Parramatta River Estuary Coastal Zone Management Plan

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Prepared for

Parramatta River Estuary Management Committee*

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Cover photo: Yachts moored in Kissing Point Bay, 8/02/2011.

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

Overview

Cardno has prepared this Coastal Zone Management Plan (CZMP) for the Parramatta River estuary for Parramatta City Council (PCC) and the Office of Environment and Heritage (OEH) on behalf of the Parramatta River Catchment Group (PRCG). A CZMP is the legislated name for a plan to manage an estuary in NSW. Preparation of this Plan has been overseen by the Parramatta River Estuary Management Committee (the Committee), whose membership includes representatives of Local and State Government, non-Governmental organisations, natural resource managers, community members and other key stakeholders.

For the purposes of this Plan, the study area comprises the whole of the Parramatta River estuary, including the waterway, bays, foreshores and adjacent lands of the Parramatta River and its tidal tributaries, extending from the tidal limit at the Charles Street weir at Parramatta to Clarkes Point, Balmain in the east, Woolwich, in the south and Yurulbin Point, Birchgrove, in the north (Figure 1.1).

One of the key requirements for the Parramatta River Estuary CZMP articulated by the Committee was that it be realistic, feasible and achievable.

Management Context

The Parramatta River estuary is the main tributary of Sydney Harbour. It is tidal up to the Charles Street weir, a distance of 19km upstream of the commencement of the River at Balmain. The Parramatta River estuary has a catchment of 252.4km^2 (OEH, 2011).

The catchment has been subject to a long history of urban development, and the lower catchment in particular has been heavily urbanised for industrial, commercial and residential land uses. Many parts of the estuary have been subject to land reclamation, and in many cases these reclaimed lands have been filled with rubbish or other waste materials. In addition, historical industrial activity has left a legacy of contamination at a number of foreshore sites, and a number of the tributaries have been channelised.

Whilst a large amount of estuarine habitats have been lost due to the development of the foreshores, significant stands of mangroves remain along the river west of Henley (along the northern shoreline) and Mortlake (along the southern shoreline). In addition, significant wetlands occur in Bicentennial Park and Newington Nature Reserve Wetland, both of which are nationally significant.

The Parramatta River estuary is an important recreational waterway, particularly for the western suburbs of Sydney. It has a long historical association with sailing and rowing, as evidenced by the large number of boat sheds and club houses along the river. There is also a regular ferry (RiverCat) service between Parramatta and Circular Quay that catered for 1.78 million journeys in the 2011-12 financial year to make it the third most popular service in Sydney Harbour, although the number of 'passengers per service hour' was the lowest at 68 (Sydney Ferries, 2012). The foreshore parks are heavily utilised by both visitors and locals for a range of recreational activities. There is an increasing demand for high quality, high amenity recreational facilities supported by commercial developments such as marinas or cafes.

In recent years there has been a shift from industrial land use to residential land use. There are a number of large residential developments either in progress or proposed for the river foreshore.

There is a need for coordinated strategic planning along the entire Parramatta River estuary to manage the diverse range of sometime conflicting issues present, but the process is complicated by the presence of a large number of stakeholders, with a total of eight local councils having foreshore frontage to the river, and numerous other State Government agencies and non-governmental organisations also playing a role in management of aspects of the estuary.

A Coastal Hazard Assessment was also undertaken by Cardno to assess the potential impacts of SLR on the Parramatta River estuary, in accordance with the *Coastal Risk Management Guide* (DECCW, 2010d) and the NSW Government's *Sea Level Rise Planning Benchmarks* (DECCW, 2009) and is provided in Appendix C.

The Management Plan

A series of management aims and objectives were developed that articulated the Committee's vision for the management of the Parramatta River estuary. This draft Plan includes an implementation strategy to address these aims and objectives, which consist of 67 prioritised actions proposed for execution within 10 years of adoption of the Plan (Section 5). These actions will be implemented by either the Committee as a whole, or by each of the respective management authorities, for which a series of individual Actions Plans have been developed (Section 5).

The estimated capital cost of implementation of the Plan is $19.4 million, with annually recurrent costs (assuming a 10 year period of implementation) of $1.6 million. The management actions within the implementation strategy have been prioritised to assist in allocating resources when carrying out the Plan, however, it is acknowledged that the resources required to progress the Plan are significant and that a flexible approach to undertaking works should be adopted. For example, there may be grants or other funding opportunities that arise that will allow the Committee to select certain types of management actions for implementation before other, higher priority actions.

In addition to the 67 prioritised actions a further 16 management actions were identified as generic actions of significant benefit or high priority that may be implemented by any council or authority in the event the necessary resources become available. These generic actions have been provided as a stand-alone list.

In order to measure the success of implementation of the Plan, a monitoring and evaluation strategy is also included (Section 6), that provides for regular assessment against a range of Key Performance Indicators, as well as more regular monitoring of estuarine health. The Parramatta River Estuary CZMP should be regarded as a 'living document' that is reviewed and updated over time in accordance with the principles of adaptive management. The monitoring and evaluation strategy will be a key input into this process.

Successful implementation of the Plan will require the continued cooperation of the many stakeholders under the guidance of the Parramatta River Estuary Management Committee.

GLOSSARY AND ABBREVIATIONS

AHD	Australian Height Datum.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of an inundation event as big as or larger than the selected event. For example, the 20 year ARI inundation event will occur, on average, once every 20 years. ARI is another way of expressing the likelihood of occurrence of an inundation event.
AusRIVAS	The Australian Rivers Assessment System; a rapid prediction approach to assessing riverine health.
Avifauna	The bird population of a particular area.
BASIX	Building Sustainability Index; developed by the NSW Government as an online tool to be used to progress certification of a property as meeting agreed sustainability targets through the design process (e.g. in relation to energy efficiency and water savings measures).
Bathymetric survey / data	Survey of ocean or river beds using depth soundings (SONAR).
Benchmarks	A standard by which something can be measured or judged. For example, predicted amounts of sea level rise to incorporate into planning considerations.
Cadastre	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
CAMBA	China-Australia Migratory Bird Agreement.
CAP	Catchment Action Plan.
Catchment	An area of land that drains to a common point, or watercourse.
CBD	Central Business District.
CHA	Coastal Hazard Assessment.
CMA	Catchment Management Authority.
Coastal processes	The set of mechanisms that affect the land-water interface. These processes incorporate sediment transport and are governed by factors such as tide, wave and wind energy.
Crest level	The height of the top of a feature (e.g. a seawall).
CSE	Chief Scientist and Engineer of NSW
DCP	Development Control Plan.
DEM	Digital Elevation Model.
DPI	NSW Department of Primary Industries.
DP&I	NSW Department of Planning and Infrastructure.
EC	Electrical Conductivity; a means of measuring the salinity of water.
EEC	Endangered Ecological Community, listed in Part 3 of Schedule 1 of the *Threatened Species Conservation Act 1995*.
EIA	Environmental Impact Assessment.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
Estuary	The lower portion of a river or creek that is subject to tidal exchange (either permanently or intermittently) with the open ocean.
FC	Faecal coliforms.
Foreshore	The area of land at the land-water interface that is likely to be affected by coastal and catchment processes.
FTE	Full Time Equivalent; a measure of full time employees.

Geographical Information System (GIS)	A system of hardware, software, data, and procedures designed to support the management, manipulation, analysis and display of spatially referenced data by trained personnel.
GPT	Gross Pollutant Trap (a type of SQID).
ha	Hectares.
Harbour REP	*Sydney Regional Environment Plan (Sydney Harbour Catchment) 2005.*
Hazard	A situation that poses a threat to life, health, property, or the environment.
HNCMA	Hawkesbury Nepean Catchment Management Authority.
Inundation	Flooding, by the rise and spread of water, of a land surface that is not normally submerged. The key types of inundation referred to in this document are: Coastal inundation: A natural process whereby elevated ocean water levels combined with wave run-up along beaches result in seawater overtopping estuarine foreshores during storm events. This process is generally rare and episodic, occurring principally around the peak of a high tide, creating a hazard particularly in areas below about 5m AHD. Tidal inundation: The submergence of land by seawater due mainly to the action of very high tides. This process is predominantly a hazard for low-lying estuarine foreshores.
IPCC	Intergovernmental Panel on Climate Change
JAMBA	Japan-Australia Migratory Bird Agreement.
KPI	Key Performance Indicator; the KPIs define a set of targets against which the Committee can measure the success of implementation of the Plan.
LALC	Local Aboriginal Land Council.
LEP	Local Environment Plan.
LGA	Local Government Area.
Management Actions	Management actions fall under the general management options. They provide more specific detail on how, where and by whom an activity will be implemented in order to progress the associated management option. See also Management Options.
Management Aims	Management aims are high level statements that provide overall context and describe what the Plan is trying to achieve. See also Management Objectives.
Management Objectives	Management objectives fall under the broad management aims. Objectives are more specific, measurable statements that describe what the Plan hopes to deliver. See also Management Aims.
Management Options	These are the general types of activities proposed to achieve the management objectives. See also Management Actions.
MER	Monitoring, Evaluation and Reporting; after the NSW MER Strategy (DECCW, 2010c)
MHWM	Mean High Water Mark.
MHWS	Mean High Water Springs is the highest level which spring tides reach on the average over a period of time (usually several years).
ML	Megalitres.
Mollusc	A large phylum of invertebrate animals with external shell and muscular foot; includes limpets, oysters, and mussels.
Mean Sea Level (MSL)	MSL is a measure of the average height of the ocean's surface such as the halfway point between the mean high tide and the mean low tide. At present, mean sea level is approximately equivalent to 0m AHD.
Nekton	The aggregate of aquatic organisms that are free floating or swimming in the water column.
NPWS	National Parks and Wildlife Service; part of OEH.
NRM	Natural Resource Management.

