background to the scientific investigations and the reasons for the speed limit changes (including photographic evidence of damage);
- Provision of information on the importance of riparian zones;
- A description of the speed limits that are being imposed and the areas where they are to be enforced;
- A map showing the location of identified eroding foreshores and sensitive ecological areas. While these have been provided by the Estuary Processes Study, it will be necessary for the mapping of sensitive ecological areas to be upgraded following more detailed study (See Strategy Ecol-8).

Guidance on the contents of the informative material can be gained by accessing existing NSW Maritime publications such as:

- "Leave only Water in your Wake" which addresses a range of environmental considerations such as erosion caused by wake, seagrass sensitivity and the spread of *Caulerpa taxifolia*,
- the stickers titled "Navigation Rules/Advisory Signs/Warning Signals/Remember", which explains the meaning of "No Wash Zones", and
- the poster "Excessive wash can cause nuisance, annoyance or danger".

There are limited opportunities within the estuary for the distribution of brochures, given the limited commercial development adjacent to the waterway. Nevertheless, brochures should be delivered to each household along the Estuary, and made freely available from outlets such as the Star Boat Shed, Woronora RSL, Caravan Park and food outlets in Woronora. Efforts should be made to distribute the brochure to any new residents moving into the area and the brochure should be made available for download from an appropriate location on the internet.

Signs should be prominently installed at all formal access locations to the estuary, including the boat ramps at Burnum Burnum Sanctuary and Bonnet Bay, and adjacent to the Wharf at Prince Edward Park Road, as well as land-based car parks used by residents of water-access only dwellings at

Deepwater Estate and Shackels Estate. At the time of writing, NSW Maritime and Sutherland Shire Council are in the process of implementing this strategy.

Timeframe: Immediate (6-12 months)

Responsibility: Sutherland Shire Council / NSW Maritime

Cost: $10,000 for preparation and distribution of education material

Performance Measure: Number of community members in receipt of new information in boat speed / boat wake impacts.

Actions:

Action Ref No.	Action description	Underway	Complete
W&F-4-1	Construct stands for informative signage around the estuary (key access locations)	☑	☐
W&F-4-2	Design and distribute informative posters and information brochures	☐	☐

See Also: W&F-1, W&F-5, W&F-16, W&F-7, Ecol-6 and (Ecol-5, M&E-2, WQ-1, Ecol-2. Ecol-4, W&F-4: dependant upon degree to which program can be expanded).

7.2.18 M&E-1: Undertake survey on recreational fishing

Priority: Medium

Description/Discussion:

A recreational fishing study is required to determine fishing compliance rates and general estuary fish stocks; and to fill an important data gap relating to the Woronora Estuary. Options for completion of this study include the engagement of an ecological consultant or university. In addition, the Woronora Fishing Club can be approached to gauge interest in participating.

Methodologies used could include site audits and diary based systems for a selected sample of fishers or a creel survey. Regardless of the approach adopted, the survey needs to be well designed to be meaningful and DPI fisheries should be contacted to discuss the survey design.

Information collected through this study will inform future management strategies including the need for education, ways to increase compliance and whether there are any requirements relating to restricting recreational fishing.

The recreational fishing study should:

- Establish the recreational fishing effort and catch in the Estuary;
- Examine the potential impact on specific species of importance (commercially important or threatened);
- Determine if any species may be affected by overfishing; and
- Determine whether there is a need for temporary or seasonal bans or modifications to limits.

Responsibility for enforcing any bans would rest with DPI Fisheries along with additional investigations to determine the response of fish stocks to any bans.

Timeframe: Immediate (6 – 12 months)

Responsibility: Department of Primary Industry: Fisheries

Cost: $30,000

Performance Measure: Documented results of fisher survey

Actions:

Action Ref No.	Action description	Underway	Complete
M&E-1-1	Design recreational survey and determine appropriate means of undertaking that survey	☐	☐
M&E-1-2	Undertake survey, possibly through engagement of external organisation	☐	☐

See Also: M&E-3

7.2.19 Ecol-3: Ensure that Woronora Estuary is considered during Environmental Flow determination

Priority: Medium

Description/Discussion:

The control of environmental flow releases from Woronora Dam is not the responsibility of the Woronora Estuary Management Committee. However, it is necessary that the needs of the Estuary are taken into account when decisions are being made regarding environmental flow releases from the Dam. The Sydney Catchment Authority controls environmental flow releases at Woronora Dam and these releases are licensed by the Department of Environment and Climate Change. It is important that the needs of the Woronora Estuary are considered when establishing or revising the environmental flow release strategy. An appropriate monitoring strategy should be established to determine the ongoing impact upon the estuary.

Timeframe: Immediate (6 – 12 months)

Responsibility: DECC

Cost: Staff time only

Performance Measure: Environmental flows assessment for the Woronora River that duly considers the needs of the estuary

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-3-1	Establish contact with appropriate individuals within DECC to ensure input from the Estuary Management Committee is provided to the Environmental Flow Release determination process	☐	☐

See Also: M&E-1, Ecol-6, Ecol-8, M&E-4, M&E-2

7.2.20 Ecol-8: Modify planning instruments to provide for landward migration of saltmarsh communities

Priority: Medium

Description/Discussion:

In recognition of the regional importance of saltmarsh communities, planning controls need to be implemented to enable migration of these communities, wherever possible, as sea levels rise in response to global warming. This strategy includes three stages:

- Identification of areas where saltmarsh vegetation could migrate as a result of sea level rise;
- Modification of Planning Instruments to allow for protection of those areas;
- Physical protection of those areas where appropriate

Timeframe: Short Term (1-3 years)

Responsibility: SCC

Cost: Staff time only

Performance Measure: Adopted Planning Instrument that accommodates future translation of saltmarsh areas.

Actions:

Action Ref No.	Action description	Underway	Complete
Ecol-8-1	Identify opportunities for salt marsh migration	☐	☐
Ecol-8-2	Modify Planning Instruments (e.g. LEP or place-based DCP)	☐	☐
Ecol-8-3	Provide physical protection as necessary	☐	☐

See Also: Ecol-6, Ecol-0, Ecol-5, Ecol-11, Ecol-2

7.2.21 WQ-5: Locate and monitor all on-site sewage systems

Priority: Medium

Description/Discussion:

Some areas within the catchment are still using on-site sewage management systems (e.g. septic tanks). These sewage systems have the potential to act as a source of human specific pathogens and nutrients to the estuary. An assessment of the condition of on-site sewage treatment systems along with the surrounding soil conditions (e.g. permeability), should be undertaken to determine the likely risks of the system to pollute the environment.

Systems should be assessed against the requirements of clauses 41-46 of the Local Government (General) Regulation which commenced in September 2005.

Systems that are found to be inappropriate should be repaired or replaced by landholders. Alternatives may include aerated holding tanks with regular pump-out, surface disposal and evaporation, or a combination of treatments. Consideration could also be given to connecting some lots to the sewerage system (particularly in areas where a reticulated service exists).

It is important that Sutherland Council obtains records of those properties not serviced by reticulated sewerage from Sydney Water, if they are not held in house by Sutherland Council and places them onto a digital database to record monitoring activities over time.

Timeframe: Immediate (6 – 12 months)

Responsibility: Sutherland Shire Council, landholders

Cost: Staff time only

Performance Measure: Records of on-site sewage system audits, and number of replacements for systems that are non-compliant.

Actions:

Action Ref No.	Action description	Underway	Complete
WQ-5-1	Locate/collect data on all on-site systems within catchment	☐	☐
WQ-5-2	Establish database for inspection/monitoring of system performance	☐	☐
WQ-5-3	Undertake regular monitoring as required	☐	☐
WQ-5-4	Repair or replace systems that are non-compliant	☐	☐

See Also: M&E-2

7.2.22 WQ-1: Emergency Plan for illegal dumping / pollution events

Priority: Medium

Description/Discussion:

Although the issue of illegal dumping or accidental spillage of pollutants into the waterway was not identified as being particularly frequent or detrimental to the health of the Estuary, both the Estuary Management Committee and individuals responding to the community questionnaire have identified this issue as one of concern. Potential illegal dumping activities that have been identified during the consultation process include:

- discharge of sewage;
- discharge of paint waste;
- dumping of household waste; and
- potential spillage of chemicals resulting from road accidents.

Clearly, the extent of waste disposal can vary significantly depending on the nature of the spillage/dumping event. The purpose of this management strategy is to develop a targeted Emergency Management Plan for potentially harmful pollution events, if it is found to be necessary.

As a first step in developing an appropriate Emergency Management Plan, contact should be made with the New South Wales Fire Brigade to gain an understanding of the services that they currently provide, and to ensure that any efforts are coordinated. Furthermore, contact should be made with the local emergency management committee.

A risk assessment of different types of potential spillage or dumping events that may occur needs to be undertaken to enable an effectively targeted Emergency Management Plan.

Additional measures required to address this issue may include:

- Provision of spillage booms and absorbent materials in the vicinity of boat access points to the Estuary;
- Consideration of employing a model to predict movement of the spill;
- Development of protocols to handle any spillage events; and
- Provision and advertisement of an emergency number for the community to use to report any pollution events. Relevant information can be provided on signs at the boat access points to the Estuary and in the brochure described as part of Strategy Ecol-11.

The plan should consider, in particular, the location of any sensitive ecological communities.

Timeframe: Short-term (1-3 years)

Responsibility: Sutherland Shire Council / NSW Maritime / New South Wales Fire Brigade

Cost: Say $10,000 for Plan preparation

Performance Measure: Adopted Plan outlining Emergency procedures that would protect the estuary from damage.

Actions:

Action Ref No.	Action description	Underway	Complete
WQ-1-1	Make contact with NSW Fire Brigade and Local Emergency Management Committee to determine responsibilities	☐	☐
WQ-1-2	Undertake risk assessment	☐	☐
WQ-1-3	Prepare emergency response plan and undertake necessary on ground works to facilitate implementation of the Plan.	☐	☐

See Also: W&F-1, W&F-7, Ecol-11, W&F-14.

7.3 Funding of the Plan

7.3.1 Funding requirements

The total cost of the Plan over the 5 year period is approximately **$2.48 million**, comprising $1.53 million for capital works, and **$950,000** for on-going funding commitments (maximum annual commitment = $195,000).

4 of the 22 strategies will require no external funding, as they can be implemented using existing staff only (although the capabilities of existing work force to take on additional tasks may need to be assessed). Some additional tasks could also be carried out internally by stakeholders depending on skills of staff (these tasks have assumed to be outsourced at present).

A summary of the funding requirements and associated timing for the funding is presented in Table 7-2. The most expensive strategies involve major investment in infrastructure (e.g. WQ-8, WQ-4), revegetation (Ecol-6) and dredging (W&F-2). These four strategies account for around half of the Plan budget.

Table 7-2 Funding requirements for Plan implementation

	Immediate	*Short Term*	*Medium Term*	*TOTAL*
High	$0 capital $120,000/yr on go.	$515,000 capital $25,000/yr on go.	$950,000 capital $0 on go.	**$1,465,000 capital $145,000/yr on go.**
Medium	$50,000 capital $50,000/yr on go.	$10,000 capital $0/yr on go.	$0	**$60,000 capital $50,000/yr on go.**
Low	$0	$0	$0	
TOTAL	**$50,000 capital $170,000 on go.**	**$525,000 capital $25,000 on go.**	**$950,000 capital $0 on go.**	***$1,525,000 capital $195,000/yr on go.***

7.3.2 Possible funding sources

Council is expected to fund parts of this Estuary Management Plan using environmental budget allocations of general revenue. Given the high costs for overall implementation, however, the Plan will be reliant upon receiving external grants and funding to be successful, some of which will require matching funding from Council.

Primary funding sources include the NSW Government's Estuary Management Program (refer Section 7.3.2.1), and a suite of grant programs offered by local, state and federal government, as well as some private organisations (refer Section 7.3.2.3).

In-kind contributions for completion of some of the elements of this Estuary Management Plan could also come from various educational institutions (such as universities), who could use the estuary for specific data collection or research projects. In-kind contributions could also come from volunteer community groups, such as Bushcare and schools.

Opportunities should also be explored to utilise environmentally-oriented volunteer teams, such as Greening Australia, Green Corps, Bushcare and Work for the Dole, to assist with physically demanding elements of the Plan, such as revegetation works.