NSW	New South Wales.
NTU	Nephelometric Turbidity Unit; a measure of turbidity of water.
OEH	NSW Office and Environment and Heritage.
PAH	Polycyclic aromatic hydrocarbons; produced during combustion.
PCC	Parramatta City Council.
pH	A measure of the acidity or basicity of an aqueous solution.
ppt	Parts per thousand, a unit of measurement.
RARC	Rapid Appraisal of Riparian Condition.
REP	Regional Environment Plan.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of inundation, communities and the environment.
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement.
Seawall	Wall or revetment structure built parallel to the shoreline to assist in protecting the shoreline from erosion and/or inundation.
SEPP	State Environmental Planning Policy.
SEWPAC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities.
SIGNAL	Stream Invertebrate Grade No. – Average Level; a measure of invertebrate biodiversity used as an indicator of water quality.
SLR	Sea Level Rise.
SOPA	Sydney Olympic Park Authority.
SQIDs	A general term applied to Stormwater Quality Improvement Devices.
Still Water Level (SWL)	Average water-surface elevation at any instant including the effects of tides and storm surge, but excluding local variation due to waves and wave set-up.
Storm surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components: the increase in water level caused by the reduction in barometric pressure (barometric set-up) and the increase in water level caused by the action of wind blowing over the sea surface (wind set-up).
Storm tide	Storm tide is different from storm surge in that it includes all the elements of storm surge (IBE, wave set-up and wind set-up) as well as the astronomical tidal level.
Astronomical Tides	The regular rise and fall of the sea level in response to the gravitational attraction between the sun, moon and Earth.
TN	Total Nitrogen.
TP	Total Phosphorous.
WRL	Water Research Laboratory.
WSUD	Water Sensitive Urban Design; integration of water cycle management into urban planning and design.

1 INTRODUCTION

The Parramatta River Estuary Coastal Zone Management Plan (CZMP) has been prepared by Cardno on behalf of Parramatta City Council (PCC) and the NSW Office of Environment and Heritage (OEH). Its preparation has been overseen by the Parramatta River Estuary Management Committee (referred to hereafter as 'the Committee'), whose membership includes representatives of a Local and State Government, non-Governmental organisations, natural resource managers, community members and other key stakeholders.

1.1 Area Covered by the Plan

For the purposes of this Plan, the study area comprises the whole of the Parramatta River estuary, including the waterway, bays, foreshores and adjacent lands of the Parramatta River and its tidal tributaries, extending from the tidal limit at the Charles Street weir at Parramatta, to Balmain in the east, to Clarkes Point, Woolwich, in the south and Yurulbin Point, Birchgrove, in the north (Figure 1.1).

1.2 Coastal / Estuary Management Process

The NSW *Coastal Protection Act 1979* provides for the '*protection of the coastal environment of the State for the benefit of present and future generations*'. The objects of the Act relate to such matters as:

- The protection and rehabilitation of coastal environments,
- The ecologically sustainable development and use of the State's coastal resources,
- The promotion of amenity and public access to the coast,
- Ensuring the co-ordination of the policies and activities of the Government and public authorities in order to facilitate the proper integration of their management activities in the coastal zone, and
- To encourage the development of adaptation strategies in response to coastal climate change impacts such as sea level rise.

Under Part 4A of the Act, coastal zone management plans can be prepared by local Government with the support of OEH. The plans are required to consider the management of threats to estuary health, as well as the potential impacts of climate change, and must be prepared in consultation with the key stakeholders and the community.

There is also reference in the *Coastal Protection Act 1979* to guidelines for preparing coastal zone management plans. In 1992 the NSW Government developed an *Estuary Management Manual* which outlined an eight stage process working up to the development of an Estuary Management Plan (Table 1.1) and provided guidance on working through the process. The Committee's scope of works for the Parramatta River Estuary CZMP was to undertake Stages 4 to 6 (in bold italics) in accordance with the Manual (NSW Government, 1992).

Table 1.1: Estuary Management Process (NSW Government, 1992)

Stage:	Status for the Parramatta River Estuary:
1. Form an Estuary Management Committee.	Completed with the establishment of the Parramatta River Estuary Management Committee.
2. Assemble, compile and interpret existing data.	Completed with the preparation of the *Parramatta River Estuary Data Compilation and Review Study* (Cardno, 2008)*.

Stage:	Status for the Parramatta River Estuary:
3. Undertake an Estuary Processes Study.	Completed with the preparation of the *Parramatta River Estuary Processes Study* (AECOM, 2010)*.
4. Carry out Estuary Management Study.	This document (now a CZMP).
5. Prepare a draft Estuary Management Plan.	This document (now a CZMP).
6. Review of the Estuary Management Plan.	Completed after public exhibition and review of the draft Parramatta River Estuary CZMP.
7. Adopt and implement the Estuary Management Plan.	To be completed.
8. Monitor and review the management process.	Ongoing pending implementation (Stage 7).

*These documents can be viewed at: www.parramattaestuary.com.au.

Subsequent to the commencement of this project, the NSW Government released new *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010b), which supersede the NSW Government (1992) *Estuary Management Manual*. An effort has been made to incorporate the requirements of both guideline documents in the Parramatta River Estuary CZMP in consultation with PCC and OEH.

The NSW CZMP guidelines (DECCW, 2010b) identify a series of Coastal Management Principles that were developed to inform strategic coastal zone management. Table 1.2 outlines each of the Coastal Management Principles that have been addressed in this CZMP and provides cross references to the relevant report section. This report endeavours to address these principles to the fullest extent possible within the scope of works for the project, acknowledging that the principles were released after commencement of this project.

Table 1.2: Coastal Management Principles Addressed by the Parramatta River Estuary CZMP

Coastal Management Principle	Addressed by Parramatta River Estuary CZMP	Report Section
Principle 1 Consider the objectives of the *Coastal Protection Act 1979* and the goals, objectives and principles of the *NSW Coastal Policy 1997* and the *NSW Sea Level Rise Policy Statement* (DECCW, 2009).	The aims and objectives developed for management of the Parramatta River estuary are consistent with the Act, the *NSW Coastal Policy 1997* and the *NSW Sea Level Rise Policy Statement* (DECCW, 2009). The SLR benchmarks were used to assess coastal hazards in the study area, and the actions in the Plan provide for ongoing monitoring and management of the estuary in relation to the NSW Government SLR projections. Although the *Sea Level Rise Policy Statement* (DECCW, 2009) has subsequently been repealed, it is noted that the NSW Chief Scientist and Engineer continues to endorse the benchmarks adopted in the Policy as being the best available information based on the available scientific information.	Sections 1.2 & 3 Sections 2.5 & 5.2 Appendix C
Principle 2 Optimise links between plans relating to the management of the coastal zone.	The aims and objectives have sought to facilitate consistency between other plans of management and the Parramatta River Estuary CZMP, and this is supported by a number of specific management actions within the Plan.	Sections 3 & 4.2

Coastal Management Principle	Addressed by Parramatta River Estuary CZMP	Report Section
Principle 3 Involve the community in decision-making and make coastal information publicly available.	Stakeholder and community consultation has been undertaken to prepare this draft Plan.	Appendix B
Principle 4 Base decisions on the best available information and reasonable practise; acknowledge the inter-relationship between catchment, estuarine and coastal processes; adopt a continuous improvement management approach.	The management framework and implementation strategy outlined in this Plan have been developed based upon the scientific information contained in the *Data Compilation and Review Study* (Cardno, 2008) and the *Estuary Processes Study* (AECOM, 2010). The need to monitor the effectiveness of implementation of the Plan is acknowledged, as is the need to update the Plan in accordance with the principles of adaptive management.	Sections 2, 3, 4 & 5 Section 6
Principle 5 The priority for public expenditure is public benefit; public expenditure should cost effectively achieve the best practical long-term outcomes.	The assessment and prioritisation of management options and actions was undertaken utilising a triple-bottom line cost:benefit assessment. This framework recognised the public benefit as a priority for management options and actions.	Sections 4.1.2 & 4.2.2
Principle 6 Adopt a risk management approach to managing risks to public safety and assets; adopt a risk management hierarchy involving avoiding risk where feasible and mitigation where risks cannot be reasonably avoided; adopt interim actions to manage high risks while long-term options are implemented.	Risk to public safety, assets, and ecological health have been assessed in a largely qualitative fashion, through the consideration of estuary processes and management issues. A quantitative assessment of coastal hazards has also been undertaken to define the risk from elevated estuarine water levels in the present and under SLR conditions.	Section 2 Section 2.5 & Appendix C
Principle 7 Adopt an adaptive risk management approach if risks are expected to increase over time, or to accommodate uncertainty in risk predictions.	In the first instance, the options assessment criteria have sought to consider the potential for climate change to impact on the sustainability of each management option. Additionally, a monitoring and evaluation framework has been developed that seeks to assess changes in levels of risk and trigger an adaptive management response as required.	Appendix E Section 6
Principle 8 Maintain the condition of high value coastal ecosystems; rehabilitate priority degraded coastal ecosystems.	In addition to developing a specific management aim and objective relating to estuarine ecology, the options assessment included a criterion that considered the potential positive or negative impacts of the option on estuarine ecology.	Sections 3.1 & 4.1.2 Appendix E
Principle 9 Maintain and improve safe public access to beaches and headlands consistent with the goals of the Coastal Policy.	In addition to developing a specific management aim and objective relating to recreation and public access, the options assessment included a criterion that considered the potential positive or negative impacts of the option on public access. The Plan also seeks to promote improved coordination between the initiatives of various agencies in providing improved public access in the study area.	Sections 3.1 & 4.1.2 Appendix E