7.3.2.1 Estuary Management Program

Given that this Estuary Management Plan has been prepared in accordance with the NSW Government's Estuary Management Process, many works recommended by this Plan are eligible for part (50:50) funding under the NSW Estuary Management Program, with the possible exception of major sewerage infrastructure works.

7.3.2.2 Sydney Metro Catchment Management Authority

The Sydney Metro CMA is in the process of preparing a Catchment Action Plan (CAP). The draft CAP (dated May, 2006) contains aims, objectives and strategies for catchment management across the whole of the Sydney Metropolitan Area. Catchment Target ECM1.5 of the CAP pertains to the review of Estuary Management Plans and the promotion and support of all high priority actions identified within those Plans. The CAP also contains biodiversity and water themes, which would also be relevant to this Estuary Management Plan. In essence, the CMA could partly or wholly fund actions related to natural resource management, and as such, could contribute to the implementation of the following strategies:

- Ecol-6;
- Ecol-0;
- M&E-2;
- Ecol-5;
- Ecol-11;
- Ecol-2;
- Ecol-4;
- M&E-1;
- WQ-4;
- WQ-1.

7.3.2.3 Environmental Grants Programs

There are a number of state and federal government grant programs and private foundations that should be explored for potential funding of various strategies outlined within this Estuary Management Plan. A number of these grant programs, along with example strategies that may be funded are listed in Table 7-3

Table 7-3 Potential Funding Programs for Management Strategies

	Funding authority	Example applicable strategies
Natural Resource Management		
Environmental Research Program	DEC	ECOL-0, M&E-1
Forging Partnerships Program	National Resources Advisory Council	W&F-14
Urban Sustainability Grants	DEC	WQ-4
Envirofund	NHT	WQ-4, ECOL-6, ECOL-2, ECOL-4, ECOL-5, ECOL-11,W&F-7,W&F-4
Restoration and Rehabilitation Program	DEC	ECOL-6, ECOL-2, ECOL-4
Environmental Education		
Eco-Schools Program	DEC	ECOL-5,ECOL-11, W&F-4, ECOL-11
Environmental Education Program	DEC	ECOL-5,ECOL-11, W&F-7,W&F-4, ECOL-11
Commonwealth Environmental Education Grants Program	DEH	ECOL-5,ECOL-11, W&F-7,W&F-4, ECOL-11
Invasive Species		
Local weed coordination and weed control	DPI	ECOL-4, ECOL-5, ECOL-11
State Priority Weed Projects	DPI	ECOL-4
Regional Weeds Plans and Group Funding	DPI	ECOL-4
Defeating the Weed Menace fund	Australian Government	ECOL-4, ECOL-5, ECOL-11
National Feral Animal Control program	NHT	ECOL-4, ECOL-5, ECOL-11
Marine and Coasts		
Estuary Management Program	DECC	Most strategies, dependant upon prioritisation Refer Section 7.3.2.1.

	Funding authority	Example applicable strategies
General, planning and community		
Community grants programs	SSC	W&F-14, ECOL-6, ECOL-2, ECOL-4
Community support grants	National Landcare Program	W&F-14, ECOL-6, ECOL-4, ECOL-2
Corporate Community Program	BHP Billiton	ECOL-11, W&F-14, ECOL-6, ECOL-2, ECOL-4
Planning Reform Funding Program	Department of Planning	ECOL-8
Project AWARE Foundation Grants	Project AWARE	W&F-14, ECOL-6, ECOL-2, ECOL-4
Macquarie Bank Foundation	Macquarie Bank	W&F-14, ECOL-6, ECOL-2, ECOL-4
Natural Environment Grants	Myer Foundation	W&F-14, ECOL-6, ECOL-2, ECOL-4
Westpac Operation Backyard	Westpac Banking Corporation	W&F-14, ECOL-6, ECOL-2, ECOL-4
Ian Potter Foundation Grants	Ian Potter Foundation	ECOL-6, ECOL-2, ECOL-4

7.4 Accommodating Future Climate Change

7.4.1 Background

Climate change as a response to increased greenhouse gases in the Earth's atmosphere is now a widely accepted phenomenon. Impacts of a changing climate are already beginning to emerge (Steffen, 2006). For example, WMO (2005) state that, with the exception of 1996, the last 10 years (1996 – 2005) have been the hottest years on record (globally averaged). In Australia, 2005 was the hottest year on record, at a temperature of 1.09°C higher than the 1961-1990 average (BoM, 2006). The past four years in Australia have been consistently significantly hotter than the 1961-1990 average (refer Figure 7-7).

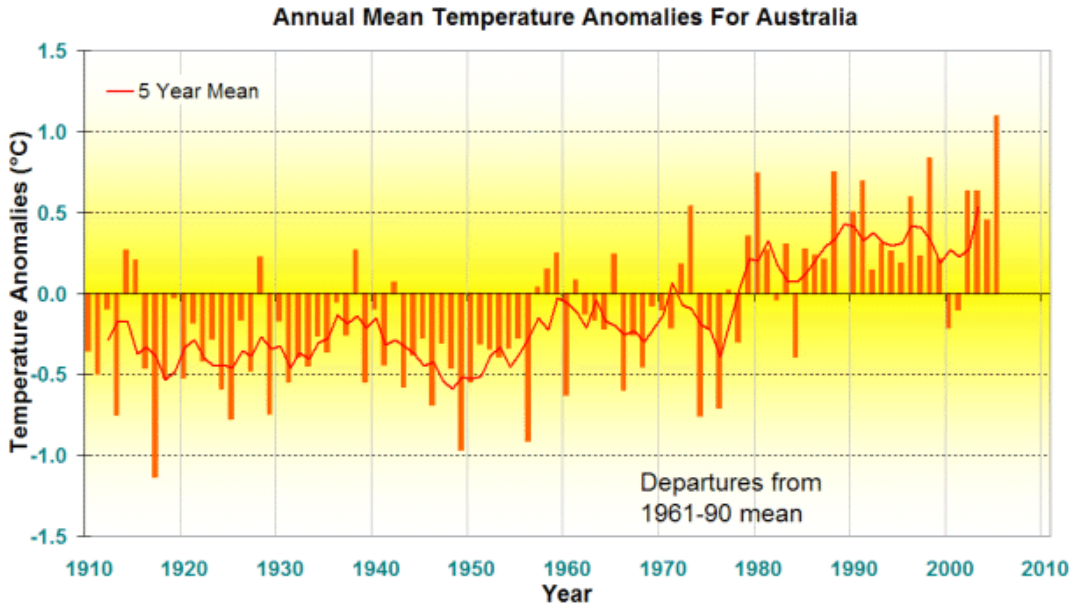

Figure 7-7 Australian average temperature variation, 1910 – 2005 compared to 1961-1990 average (Source: BoM, 2006)