Coastal Management Principle	Addressed by Parramatta River Estuary CZMP	Report Section
	It is noted that there are no beaches or headlands within the study area, and that this principle has therefore been applied in relation to access to and along the estuary foreshores and waterway.	
Principle 10 Support recreational activities consistent with the goals of the NSW Coastal Policy.	In addition to developing a specific management aim and objective relating to recreation and public access, the options assessment included a criterion that considered the potential positive or negative impacts of the option on recreational amenity. The Plan also seeks to promote improved coordination between the initiatives of various agencies in providing for recreational amenity in the study area.	Sections 3.1 & 4.1.2 Appendix E

It should be acknowledged that the NSW Government announced its Stage One Coastal Management Reforms on 8 September 2012. As part of these reforms, the NSW Government no longer recommends state-wide sea level rise (SLR) benchmarks for use by local councils, with councils having the flexibility to consider local conditions when determining local future hazards.

Accordingly councils should consider information on historical and projected future SLR that is widely accepted by competent scientific opinion. This may include information in the NSW Chief Scientist and Engineer's Report entitled *Assessment of the Science behind the NSW Government's Sea Level Rise Planning Benchmarks* (CSE, 2012).

The NSW Chief Scientist and Engineer's Report noted the evolving nature of the science, which will provide a clearer picture of the changing sea levels into the future. The report identified that:

- The science behind SLR benchmarks from the NSW *Sea Level Rise Policy Statement* (DECCW, 2009) was adequate;
- Historically, sea levels have been rising since the early 1880s;
- There is considerable variability in the projections for future SLR;
- The science behind future SLR projections is continually evolving and improving.

As the majority of the tasks associated with this current CZMP were completed prior to the announcement of the NSW Government's Coastal Management Reforms in September 2012, the potential impacts of estuarine water levels have been based on SLR projections from the 2009 *NSW Sea Level Rise Policy Statement*. Given that the Chief Scientist and Engineer's Report identifies the science behind these SLR projections is adequate, the Committee is satisfied that the potential impacts of SLR for the Parramatta River estuary have been based on the best available information at the time of preparation of this report.

1.3 Management Context and Need for the Plan

Management Context

The Parramatta River estuary is the main tributary of Sydney Harbour. It is tidal up until the Charles Street weir, a distance of 19km upstream of the commencement of the River at Balmain. The Parramatta River estuary has a catchment of 252.4km^2 (OEH, 2011).

The Parramatta River estuary is one of Australia's most iconic waterways. The catchment has been subject to a long history of urban development, and the lower catchment in particular has been heavily urbanised for industrial, commercial and residential land uses. Up until the 1970's the Parramatta River estuary was subject to significant impacts from industrial pollution, and consequently there is a legacy of contamination in the estuarine sediments and foreshores. Industrial development has impacted on the southern side of the estuary more substantially than the northern side due to the presence of well-established infrastructure prior to the opening on the Sydney Harbour Bridge in 1932. Contamination in the estuary has resulted in a complete commercial fishing ban in Sydney Harbour, including the Parramatta River estuary.

Many parts of the estuary have been subject to land reclamation, and in many cases these reclaimed lands have been filled with rubbish or other waste materials. Several foreshore playing fields, including George Kendall Reserve and Meadowbank Park are located on former landfill sites. A number of the tributaries have also been channelised.

Whilst large areas of estuarine habitats have been lost due to the development of the foreshores, significant stands of mangroves are still present along the Parramatta River west of Henley (along the northern shoreline) and Mortlake (along the southern shoreline). In addition, significant wetlands occur in Bicentennial Park and Newington Nature Reserve Wetland, both of which are nationally significant.

The Parramatta River estuary is an important recreational waterway, particularly for the western suburbs of Sydney. It has a long historical association with sailing and rowing, as evidenced by the large number of boat sheds and club houses along the river. There is also a regular ferry (RiverCat) service between Parramatta and Circular Quay used by over 1.78 million people per year, based on data for the Parramatta River service area from the 2011-2012 financial year (Sydney Ferries, 2012). The foreshore parks are heavily utilised by both visitors and locals for a range of recreational activities.

In recent years there has been a shift from industrial land use to residential land use, and this has resulted in increased pressure to remediate contaminated areas and to provide additional recreational amenity. Foreshore and waterway linkages between existing commercial and recreational areas will also need to be improved to support these activities. There are a number of large residential developments either in progress or proposed for the river foreshore, and there is an increasing demand for high quality, high amenity recreational facilities supported by commercial developments such as marinas or cafes. Figure 2.2 shows the major areas of redevelopment through land use change since 1943.

There is a need for coordinated strategic planning along the entire Parramatta River estuary to manage these issues; however, it is noted that the process is complicated by the presence of a large number of stakeholders, with a total of eight local councils having foreshore frontage to the river (see below).

Institutional Framework and Key Stakeholders

Care and control of different aspects of management for the Parramatta River estuary is undertaken by a large number of local and State Government authorities. There are also a number of other organisations that control lands along the river foreshore, or have some involvement in management of the river. Several of these key stakeholders are represented on the Parramatta River Estuary Management Committee, which is a sub-committee of the PRCG.

This arrangement results in a complex institutional and regulatory environment, and it is the intention of the CZMP to consider the Parramatta River estuary as a whole, and suggest a balanced approach to the sustainable management of the estuary that considers the needs of all users.

Table 1.3 provides a summary of the key stakeholders involved in management of the Parramatta River estuary and some brief details on their roles and responsibilities. Those organisations that are represented on the Parramatta River Estuary Management Committee are identified with an asterix (*).

There are a number of other Government agencies that have some role in relation to regulation or management of activities in the study area. An overview of the key relevant legislation, policies and plans is provided in Appendix A. Figure 1.2 shows the boundaries for LGAs and some of the other management authorities.

Table 1.3: Key Stakeholder Roles and Responsibilities

Stakeholder	Roles and Responsibilities
Ashfield Municipal Council* Auburn Council* City of Canada Bay* City of Ryde* Hunters Hill Council* Leichhardt Municipal Council* Parramatta City Council* Strathfield City Council*	These councils have foreshore frontage on the river and also have a role on the Committee. They are responsible for a range of activities, including: ▪ Land use zoning and strategic planning. ▪ Assessment and determination of development applications. ▪ Compliance monitoring and auditing on a range of issues from parking infringements to contaminated land. ▪ Asset management (e.g. local roads, parks and reserves, and some seawalls). ▪ Natural resource management and planning for a range of issues such as biodiversity, flooding, catchments, estuaries, creeks and waterways. ▪ Environmental monitoring and reporting (e.g. State of the Environment reporting).
Bankstown, The Hills Shire, Blacktown, Burwood and Holroyd Councils	These councils are all located in the catchment and do not have foreshore frontage. They perform the same functions as those identified as foreshore councils, although their key roles in relation to this Plan are in land use zoning and general catchment management.
Hawkesbury Nepean Catchment Management Authority (HNCMA)*	The HNCMA is a State Government agency responsible for natural resource management at the catchment level. HNCMA plays a role in community engagement and education on natural resource management. They have an overarching role in facilitating the coordination of initiatives by a range of agencies in management of waterways. This translates into supporting local Government in developing CZMPs. The HNCMA and the Sydney Catchment Management Authority were recently amalgamated into a single CMA, referred to in this document as the HNCMA.
NSW Office of Environment and Heritage (OEH)*	There are a number of groups within OEH who have some role in estuary management. The key groups are the: ▪ Climate Change, Policy and Programs Group – direct role in funding CZMPs and providing technical assistance. A representative of this group sits on the Committee. ▪ Environment Protection and Regulation Group – management of waste, pollution and contaminated lands. ▪ Parks and Wildlife Group – management and protection of threatened species, and National Parks and Nature Reserves.