Increasing air temperatures across the globe in the future will cause a variety of climatic effects, including sea level rise, increased atmospheric and ocean temperatures, and changes to rainfall and drought patterns. Changes to climate in the next 30 – 50 years are considered inevitable, regardless of possible reductions in global greenhouse gas emissions (Lord *et al.* 2005).

The United Nations Intergovernmental Panel on Climate Change is presently in the process of updating its assessment on the expected magnitude and impacts of climate change within the coming century and beyond. The assessment is being prepared as the Fourth Assessment Report (AR4), which updates the findings of the Third Assessment Report released in 2001. AR4 will comprise three separate reports from three working groups:

1. Working Group I (The Physical Sciences Basis);
2. Working Group II (Impacts, Adaptation and Vulnerability); and
3. Working Group III (Mitigation of Climate Change).

At present, a "Summary for Policymakers" has been released for the first two working groups, with the third due for release in May, 2007. Accordingly, the third summary was not available for review at the time of writing. The expected climate changes and impacts discussed in following sections derive largely from the most recently available findings of the IPCC. This field of research has generated enormous current political and scientific interest in the six months leading to the finalisation of this plan. Accordingly, during the life span of this plan, the best available estimates may change, and the plan requires the flexibility necessary to accommodate changes in the level of scientific certainty.

7.4.2 Predicted Changes Associated with the Enhanced Greenhouse Effect

Although there is still uncertainty over the magnitude of changes expected as a result of the enhanced greenhouse effect, the science has advanced significantly since release of the IPCC's third assessment report in 2001. A summary of the expected changes to the climate of South-East Australia in the future is provided in Table 7-4.

Global atmospheric temperatures are expected to rise (IPCC, 2007A). The best estimates for average surface air warming range from an increase of 1.8 degrees for a 'low' emissions scenario (range 1.1 to 2.9 degrees), to 4.0 degrees for a 'high' emissions scenario (range 2.4 to 6.4 degrees).

Table 7-4 Expected Climatic Changes (IPCC 2007A)

Phenomenon and direction of trend	Likelihood of future trend
Warmer and fewer cold days and nights over most land areas	Virtually Certain
Warmer and more frequent hot days and nights over most land areas	Virtually Certain
Warm Spells / Head Waves. Frequency increases over most land areas	Very likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls increases over most areas	Very likely
Area affected by droughts increases	Likely
Intense tropical cyclone activity increases	Likely
Increased incidence of extreme high sea level (excludes tsunamis)	Likely

Source IPCC 2007A. Probabilities of occurrence are: Virtually Certain > 99%; Extremely Likely >95%; Very Likely >90%; Likely > 66%.

Sea level rise is the most accepted of the predictions associated with climate change, however predictions as to the extent of this rise vary greatly due to the uncertainty of greenhouse gas concentrations in the future and disagreement on the effect of various levels of such gases (Walsh 2004b). For a 'low' emissions scenario a sea level rise of between 0.18 and 0.38 m is expected during the present century. Similarly, a rise of between 0.26 and 0.59 m is expected, given a 'high' emissions scenario (IPCC, 2007A). Changes are expected to be smaller during the first half of the century (i.e. to 2050) than in the latter half. This variation results from thermal inertia in the oceans (Walsh *et al*., 2002) given that ocean surface layers take approximately three decades to absorb heat from the atmosphere (Flannery, 2005). The subsequent transfer of heat from surface layers to the deep oceans is likely to take several centuries due to weak diffusion and slow ocean circulation processes (IPCC, 2001). Thermal expansion of the deep oceans could result in a sea level rise of up

to 4 metres (occurring over a period of several centuries). When combined with anticipated melting of polar ice sheets, the predicted ultimate sea level rise is in the order of 7 metres.

Sea level rise in Australia is also likely to be affected by the El Nino Southern Oscillation (ENSO), a decadal cycle characterised by periods of drought and dryer weather during the El Nino phase of the cycle, and relatively high rainfall and wetter weather during the La Nina phase. The likely effects of a warmer climate on the ENSO are not currently well understood.

On-going sea level rise beyond our immediate planning horizon prompts the recommendation for adoption of conservative sea level rise estimates, as well as the initiation of a program of adaptation and accommodation of continuously rising seas in the future.

Changes to wave climates and the direction of wave impact are also predicted in association with the enhanced greenhouse effect. Specifically, east coast low pressure systems, which are currently responsible for the majority of storm surge water levels and coastal erosion on the NSW coast, may increase in frequency in the future (Walsh 2004a, Hennessey *et al*. 2004b). Hennessey *et al.* (2004b) suggest that in NSW, waves from the southeast will become more dominant, and waves from the northeast will become less so.

The intensity of summer storms is forecast to increase by nearly 22% by 2030 (Hennessey *et al.* 2004b) across NSW. Both Walsh (2004a) and Hennessey *et al.* (2004b) (in relation to NSW specifically) comment that, overall, annual rainfall is likely to decrease, but rainfall volume per storm could potentially increase.

In addition to rainfall changes, higher atmospheric temperatures are likely to increase evaporation rates (Hennessy *et al*., 2004a). As a consequence of reduced rainfall and increased evaporation, it is expected that average streamflow in Australia will decrease (Walsh, 2004a).

A range of studies are currently underway to better appreciate the likely impacts of climate change on the Australian environment. It is anticipated that as these study findings become available, our management responses will also change. Therefore, ensuring some flexibility in the provision for future planning is an essential component of any NRM Plan.

7.4.3 Impacts of Climate Change on Woronora Estuary

Given the above discussion, the Woronora Estuary is expected to be impacted by Climate Change in the future in the ways outlined in Table 7-5.