Stakeholder	Roles and Responsibilities
	▪ Country, Culture and Heritage Division – Aboriginal affairs and the protection of Aboriginal cultural heritage.
NSW Office of Water	The Office of Water has a range of functions including water policy and planning, licensing and compliance, management, and environmental evaluation.
NSW Department of Primary Industries (DPI)*	There are a number of groups within DPI with relevance to estuary management. The first is DPI (Fisheries), which has a role in: ▪ Aquatic ecological research, monitoring, evaluation and reporting. ▪ Management and protection of marine vegetation and aquatic (freshwater, estuarine and marine) fauna, including threatened and protected species. ▪ Fisheries and aquaculture research, policy, planning and regulation. Commercial fishing is currently banned in Sydney Harbour (including the Parramatta River) due to contamination. The NSW Food Authority (also part of DPI) and DPI (Fisheries) have also implemented recommended restrictions on the consumption of fish caught by recreational fishers west of the Harbour Bridge. Also within DPI is the Crown Lands Division, which plays an important role in estuary management: ▪ Land owner of Crown lands, which includes many foreshore reserves and wetlands. This excludes land below the MHWM, which in this case is managed by NSW Roads and Maritime Services (RMS) (Maritime). ▪ Management of Crown reserves through reserve Trusts and/or with local councils. ▪ Administration of the NSW *Crown Lands Act 1989*. ▪ Issue and management of leases and licences for Crown land.
NSW Roads and Maritime Services (RMS) (Maritime)*	RMS (Maritime) is the landowner of the bed of Sydney Harbour and some foreshore lands. RMS (Maritime) plays a role in the regulation, planning and approval of development in Sydney Harbour, including the Parramatta River. Their roles and responsibilities also include: ▪ Management and regulation of waterway safety and boating. ▪ Funding and management of public and private boating infrastructure and associated facilities (e.g. moorings, wharves and boat ramps). They administer leases for commercial, domestic and community purposes. RMS (Maritime) currently enforces a ban on boating west of the Silverwater Bridge (except for RiverCats and other authorised vessels). In addition, they conduct a program of clearing gross pollutants from the waterway.
Shell Refining (Australia) Pty Ltd*	Shell has a refinery located in Clyde at the confluence of the Parramatta and Duck Rivers. As a major landholder, the refinery is represented on the Committee. Note that Shell plan to cease refining operations at the Clyde refinery and convert it and their Gore Bay Terminal (10ha of land at Greenwich) into a fuel import facility before mid-2013.
Sydney Ferries Corporation*	The Sydney Ferries Corporation operates the ferry services on Sydney Harbour, including the RiverCat service between Parramatta and Circular Quay. Sydney Ferries Corporation now operates as Harbour City Ferries.
Sydney Harbour Federation Trust*	The Harbour Trust was set up to provide for the ongoing management of former defence sites located on Sydney Harbour, and therefore has a role in: ▪ Improving public access to their sites. ▪ Heritage preservation.

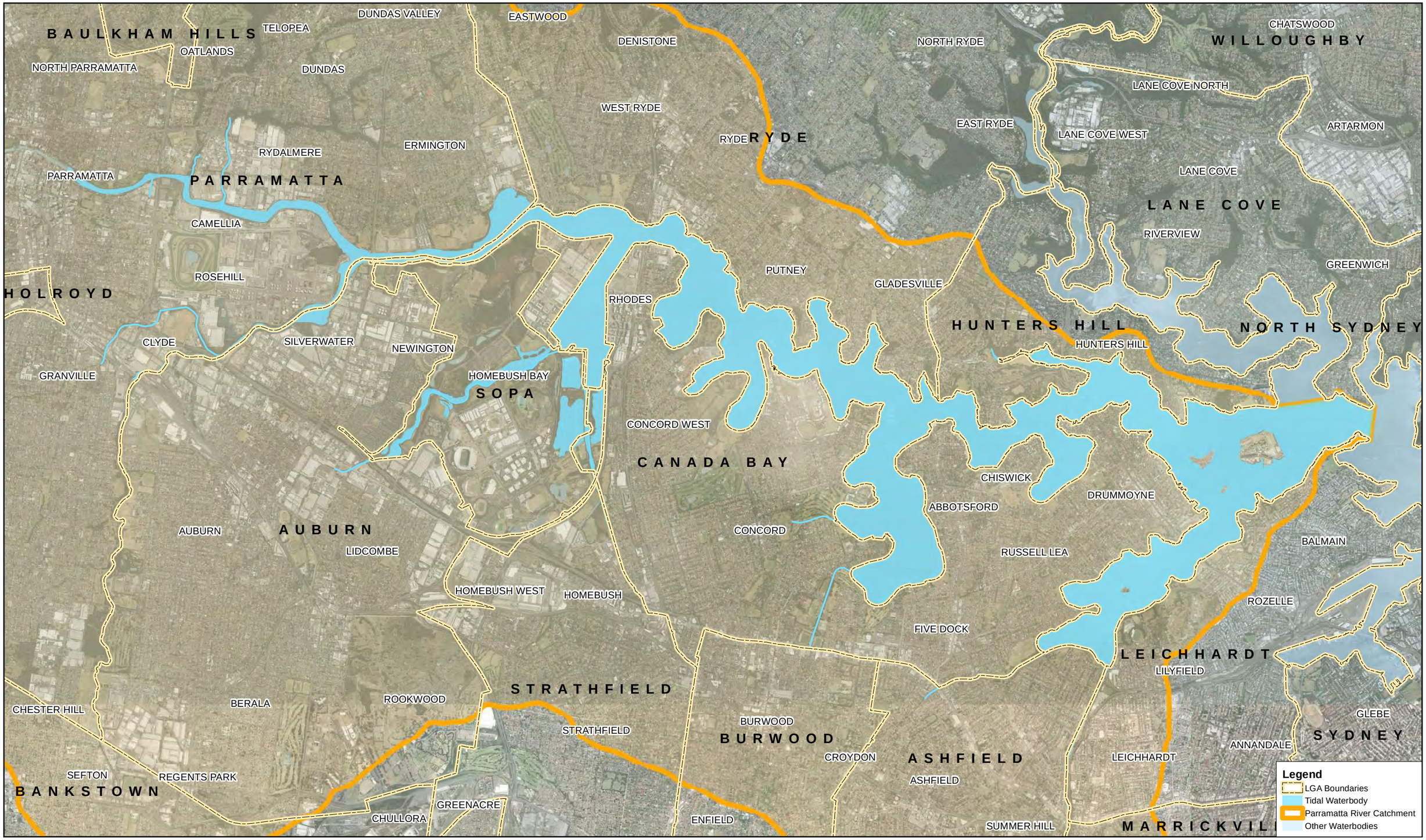
Stakeholder	Roles and Responsibilities
	Harbour Trust sites located within the study area include Cockatoo Island, Woolwich Dock and Parklands, and Snapper Island.
Sydney Metropolitan Catchment Management Authority (SMCMA)*	The SMCMA was a State Government agency responsible for natural resource management at the catchment level. The SMCMA has now been has been merged with the HNCMA as part of the changes to the regional service delivery model.
Sydney Olympic Park Authority (SOPA)*	SOPA is a statutory authority with responsibility for promoting, coordinating and managing the orderly use and economic development of Sydney Olympic Park, including the provision and management of $1.8 billion of infrastructure. The 640ha of land is managed by SOPA; this includes parts of the Parramatta River foreshore, and the lower ends of Powells Creek, Haslams Creek and Boundary Creek. SOPA has comprehensive programs for management and rehabilitation of the natural resources within the Park, including biodiversity conservation and remediated landfill management. SOPA also conducts and facilitates scientific research and education programs.
Sydney Water*	Sydney Water is responsible for the delivery of water supply, wastewater and/or some stormwater services for all of the study area. They therefore have an important role in relation to management of water quality in the estuary.
Darug Tribal Aboriginal Corporation* and Deerubbin Local Aboriginal Land Council (LALC)*	These two entities represent the interests of Aboriginal people, and seek to preserve and promote Aboriginal cultural heritage. The Deerubbin LALC is also a landholder of some large areas of land in the north-western part of the catchment.
Community groups*	The community also play an active role in environmental management and rehabilitation through a range of volunteer programs such as Bushcare, for which there are a number of active groups within the study area. Other important community groups are those representing sailors, rowers and canoeists. Community and conservation organisations represented on the Committee include Friends of Duck River, the Ryde Hunters Hill Flora and Fauna Preservation Society, and Concord and Ryde Sailing Club.

*Represented on the Parramatta River Estuary Management Committee.

Need for the CZMP

It is apparent that there a range of different aspects of estuary management that are undertaken by a number of different organisations, and that in many cases there are overlapping jurisdictional boundaries, which requires significant coordination and cooperation. Within the context of the existing management framework and management issues currently affecting the Parramatta River estuary, there is a demonstrated need for a holistic plan for management of the estuary as a single system, and in a sustainable and equitable fashion.

The Parramatta River Estuary CZMP seeks to consider the estuary as a whole, identify priority issues, and set out a management strategy for implementation by the key stakeholders.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:45,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Study Area

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 1.1

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G1001_StudyArea 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Sydney Metropolitan Catcnment Management Authority, Google and associated third party suppliers.

OATLANDS
DUNDAS
NORTH PARRAMATTA
DENISTONE
NORTH RYDE
CHATSWOOD
WILLOUGHBY
LANE COVE NORTH
WEST RYDE
EAST RYDE
LANE COVE WEST
ARTARMON
RYDALMERE
ERMINGTON
PARRAMATTA
RYDE
RYDE
LANE COVE
MEADOWBANK
CAMELLIA
HARRIS PARK
PARRAMATTA
RIVERVIEW
ROSEHILL
PUTNEY
GLADESVILLE
RHODES
HUNTERS HILL
HUNTERS HILL
CLYDE
SILVERWATER
NEWINGTON
GRANVILLE
HOMEBUSH BAY
SOPA
WOOLWICH
CONCORD WEST
CANADA BAY
ABBOTSFORD
CHISWICK
DRUMMOYNE
AUBURN
AUBURN
CONCORD
RUSSELL LEA
BALMAIN
HOMEBUSH WEST
HOMEBUSH
LIDCOMBE
ROZELLE
FIVE DOCK
STRATHFIELD
BERALA
ROOKWOOD
STRATHFIELD
BURWOOD
BURWOOD
ASHFIELD
CROYDON
LEICHHA
ASHFIELD
SEFTON
REGENTS PARK
GREENACRE

Legend

- LGA and Authority Boundaries
- SOPA Boundary
- RYDE LGA and Authority Names
- RYDE Suburb Names
- NPWS Estate (OEH)
- Oil Refinery
- Sydney Harbour Federation Trust
- RMS Maritime
- Crown Land (LPI)
- Road Corridors
- Waterbodies and Creeks

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:42,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Jurisdictional Boundaries

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 1.2

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G1002_JuristictionalBoundaries 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.

1.4 Study Approach

One of the key requirements for the Parramatta River Estuary CZMP articulated by the Committee was that it be realistic, feasible and achievable. In recognition of the large number of management issues associated with the estuary, and the complex institutional framework which exists, a hierarchical approach was developed in order to focus the CZMP (Figure 1.3). This approach also recognises that, in accordance with the requirements of the Coastal Zone Management guidelines (DECCW, 2010b) the Plan should be subject to review and update (as required) every 5 to 10 years.

A collaborative approach has been adopted in the development of this Plan. A range of different consultation activities have been conducted in order to seek input on the direction of the Plan. In addition, regular review of components of the Plan has been undertaken by the Committee.

One of the key exercises undertaken was a critical analysis of the management issues, and identification of key issues that should be the focus for management. The list of key issues is provided in Section 2.8 and has been based on our understanding of how the estuary functions, and how it is used by the community (Section 2). Once the key issues were identified, the Committee worked with the Cardno project team to establish the framework for the Plan, the aims, objectives and management options. These aspects were workshopped with the Committee during the following activities:

- Foreshore estuary tour by the Cardno study team in the company of Committee members – 8 February 2011,
- Committee Workshop 1: Key management issues, aims and objectives – 2 March 2011,
- Committee Workshop 2: Management options – 18 May 2011, and
- Committee Workshop 3: Management actions – 9 June 2011.

A series of management actions were developed for implementation by either the Committee as a whole, or by each of the respective management authorities. The management actions was considered by each relevant authority and prepared in consultation with the study team. These activities are discussed in more detail in Sections 3, 4 and 5.

A Coastal Hazard Assessment was also undertaken by Cardno and is provided in Appendix C. The purpose of the Coastal Hazard Assessment was to assess the potential impacts of extreme water levels and SLR on the Parramatta River estuary, in accordance with the *Coastal Risk Management Guide* (DECCW, 2010d).

Figure 1.3: Approach to the Parramatta River Estuary CZMP

Opportunity was also provided to the community to provide input to the Parramatta River Estuary CZMP via a series of consultation activities conducted during the course of this project:

- Establishment of a project email (parramatta.estuary@cardno.com.au) and website (www.parramattaestuary.com.au) – 23 February 2011;
- Media release issued announcing the commencement of the project – February 2011;
- Community Information Sessions – 21 July 2011 and 12 March 2013;
- A community survey made available on the internet and handed out to RiverCat passengers in the Parramatta River service area – 29 June to 26 August 2011;
- Public exhibition of the Draft CZMP – 19 February to 29 March 2013.

These consultation activities are discussed where relevant in the text of this report. A consultation summary is also provided in Appendix B.

Finally, the outcomes of the consultation program fed into the development of the implementation strategy that forms the Plan.

The Draft Parramatta River Estuary CZMP was placed on public exhibition as outlined above. Submissions received during the public exhibition period were reviewed prior to finalisation of the Plan, and amendments made as required.

This Final CZMP will be formally adopted by the eight foreshore Councils prior to commencement of implementation of management actions identified herein. Depending on the outcomes of the Stage 2 coastal reforms, the plan may be submitted to the Minister for certification, allowing the plan to be gazetted in the future.

2 OVERVIEW OF KEY ESTUARY PROCESSES AND MANAGEMENT ISSUES

This overview of key estuary processes operating within the Parramatta River estuary presents the key findings of the *Data Compilation and Review Study* (Cardno, 2008) and *Estuary Processes Study* (AECOM, 2010). At the time of preparing this Plan these studies were available online at http://parramattariver.org.au. Table 2.1 lists some of the key parameters for the estuary.

Table 2.1: Key Parameters for the Parramatta River Estuary (Source: Cardno, 2008)

Key Parameters		Source
Estuary Characteristics		
Classification	*Estuary group:* Tide dominated estuary *Estuary type:* Drowned river valley *Evolution stage:* Intermediate	OEH, 2011
Condition	Extensively modified and highly urbanised	Cardno, 2008
Estuary length	Approximately 19km	Cardno, 2008
Entrance conditions	Permanently open	OEH, 2011
Waterway area	13.7km^2	OEH, 2011
Estuary volume	69,700ML	OEH, 2011
Average depth	5.1m AHD	OEH, 2011
Total tidal length of foreshore	Approximately 135km, including all tidal areas of the estuary's tributaries and canals	AECOM, 2010
Length of tidal foreshore protected by seawalls	Total of 36km surveyed as part of the *Estuary Processes Study*: ▪ City of Canada Bay - 16.2km ▪ Parramatta LGA - 5.0km ▪ Auburn LGA - 3.2km ▪ Leichhardt LGA - 3.2km ▪ City of Ryde - 3km ▪ Hunters Hill LGA - 2.2km ▪ Sydney Olympic Park - 2.2km ▪ Ashfield LGA - 1.0km.	AECOM, 2010
Length of tidal foreshore canalised (canals)	Total of 21km surveyed as part of the *Estuary Processes Study.*	AECOM, 2010
Length of natural shoreline	Total of 74km surveyed as part of the *Estuary Processes Study.* Assumed that remaining length is non-natural (seawalls, canals and infrastructure): 61 km.	AECOM, 2010
Catchment Characteristics		
Total catchment area	252.4km^2	OEH, 2011
Main sub-catchments	▪ Upper Parramatta River estuary catchment (108.4km^2); ▪ Duck River (45.3km^2); ▪ Homebush Bay (29.9km^2); ▪ Iron Cove Bay (18.1km^2) ▪ Hen and Chicken Bay (8.5km^2) ▪ The Ponds/Subiaco Creek system (8.5km^2); ▪ Vineyard Creek (4.1km^2).	AECOM, 2010
Major tributaries	26 in total, with the 14 below directly entering the estuary: ▪ Saltwater Creek ▪ Powells Creek	Cardno, 2008

Key Parameters		Source
	▪ Boundary Creek ▪ Haslams Creek ▪ Duck River ▪ Clay Cliff Creek ▪ Vineyard Creek ▪ The Ponds/Subiaco Creek ▪ Archer Creek ▪ Charity Creek ▪ Smalls and Tarban Creeks ▪ Hawthorne Canal ▪ Iron Cove Creek (Dobroyd Canal).	
Main catchment land uses	▪ Residential - 60.7% ▪ Parkland - 16.8% ▪ Industrial - 6.4% ▪ Commercial - 5.8% ▪ Education - 3.5%.	Cardno (calculated from a GIS layer sourced from ABS)
Waterfront reserves	Total area 638.5ha: ▪ Auburn (incl. Sydney Olympic Park) - 419.6ha ▪ City of Ryde - 54.6ha ▪ City of Canada Bay - 53.5ha ▪ Parramatta - 46.9ha ▪ Hunters Hill - 40.7ha ▪ Leichhardt - 23.2ha.	AECOM, 2010
Estuarine Vegetation		
Area of aquatic macrophytes	▪ Mangroves – 149ha ▪ Saltmarsh – 23ha ▪ Seagrass - 10ha approx.	AECOM, 2010; West & Williams, 2008
Riparian vegetation communities	Total area 71ha: ▪ Swamp-oak Floodplain Forest ▪ Coastal Sandstone Gully Forest ▪ Coastal Sandstone Ridgetop Woodland ▪ Sydney Turpentine-Ironbark Forest.	AECOM, 2010

2.1 Catchment Processes

2.1.1 Land Use and Land Tenure

Land use and land tenure are important aspects of estuary management as the land uses determines the type and extent of developments across the catchment, which are the primary stressor on the natural estuarine environment. There is also a strong correlation between land use, sedimentation and water quality in estuaries as pollutants are washed into waterways in stormwater runoff. This is particularly relevant for the Parramatta River estuary as the catchment and its foreshores are highly urbanised.

Land tenure can have implications for management, particularly when responsibility for a contiguous reach of land, such as the estuary foreshore and creek lines, is divided across a number of landowners and governing authorities. In such situations a coordinated management approach is important for ensuring provision of recreational access and amenity, and for biodiversity conservation.

Historical Land Use

The estuary and its catchment have been exposed to persistent stress over the last two centuries due to historical and current anthropogenic impacts. Up until the 1970's the Parramatta River estuary was treated as an open drain for industry in Sydney, and consequently the estuary's embankments and sediments are contaminated with a range of heavy metals and other chemicals. Various industrial developments were situated along the estuary foreshores, some of which continue to be active today, while others have been converted for alternative uses (Figure 2.1). Historically, industrial development has impacted upon the southern side of the estuary substantially more than the northern side (see Figures 2.2 and 2.3).

a) Heavy industry behind mangroves, Silverwater (source: D. Wiecek, date unknown).

b) Industrial site with rail line, Silverwater (source: M. Campanelli, date unknown).