Table 7-5 Climate Change Impacts on the Woronora Estuary

Phenomenon and direction of trend	Potential (hypothetical) Impacts on the Woronora Estuary
Rise in Sea Levels	-Increase in mean water level in Estuary; -Increase in frequency of inundation of low lying foreshore property (e.g. Prince Edward Park); -Increasing depths, offset by increasing tendency toward deposition; -Displacement of intertidal habitats, including potential loss of saltmarsh and wader bird habitat. -Increases in foreshore erosion
Reduced total rainfall with increasing high intensity event frequency	-Minor reduction in effectiveness of flushing at upper end of Woronora Estuary; -Reduced pollutant loads due to reduced total catchment runoff -Increase in the frequency of flood events that move, reshape and modify the plan form of shoals in the Estuary, impacting upon the reliability of navigation; -Reduction in 'attractant' flows to prompt fish migration between estuarine and fresh water reaches of the River.
Increase in temperature and evaporation	-Reduction in availability of water for environmental flows from Woronora Dam, resulting in a reduction in attractant flows; -Reduction in effectiveness of flushing at upper end of Woronora Estuary. -Increase in pelagic and possibly benthic primary production, reduced availability of oxygen within water -Deleterious effects resulting from the solution of salts and therefore dissolved nutrients, metals and pollutants in the water column; -Potential changes in distribution and composition of estuarine vegetation communities
Increase in Coastal Storm Frequency	-Higher frequency of extreme water levels at the downstream end of the Woronora; -Increase in the frequency and magnitude of extreme inundation events resulting from coastal storms

7.4.4 Planning Considerations for Future Climate Change in the Woronora Estuary

Management of climate change in the future will involve adaptation of systems to new environmental conditions. Momentum associated with the climate system will result in many more impacts over the

next several decades (Steffen, 2006). It is considered that the ability of a system to adapt to these changes and impacts will determine its ability to survive in a future warmer world.

Many environmental systems, such as wetlands, will survive providing that their migration path is not inhibited and that the rate of migration / species adaptation can keep-up with rate of climate change (see DEH 2003).

When planning for future development, consideration should be given to conditions at the end of (and beyond) a realistic planning horizon (say 100 years for residential development). It is important that protection of property and infrastructure built today will not be reliant upon artificial intervention at some point in the future. Imposing such conditions on future generations is considered inconsistent with the principles of Ecologically Sustainable Development (which this Estuary Management Plan is required to satisfy, in accordance with the central theme of the NSW Coastal Policy). Adequate vertical and horizontal buffers, capable of accommodating the effects of water level rise should be adopted.

This Estuary Management Plan has not made specific recommendations with respect to Floodplain Risk Management, and the need to manage flooding risk in the context of future climate change.

Management of existing development within the vertical and horizontal buffer provisions will need to be on a site by site basis. Periodic review of this Estuary Management Plan will provide a mechanism for slowly modifying the management of existing assets and infrastructure in the future. Over the expected time before the first review of this plan (i.e. 5 years), it is not expected that the impact of climate change will result in drastic impacts upon the estuary. However, during this time, the understanding of impacts is likely to improve substantially. It is expected that subsequent reviews of the plan will need to further consider climate change.

7.5 Protecting Heritage

Implementation activities associated with this plan will consider the protection of both Aboriginal and European heritage sites in the Estuary and catchment.

The Estuary and its surrounds are rich in both European and Aboriginal heritage. Due to the cultural significance and sensitivity of a number of places of heritage importance, the locations of these sites has not been documented within this Plan. SSC has undertaken studies to identify those sites of interest and presently has policies which identify and guide management of them. These policies shall be adhered to in the execution of this plan.

Prior to the commencement of any activities that could uncover or damage previously unknown sites of potential significance, personnel undertaking the works will be provided information that enables them to identify such sites if they are encountered.

Furthermore, should such sites be uncovered, contact will be made with the NSW Heritage Office or National Parks and Wildlife Service to determine an appropriate course of action with respect to management of that site. Any relevant policies or guidelines issued by the Heritage Office or the National Parks and Wildlife Service shall be adhered to in the management of sites of cultural heritage significance during the execution of this plan.

7.6 Monitoring, Evaluation and Amendments

The estuary management program is intended to be iterative, contributing to better management practice through increasing knowledge, understanding, and awareness of estuary issues, processes and management alternatives. An important aspect of its implementation will therefore be the periodic review of effectiveness and progress and subsequent modification of strategies, responsibilities and funding arrangements.

Ongoing monitoring of the activities that are being undertaken as part of the plan, and reporting on the outcomes of individual management actions, should be undertaken to ensure proper implementation and to allow for assessment and evaluation of plan performance.

Community participation and involvement in decision making are integral to the success of the process. The community should be informed of periodic reviews by using the project database established during the community consultation phase. This database includes over 180 individuals that have expressed an ongoing interest in the management of the Woronora Estuary.

While the measures outlined below are important, it is also important to ensure that the focus remains firmly on achieving the identified management objectives through the implementation of appropriate actions. If the plan monitoring measures do become cumbersome enough to affect the focus of the plan, reconsideration of the way in which monitoring is undertaken will be required. Any proposed changes to the monitoring must ensure that effective, informed decision making and community involvement are not jeopardised.

7.6.1 Monitoring of Plan Success

The success of the Estuary Management Plan should be gauged through its ability to achieve the designated targets. The overarching targets are the Management Objectives, as described in Section 5. However, the timeframe for achieving some of these objectives is long (given the slow rate of vegetation establishment and growth, for example). To gain a better appreciation for the relative success of the Plan, a series of evaluation measures can be assessed on a periodic basis. Different types of evaluation measures are discussed in more detail below.

7.6.1.1 Primary Evaluation Measures

The first set of evaluation measures should ascertain whether the strategies are being implemented within the timeframe designated in the Plan. As such, the primary performance measures are simply a *measure of implementation*.

The Estuary Management Plan recommends some 22 different strategies over a period of 5 years. Many of these strategies will need to be carried out concurrently. Organisations responsible for implementation will need to review the Plan carefully and ensure that adequate resources are allocated to the various strategies to ensure that the timeframe for implementation is achieved.