Figure 2.1: Industrial Development along the Parramatta River

There has been a large amount of land reclamation over the years, as analysed by AECOM (2010) based on a comparison of aerial photography from 1943 and the present day. The majority of land reclamation in the study area occurred prior to 1943, primarily within Homebush Bay, Iron Cove Bay, Hen and Chicken Bay, and the Auburn LGA (Figure 2.2, after AECOM, 2010). It is estimated that around 292ha of land was reclaimed in total and approximately 1km of foreshore lost as a result.

The amount of land use change between 1943 and 2009 is shown on Figure 2.3 (after AECOM, 2010). The greatest changes since 1943 have occurred mostly in the western areas of the catchment, where large areas of agricultural land have been subdivided for residential development. Some historical industrial areas, particularly along the foreshore, have been redeveloped since 1943 for residential and open space uses; however a legacy of industrial contamination of these areas is still a concern.

Historically, Auburn LGA encompassed large areas of industrial land use, and also contains large areas of reclaimed land. Therefore, parts of the estuary and foreshores more likely to be contaminated with industrial pollutants and leachates from reclaimed land are located in Parramatta and Auburn LGAs in the Parramatta River, Duck River and Homebush Bay. Other known areas of potential concern include several bays in the City of Canada Bay where land reclamation has also occurred, including Iron Cove Bay and Hen and Chicken Bay.

Contemporary and Future Land Use

Strategic land use planning and land zoning is governed by each of the individual councils through their Local Environment Plans (LEPs). In the present day, the major land use in the Parramatta River estuary catchment is

residential (60.7%), followed by parkland (understood to include all reserves and open space areas, 16.8%), with industrial and commercial land uses making up around 6% each.

All foreshore LGAs within the catchment are primarily residential land use, with open space and recreational land use areas often adjacent to the local waterways or along the estuary foreshore. Much of the residential development within the lower catchment consists of old building stock. Parramatta and Auburn LGAs contain the greatest areas of contemporary industrial land use.

In the future it is likely that parts of the catchment will be re-developed. The *Metropolitan Plan for Sydney 2036* (NSW Government, 2010) identifies the need to accommodate a large number of new dwellings in Sydney primarily within walking distance of centres that are well serviced by public transport. It also identifies Parramatta as Sydney's second Central Business District (CBD). Hence, it is likely there will be significant changes in land use, with an increase in development intensities in some parts of the catchment as brownfields sites are re-developed. Along the estuary foreshores some former industrial sites may be redeveloped for residential use, as has been the case at Rhodes in the City of Canada Bay.

Intensification of development within the catchment, including brownfields (redevelopment) and greenfields development, primarily for residential or commercial purposes has potential to result in increasing pressure on the estuary, which is a key issue for the estuary. However, it also presents an opportunity to ensure measures such as Water Sensitive Urban Design (WSUD) and riparian buffers are incorporated in new developments, as well as enhancing public access to the foreshore. Key areas of concern for land use planning identified by the Committee and the community include:

- Water cycle management;
- Biological connectivity/corridors and sustainable management of the environment;
- Connectivity along the foreshore and the availability of alternative forms of public transport;
- Equity of public access and recreational amenity along the estuary foreshores; and
- Management of coastal hazards, particularly under climate change conditions.

The current fragmented approach to management of the estuary, whereby a number of authorities regulate land use planning and development represents a challenge to efficient integrated management. Planning reforms currently being implemented by the DP&I include the preparation of standard instrument LEPs and DCPs by all local councils. There is opportunity through this process for the member councils of the Committee to work together to integrate some of their strategic planning activities with the objective of improving management and environmental outcomes for the estuary. Coordinating land use planning and development across all governing bodies involved in management of the estuary is the key mechanism to achieving this objective.

Land Tenure

Land tenure describes who owns a particular parcel of land or an asset (e.g. a stormwater channel). Land tenure is important from the perspective of implementation of the CZMP as consent must be obtained from the land owner prior to undertaking any works on their land, or works that affect their asset(s). Permits or approvals required to undertake works may also be dependent on the tenure status of the land in question.

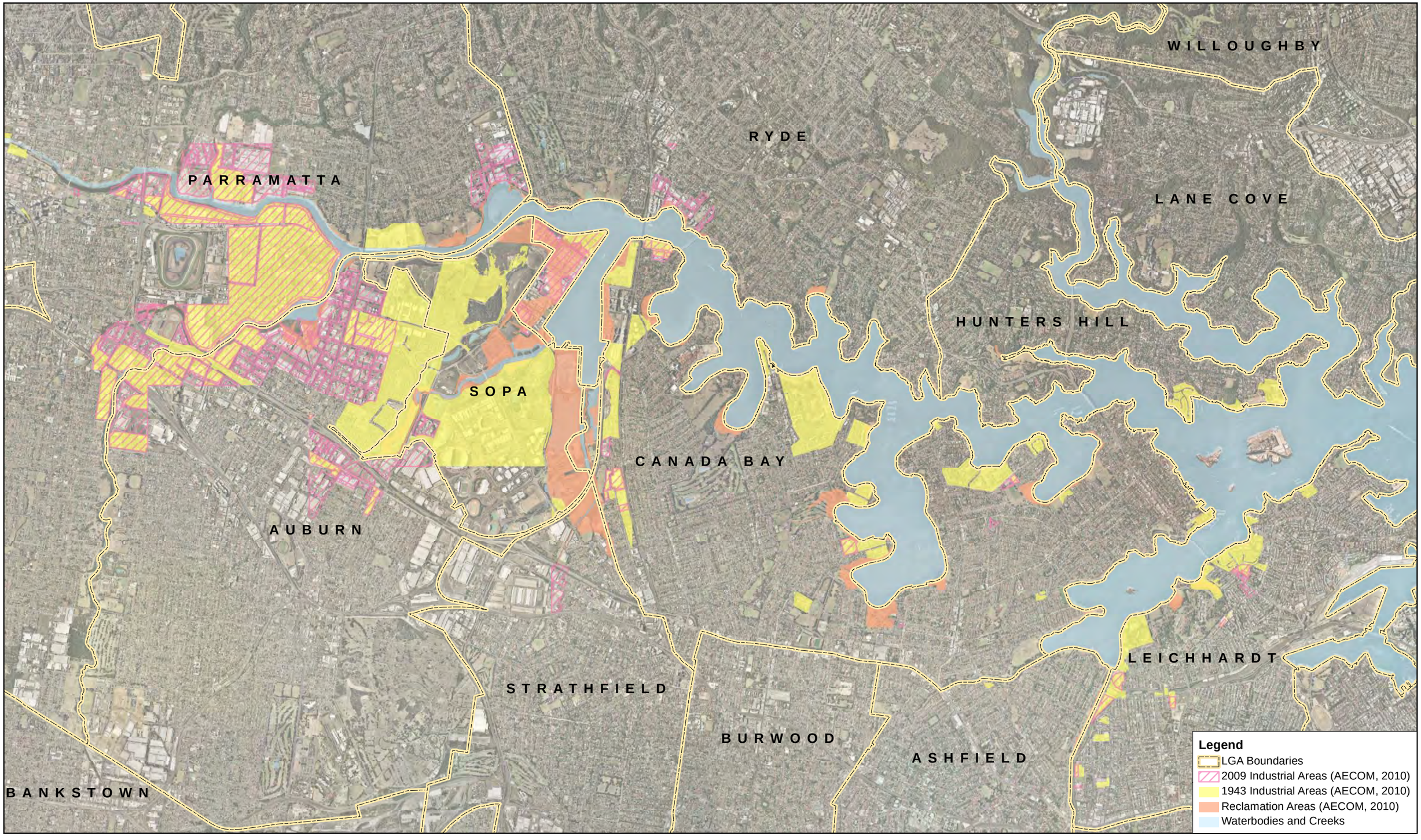
The ownership and control of estuarine foreshore and submerged lands ranges across a spectrum of private landholders, local councils, trustees, the Crown and other NSW Government authorities. Public land tenure has

been mapped for the study area in Figure 2.4 based on available GIS layers (assumed to be of sufficient accuracy and resolution for the purposes of preparing this CZMP), including:

- Crown land – CrownLand.shp (source: Crown Lands);
- Crown land held under tenure – CrownTenure.shp (source: OEH);
- National Parks – NPWS Estate.shp (source: OEH); and
- RMS (Maritime) land/properties – nsw_maritime_title_boundary.shp and premises.shp (source: RMS (Maritime)).

Land below the Mean High Water Mark (MWHM), including the bed of the Parramatta River estuary, is held under title by RMS (Maritime). RMS (Maritime) also has some foreshore land holdings (Figure 2.4), and is responsible for the management of moorings, wharves and jetties. The Crown Lands Division within the DPI is responsible for the management of Crown lands, which can be held under tenure (lease or licence). There are also some National Parks Estate lands within the study area, which are under the care and control of the National Parks and Wildlife Service (NPWS) within OEH.