Clearly, a high degree of co-ordination will be required to manage the successful implementation of all the strategies within the designated timeframe. This co-ordination should be facilitated by the Woronora Estuary Management Committee, who would be required to meet regularly to discuss and manage the implementation of the estuary management strategies.

If it is determined that the strategies are not being implemented to the nominated timeframe then one or both of the following *contingencies* should be adopted:

- Determine the cause for the delay in implementation. If delays are funding based, then seek alternative sources of funding, including a formal request to Council to increase contributions to the Plan. If delays are resource-based, seek additional assistance from stakeholder agencies and/or consider using an external consultancy to coordinate implementation of the Plan;
- Modify and update the Estuary Management Plan to reflect a timeframe for implementation that is more achievable. The revised Plan would need to be endorsed by all relevant stakeholders and agencies responsible for implementation.

7.6.1.2 Secondary Evaluation Measures

The second set of evaluation measures relate to *measuring specific performance outputs* from the individual strategies, as appropriate. The specific outputs from each strategy, are provided within the Implementation Schedules (refer Section 7.2) under '**Performance measure**'. These measures define what the specific outcome from each strategy should be. If these outputs are delivered as defined, then the strategy is considered to have been successful.

If the defined performance measures are not generated as a result of implementation of the strategy then the following *contingencies* need to be adopted:

- Determine the reason for not producing the specified output. If the reason involves a lack of funding or resources, then similar contingency measures to those described for the primary performance measures (refer Section 7.6.1.1) should be adopted. If the reason is of a technical nature, then expertise in the area should be consulted to overcome the technical problem. DECC and other government agencies should have the necessary in-house expertise to assist in most cases.
- Review the appropriateness of the specific output of the management strategy, and if necessary, modify the output described in the Plan to define a more achievable product.

7.6.1.3 Tertiary Evaluation Measures

The third set of evaluation measures are aimed at *measuring the outcomes of the Plan*, and as such relate to the specific *management objectives* of the Plan (as described in Section 5), and how implementation of the Plan has made a difference to the biophysical and social environments of the Woronora Estuary (e.g. reduction in pollutant loads, improvement in swimming conditions, increase in biodiversity etc). The main mechanism for gauging whether these objectives have been achieved, or not, is monitoring. Therefore, monitoring of various elements of the physical, biological and social environment is an essential component of assessing the overall success of the Estuary Management Plan.

If, after a reasonable period of time, the specific objectives of the Plan are not being achieved by the strategies being implemented, then the following contingencies should be adopted:

- Carry out a formal review of the implemented management strategies, identifying possible avenues for increasing the effectiveness of the strategy in meeting the Plan objectives;

- Commence implementation of additional management strategies that may assist in meeting Plan objectives (possibly 'fast-track' some longer term strategies as necessary);
- Reconsider the objectives of the Plan to determine if they set impossible targets for future estuary conditions, and adjust the Plan, as necessary. Any such changes to the Plan would need to be endorsed by the stakeholders and relevant government agencies, as well as the public.

7.6.1.4 Reviews and Amendments

Periodic reviews and amendments of this Estuary Management Plan are necessary to ensure that it remains current and relevant to the environmental management and planning framework in which it operates. Future reviews of the Plan should consider:

- Is the level of community support and involvement being maintained?
- Are Council and government agencies still supportive and involved in the implementation?
- Are the objectives still relevant, or have conditions, circumstances, priorities and the level of understanding changed?
- Are the indicators selected to assess performance of a given strategy and monitoring parameters the most appropriate?

It is proposed that the Woronora River Estuary Management Plan is reviewed on a regular basis, and completely updated within a period of about 5 years (i.e. before end 2012). A regular review of the Plan (which may occur annually, for example) is necessary to allow modifications / alterations to the management of the estuary, on an as-needed basis, within the context of an adaptive management framework.

Any modification to the Plan will need to be exhibited to the community and referred to Council for adoption.

The periodic Estuary Management Plan reviews should cover the topics described in Table 7-6. This table also outlines who is responsible for conducting the periodic reviews.

It is possible that the NSW Government's Estuary Management Program, under which this Plan has been prepared and will be implemented, may change in the future. A new Coastal Zone Management Manual is currently in preparation, and will combine and replace the existing Estuary Management Manual (1992) and the Coastline Management Manual (1990). Therefore, on-going liaison between Council, DECC and the Estuary Management Committee is necessary to ensure that the aims and objectives of the Woronora River Estuary Management Plan continue to be achieved in the future.

Table 7-6 Framework for Future Estuary Management Plan Review

Review Period	Review tasks	Responsibility
Annual	• Assess primary, secondary and tertiary evaluation measures, and determine appropriate contingencies if	Estuary Management Committee or appointed

	performance measures do not meet targets • Review funding arrangements and allocations for current and future management strategies • Review resourcing and staffing allocations for current and future management strategies • Provide report on progress of Estuary Management Plan implementation, results of annual review, and any modifications required to the Plan coming out of the review	external consultant* To be coordinated through Council and reported to Council, relevant stakeholders and government agencies
5 Yearly *(first review to be completed by end 2012)*	• Assess the overall effectiveness of each management strategy implemented to date • For strategies requiring on-going commitment, assess the value in maintaining implementation of those strategies • Reconsider the management options that were not short-listed and included in the original Plan • Provide implementation details of additional strategies that are to be included in the subsequent 5 year Plan • Update the Estuary Management Plan document to reflect proposed strategies for implementation over the next 5 year period, and seek endorsement by stakeholders, government agencies and the community.	Estuary Management Committee or appointed external consultant* To be coordinated through Council and reported to Council, relevant stakeholders government agencies and the general community

** It would be advantageous for the same consultant responsible for initially preparing the Estuary Management Plan to be involved in the annual review and 5-yearly update, given their appreciation of the study area and the details of the Plan and associated strategies.*

7.6.2 Amendment Record

This Plan was last reviewed and amended on ……..

The next scheduled review is due ……

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APPENDIX A: RESULTS OF MULTI CRITERIA ASSESSMENT

The spreadsheet that has been used to assess the various management options considered as part of this study is reproduced on the following page. The following describes the way in which the final score for each management option has been derived.

The different management options are listed in the "Strategies" column. Immediately to the right of the Strategies column are 19 columns representing management objectives 1 through to 19, as summarised in Table 5-1. The second row at the top of each of these objective columns contains a "Relative Score". The relative score is equal to the score that has been used to obtain the priority ranking of management objectives as summarised in Table 5-1.

Each management option has been assessed against each management objective with "Effectiveness Scores" assigned as follows:

- Column Blank: Management Option does not appreciably address this objective
- Score = 0.5 : Management option addresses this objective, but only in a secondary manner (i.e. there is a weak interaction);
- Score = 1.0 : Management option is expected to address this objective significantly; and
- Score = 1.5: Management option is expected to address this objective extremely well.

The effectiveness score has been assigned on the basis of experience in both other locations and in the Woronora Area, feedback obtained from community consultation, findings from the Estuary Processes Study and an overall understanding of the functioning of the Estuary and the community that lives within its catchment. While these scores are well informed, there is definitely a degree of subjectivity that could be queried. However, the resulting short listed of management options have been assessed as reasonable.

A cumulative total representing the ability of each option to address the objectives has been determined by calculating the total of these scores multiplied by the relative score of each management objective with which it interacts. Mathematically, this could be represented as

$$Total = \sum_{1}^{19} RS_{OBJ} \times ES_{OPT}$$

Where RS_{OBJ} is the relative score of the objective, ES_{OBJ} is the effectiveness score representing the interaction of the objective and option being considered.

The total is subsequently multiplied by a cost factor (Low Cost = 3, Medium Cost = 2, High Cost = 1- see the cost factor and cost columns) and a community acceptance/effectiveness factor (High = 3, Moderate = 2, Low = 1 – see the effectiveness/acceptance and effect factor columns). The resulting Score has been multiplied by ten and rounded to give a whole number and then ranked on the basis of that number.