The NSW Government has a documented policy in relation to access to the harbour and river foreshores, including public access to intertidal lands where landowners have absolute waterfronts but where the waterfront is exposed at low tide. The process of redevelopment of foreshore land may present opportunities to transfer private land holdings into public ownership, thereby increasing the extent of open space, and improving linkages between existing open space areas.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Reclaimed Land and Historical Industrial Areas

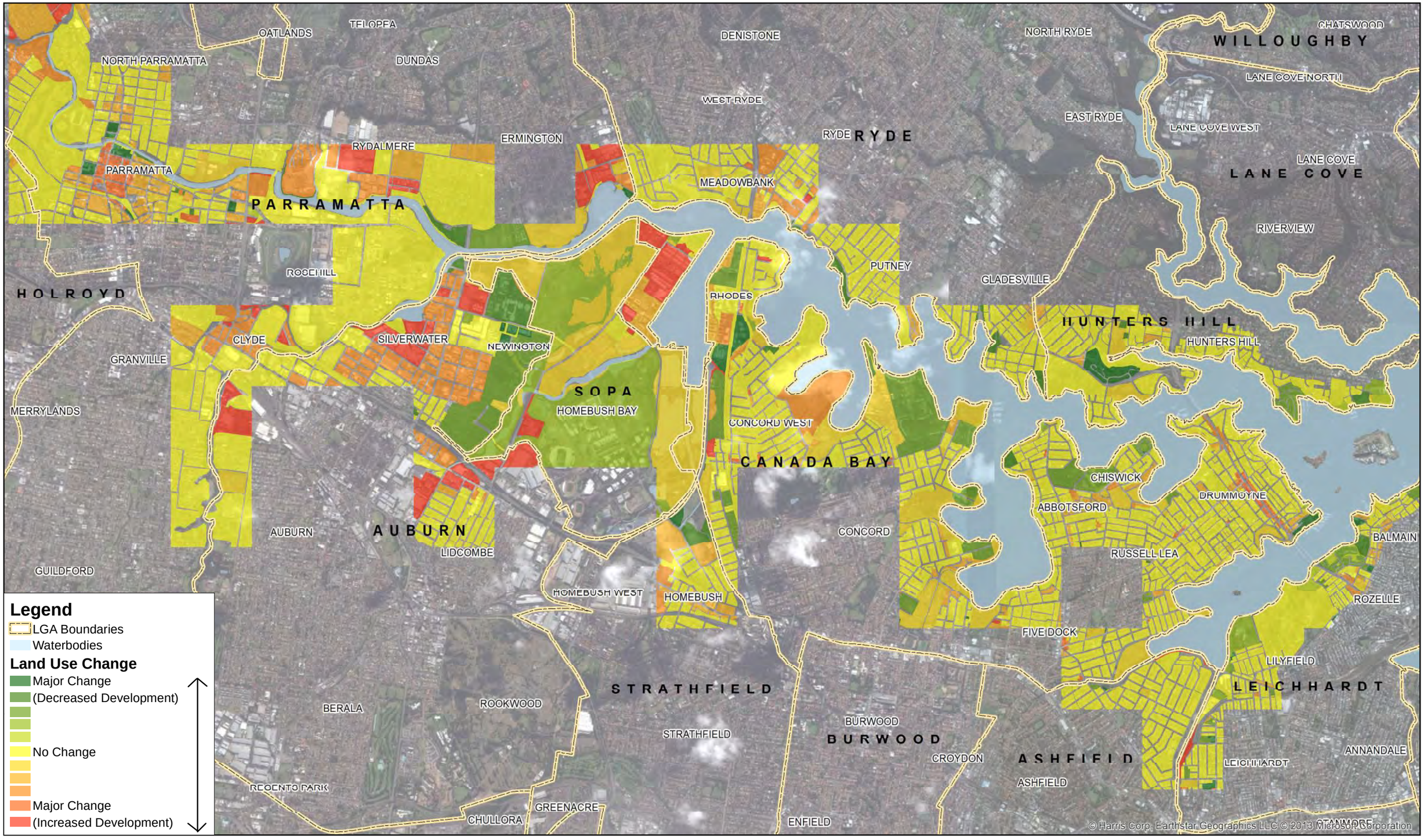
PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.2

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2002_ReclaimedLand 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Google and associated third party suppliers.



Legend

- LGA Boundaries
- Waterbodies

Land Use Change

- Major Change (Decreased Development)
- No Change
- Major Change (Increased Development)

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Land Use Changes (1943 - 2009)

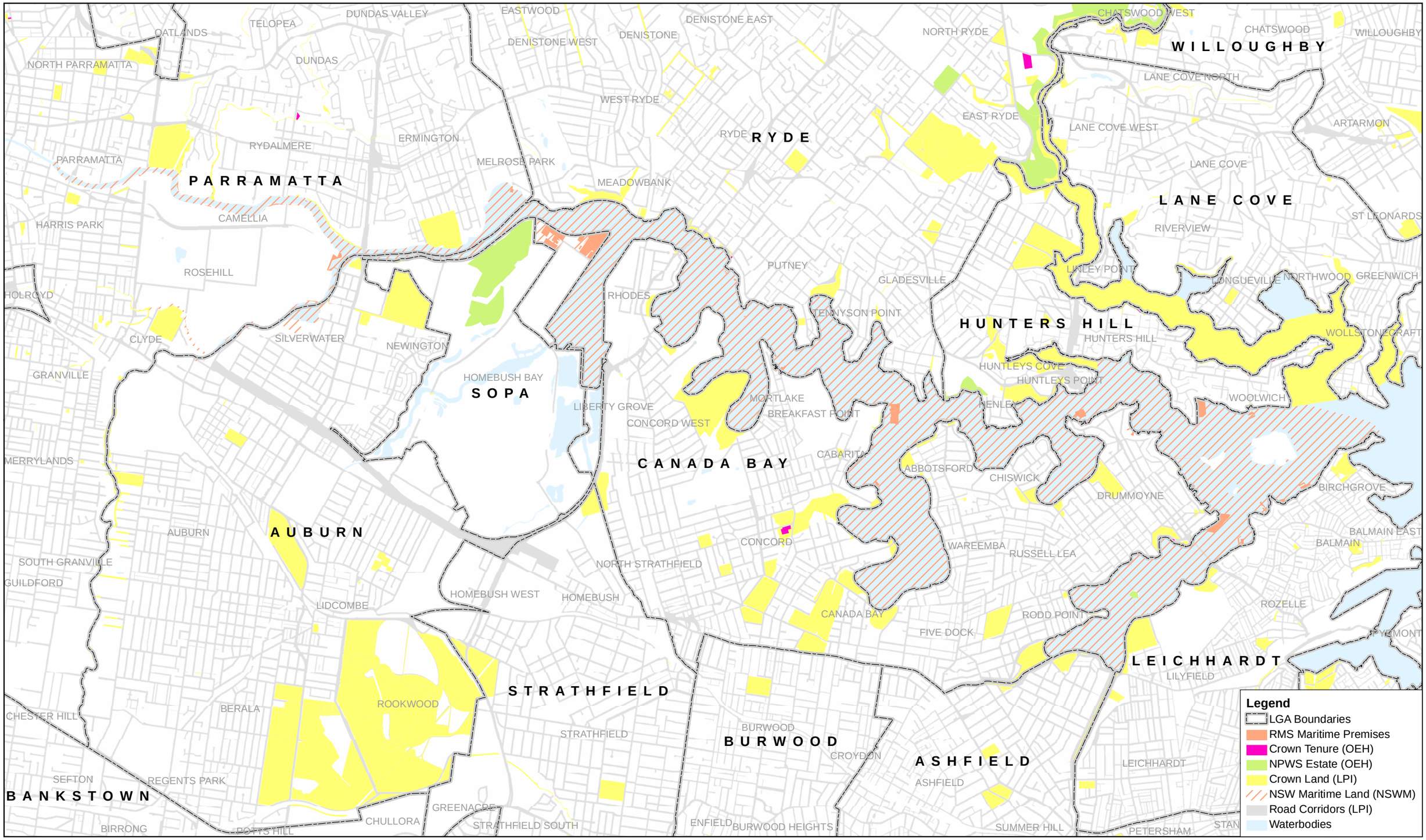
PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.3

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2003_LandUseChanges 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.



Note: Only Public Land Tenure has been mapped.

Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Kilometers

0 0.5 1 1.5 2 2.5

Land Tenure

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.4

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2004_LandTenure 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)

2.1.2 Stormwater Runoff

Stormwater Pollutants

Water and sediment quality within the estuary is generally poor, a key issue for the estuary, and this is largely due to polluted stormwater runoff. The community strongly agreed that this is a key issue, ranking the management of pollution and sedimentation associated with creeks and stormwater outlets in order to protect the natural environment as the number one priority in the community survey (Appendix B).

The urbanisation of the catchment has resulted in a significant increase in hard surfaces as roads, buildings and the like have been constructed in place of vegetated areas. This results in reduced green open space areas for the absorption and filtration of stormwater, and as such a larger volume of stormwater reaches the estuary more quickly than would previously have been the case prior to development of the catchment. These higher velocity flows can cause erosion and sedimentation, although it is noted that some of the larger catchment tributaries are channelised, and therefore there is low potential for erosion from the lower catchment. Land use change has also resulted in a change in the amount and type of pollutants that become entrained in stormwater flows.

There are a large number of different sources of pollutants from urban areas in the Parramatta River estuary catchment, such as:

- Nutrients, e.g. from fertilisers and cleaning products;
- Heavy metals, e.g. from some industrial sites and roads;
- Organochlorine (such as DDT) and organophosphate pesticides;
- Polycyclic aromatic hydrocarbons (PAHs) associated with heavy industry/combustion;
- Phenols used in industrial chemical synthesis; and
- Sewage from sewer overflows.