	TYPE	TIMEFRAME	Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TOTAL	COST (H-M-L)	COST FACTOR	Obj*costfact	EFFECTIVENESS / ACCEPTANCE (H-M-L)	EFFECT FACTOR	Obj*costfact*effectfact=TOTAL	Score * 10 (Rounded)	RANK
			Relative Score	0.42	0.30	0.37	0.34	0.23	0.26	0.30	0.19	0.20	0.32	0.31	0.29	0.22	0.16	0.35	0.17	0.16	0.18	0.22									
			Strategies																												
WQ-1	Planning	ST	Emergency Plan for Illegal Dumping. This would include the provision of appropriate clean up infrastructure at various locations along the River.					1				0.5											0.3297101	L	3	0.989130286	H	3	2.97	30	16
WQ-2	On-ground Works	MT	End of Pipe Treatment for Stormwater Outlets. Suggestions include provision of 'meshes' or 'grates' at outlet locations. This would primarily be to trap rubbish	1																			0.4222602	H	1	0.422260207	H	3	1.27	13	34
WQ-3	Planning	MT	Restrict Waterfront and Ridge Top Development. The restriction of these types of development would prevent the exacerbation of any sediment (silt/sand) coming off the catchment, which is seen by many as the source of siltation of the River.	1			0.5																0.5944955	M	2	1.188991038	M	2	2.38	24	27
WQ-4	On-ground Works	MT	Source Control in Catchment Stormwater (slowing runoff). This would involve the retrofitting of existing stormwater infrastructure with appropriate GPT, sediment traps to protect the river at source and controlling runoff speed.	1.5			1.5																1.1500962	H	1	1.150096246	H	3	3.45	35	11
WQ-5	Monitoring	ST	Locate and monitor all OSS systems		1																		0.2957645	L	3	0.887293531	M	2	1.77	18	31
WQ-6	Education	ST	Education Program (unsealed surfaces etc. etc.)	1																			0.4222602	L	3	1.266780622	M	2	2.53	25	24
WQ-7	Administration	ST	More effective policing and penalties for people caught dumping into the River.					1															0.2295385	L	3	0.68861539	L	1	0.69	7	41
WQ-8	On-ground Works	LT	Assess and upgrade Sewerage System to minimise overflows	1		1.5																	0.9709654	H	1	0.970965374	H	3	2.91	29	19
WQ-9	Planning and Controls	MT	Prepare Council Policy for Best Practice Management of Stormwater - i.e. WSUD	1			1																0.7667308	L	3	2.300192492	M	2	4.60	46	6
WQ-10	Planning and Controls	ST	Don't open the fire trail. This is a proactive measure to prevent the additional runoff from the road, introducing pollutants and sediment into the river.	1																			0.4222602	L	3	1.266780622	L	1	1.27	13	34
Ecol-1	On-ground Works	Imm	Fish Passage: Construction of an effective fish passage at the pass of Sabugal. This area is a priority barrier to fish Migration for DPI, and is being addressed at present, although the barrier is not being completely removed								1												0.1880766	L	3	0.564229763	H	3	1.69	17	33
Ecol-2	On-ground Works	Imm	Bushcare Groups: Revegetate areas close to and within ecologically sensitive areas							1			1										0.6206531	L	3	1.861959311	H	3	5.59	56	4
Ecol-3	Administration	ST	Contact appropriate task force re. the subject of environmental flows and provide input to that process						1		1												0.4511056	L	3	1.35331669	M	2	2.71	27	23
Ecol-4	On-ground Works	ST	Targeted Bush Regeneration at Shackels Estate. There is a proliferation of terrestrial weeds upon properties "bought back". A problem may be the presence of Asbestos.										1										0.3166871	L	3	0.950061241	H	3	2.85	29	20
Ecol-5	Education	ST	Mark key habitat areas on boating charts and at recreational access points to the estuary							1		1											0.5043093	L	3	1.512927864	H	3	4.54	45	7
Ecol-6	On-ground Works	ST	Bushcare groups used to revegetate a riparian buffer zone for the protection of aquatic ecosystems.							1			1	1									0.9314351	L	3	2.794305303	M	2	5.59	56	3
Ecol-7	Investigation and Review	Imm	Mapping Study of saltmarsh and seagrass, overlaid with threats (e.g. stormwater etc.) or erosion							1		1											0.5043093	L	3	1.512927864	H	3	4.54	45	7
Ecol-8	Planning and Controls	MT	In planning, include upstream buffer zones to allow upward migration of salt marsh with sea level rise.							1		1											0.5043093	L	3	1.512927864	M	2	3.03	30	15
Ecol-9	Planning and Controls	MT	Foreshore structures designed to minimise impact on aquatic vegetation							1													0.303966	L	3	0.911898071	L	1	0.91	9	39
Ecol-10	Planning and Controls	ST	Additional Promotion of Green Web Program to protect the important ecological corridor in the Forbes/Loftus Creeks areas							1													0.303966	L	3	0.911898071	M	2	1.82	18	29
Ecol-11	Education	MT	Community Education Program on Ecology and Heritage							1							1						0.4687252	L	3	1.406175583	M	2	2.812351166	28	21
W&F-1	Education	Imm	Replace and/or Improve Speed Limit Signage. The aim of this is to ensure that everyone actually knows what the waterway speed limits are, as boat wake is almost definitely the main cause of foreshore erosion									1			1								0.487392	M	2	0.974784005	H	3	2.92	29	17
W&F-2	On-ground works	ST	Moderate, targeted and ongoing dredging with regular monitoring with appropriate safeguards. This is the most commonly recommended strategy from community respondents. The need for dredging has been earmarked at numerous locations along the entire river. Suggestions include, near Bonnet Bay, Forbes Creek, areas upstream of Deepwater (for fire access) and the entrance shoals															1			1		0.5363898	M	2	1.072779614	H	3	3.22	32	13
W&F-3	On-ground works	LT	Extensive Dredging. One community respondent has made particular reference to the loss of seawalls following extensive dredging and this would need to be considered, along with the loss of seagrass. Some consider that major sedimentation has resulted from activities during construction of the Bridge.															1					0.3519531	H	1	0.351953114	L	1	0.35	4	43
W&F-4	Education	Imm	Education of Boaters on Speeding and the damage it does. This could include appropriate signage at points of access to the river. Leaflets at various commercial establishments.									1			1	0.5							0.59653	L	3	1.789589973	H	3	5.37	54	5
W&F-5	Planning and Controls	Imm	Limit Speed Limit to 4 knots in River or review speed limits in vicinity of eroding foreshores (also no-wake zones)									1			1	0.5							0.59653	L	3	1.789589973	M	2	3.58	36	9
W&F-6	Planning and Controls	ST	Prevent Large Boats. Large boats are implicated in causing boat wake erosion. Of particular note is Council's waste barge. This needs to be resolved.												1								0.2870487	L	3	0.861146214	M	2	1.72	17	32
W&F-7	Administration	Imm	More frequent and effective policing of waterway users					1				1			1								0.7169305	L	3	2.150791397	H	3	6.45	65	1
W&F-8	On-ground works	MT	Soft Protection of eroding foreshores. This may be appropriate in more natural areas such as fronting the scout camp etc, areas fronting Mangroves etc.							1				1									0.614748	H	1	0.614748021	M	2	1.23	12	37
W&F-9	On-ground works	ST	Hard Protection/Repair of Eroding Foreshores. Areas where this needs to be targeted include Janalli Reserve (Burnum Burnum Sanctuary) Prince Edward Park (do we need to prevent tidal inundation).							1				1.5		1							0.988415	M	2	1.976829992	H	3	5.93	59	2
W&F-10	Education	ST	Community education program aimed at the sedimentary processes of the River to enable people to understand what causes	1																			0.4222602	L	3	1.266780622	L	1	1.27	13	34
W&F-11	On-ground works	LT	Upgrade PEP Wharf - Has already been done, however there were issues with seagrass that limited the extent to whifh it could be fixed															1					0.3519531	M	2	0.703906228	L	1	0.70	7	40
W&F-12	On-ground works	MT	Upgrade of public facilities in reserves, e.g. near public boat ramp at Prince Edward Park.													1							0.218276	M	2	0.436551954	L	1	0.44	4	42
W&F-13	Planning and Controls	MT	Prepare Council Policy on Erosion and Sedimentation within Catchment (could include this with the WSUD Policy)	1																			0.4222602	L	3	1.266780622	M	2	2.53	25	24
W&F-14	Education	ST	Clean up foreshores campaign to educate and encourage the public land owners to take some pride in their community and tidy up areas fronting their properties. This could be done in conjunction with Council cleaning up their foreshore properties.										0.5			1							0.3766195	L	3	1.129858552	H	3	3.39	34	12
W&F-15	Planning and Controls	MT	Restrict/prevent additional development of foreshores	1																			0.4222602	L	3	1.266780622	M	2	2.53	25	24
W&F-16	Planning and Controls	Imm	Ban Wakeboarding									1			1								0.487392	L	3	1.462176007	M	2	2.92	29	17
W&F-17	On-ground works	MT	Construct Right of Way fronting all foreshore properties through buy back etc.													1							0.218276	H	1	0.218275977	L	1	0.22	2	45
W&F-18	On-ground works	LT	Construct Groynes on Forbes Creek and dredge to clean up creek and move flood flows away from residential properties															1					0.3519531	H	1	0.351953114	L	1	0.35	4	43
M&E-1	Investigation and Review	ST	Undertake survey on Recreational Fishing									1											0.2003433	L	3	0.601029793	H	3	1.803089379	18	30
M&E-2	Investigation and Review	Imm	Water Quality Monitoring Program	0.5															1				0.3849826	L	3	1.154947781	H	3	3.464843344	35	10
M&E-3	Investigation and Review	Imm	Ecological Health Monitoring Program							1										1			0.4657511	M	2	0.931502297	H	3	2.794506892	28	22
M&E-4	Investigation and Review	ST	Hydrosurvey Monitoring.															1			1		0.5363898	M	2	1.072779614	H	3	3.218338842	32	13
M&E-5	Investigation and Review	ST	Monitor Stormwater Quality Devices (perhaps FC vs EC)																1				0.1738525	L	3	0.521557471	M	2	1.043114941	10	38
M&E-6	Investigation and Review	MT	Periodic Review of Implementation Progress																			1	0.2171675	L	3	0.651502543	H	3	1.954507628	20	28

APPENDIX B: COMMUNITY CONSULTATION

Appendix B1: Community Newsletters and Questionnaire

Appendix B2: Correspondence with Local Aboriginal Land Council

Appendix B3: Management Study Stakeholder Letter