Some of these pollutants are associated with point sources, that is, they enter the waterbody at a specific location. Types of point sources include sewer overflow points or specific sites (e.g. industrial sites along the foreshore). There are a number of historically contaminated sites located in the catchment and along the estuary foreshores that have potential to act as significant point sources of pollution (Figure 2.5). Illegal dumping and spills can also act as point sources of pollution.

Alternatively, pollutants may originate from diffuse sources and enter the estuary, which are generally more difficult to manage. Diffuse source water pollution is caused when pollutants from a range of dispersed land use activities contaminate waterways. Many activities that people engage in contribute to diffuse pollution, such as littering, fertilising gardens within the catchment or disposal of cleaning products down the drain. Another diffuse source of pollution is atmospheric fallout, whereby dust that contains pollutants (such as heavy metals) falls out of the air and onto the ground where it can be washed into the estuary. The prevalence of old residential areas in the catchment may also act as a diffuse source of pollution due to the use of materials such as lead paint that are harmful to the environment. Education of the community and industry to provide improved awareness of stormwater issues would go some way to addressing diffuse and point sources of pollution.

Fate and Management of Stormwater

As summarised in Table 2.1, there are a number of tributary creeks that drain to the Parramatta River estuary. These convey some of the stormwater flow; however, a significant portion of stormwater flows make their way into the estuary via the stormwater drainage network (Figure 2.6). The larger volumes of stormwater runoff that are generated from the urban catchment are managed via the provision of pipe networks, overland flow paths and open channels discharging to the estuary. Controls on the pollutant loadings take the form of Gross Pollutant Traps (GPTs) and other Stormwater Quality Improvement Devices (SQIDs) that provide pre-treatment of stormwater before it is discharged to the estuary (Figure 2.6 provides the location of many GPTs throughout the catchment, Figure 2.7 provides photographic examples of GPTs and SQIDs present). The type and amount of pollutants removed will depend upon the type of device used, and during very heavy rainfall events, flows may bypass the devices.

Figure 2.6 (after AECOM, 2010) shows the main sub-catchments and the extent of the stormwater drainage network within the study area. Stormwater and stormwater infrastructure can have significant impacts on the estuarine environment, such as:

- Scour around the stormwater outlet due to the discharge of high velocity flows (Figure 2.8);
- Erosion and sedimentation;
- Sedimentary contamination, where pollutants such as heavy metals are bound to sediment particles;
- Water contamination, especially as dissolved pollutants that remain in the water column (do not settle out) can be transported throughout the estuary by tidal flushing;
- Stimulation of primary productivity by increased nutrient loads;
- Blockages to the passage of fish and other aquatic organisms; and
- Smothering of aquatic macrophytes and fauna by sediments discharged from stormwater outlets.

This is a particular issue where stormwater impacts on sensitive estuarine habitats, such as seagrass areas as documented in AECOM (2010).

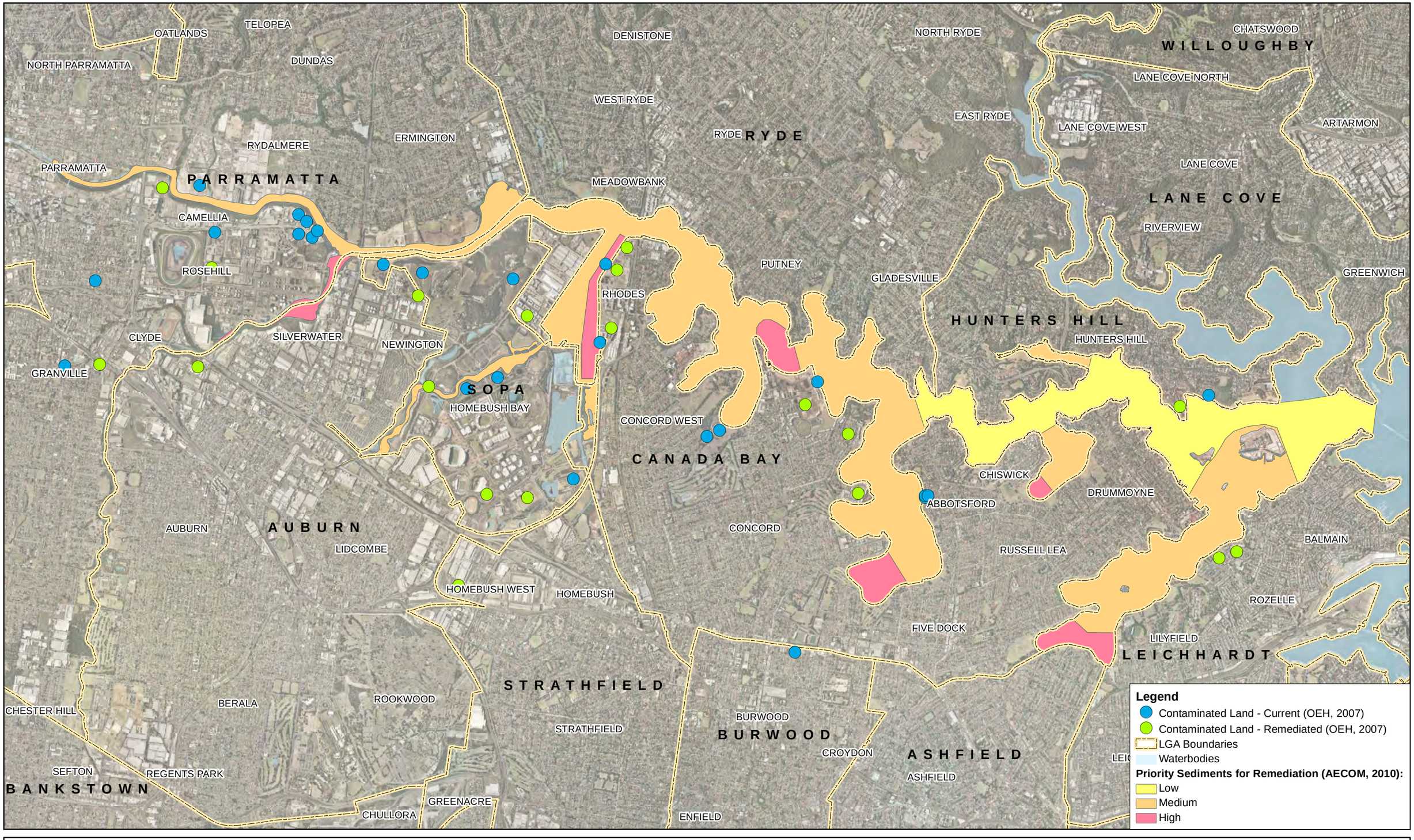
It is the responsibility of councils within the study area to manage gross pollutants, and there are a number of GPTs in place that attempt to capture material from stormwater (Figure 2.6, after AECOM, 2010). However, a large amount of gross pollutants still make their way into the estuary, bypassing GPTs, by blowing onto the waterway, or direct littering. RMS (Maritime) collects gross pollutants directly off the waterway, with a total of more than 3,500m^3 of rubbish collected from the Parramatta and Lane Cove Rivers every year.

In recent years WSUD has been actively implemented within the Parramatta River estuary catchment as a measure to control stormwater issues (see Figure 2.9 for some examples in the catchment). The PRCG recently implemented the Working to Sustain the Parramatta River Project over three years from 2007-2010 under grant funding of $1.9 million. The aim of the project was to implement widespread changes in the way that stormwater is managed within the Parramatta River estuary catchment, through a practical, hands-on approach using WSUD principles and new technology in the collection, treatment and reuse of stormwater runoff. The project involved seven of the eight foreshore local councils in the Parramatta River estuary catchment, involving on-ground demonstration projects and training opportunities for each council involved, such that they had the opportunity to build WSUD skills and capabilities and make changes to their internal policies and practices to manage stormwater (Cardno, 2010).

However, an insufficient number of devices, poor maintenance of these features due to lack of resources and their inconsistent spatial distribution across the catchment means significant volumes of stormwater carrying heavy pollutant loads still enter the estuary. Effective stormwater management can be difficult to achieve as it needs to be managed on a site by site basis, which is difficult to coordinate across such a large catchment area. Changes to internal policies and practices within councils in the catchment to incorporate WSUD into new developments (or redeveloped areas) will assist in coordinating the site by site approach across the catchment and should primarily be focused on pollutant hotspots.

One of the main challenges is that the stormwater network and associated stormwater treatment devices are owned and managed by a number of different stakeholders. Management of stormwater is typically the responsibility of local councils, although ownership of the physical infrastructure is more complicated. Some stormwater infrastructure is owned by Sydney Water, including sections of pipes, pits and some stormwater canals (e.g. Hawthorne and Dobroyd Canals). GPTs and other SQIDs are also typically managed by local councils, but may be placed on land that is subject to a different management regime. Therefore, any stormwater management works proposed within the study area need to confirm the owner and manager of the subject infrastructure, and require significant liaison and coordination between authorities. This is a particular issue where stormwater management is targeting a particular pollution hot spot, such as Iron Cove Bay, where the local drainage catchment includes land falling within five different LGAs and includes significant stormwater infrastructure that is owned and managed by Sydney Water (i.e. Hawthorne and Dobroyd Canals).

The HNCMA is currently leading another project, the *Sydney Harbour Catchment Water Quality Improvement Plan* that aims to develop a catchment scale approach for improving water quality in Sydney Harbour, including the Parramatta River estuary. It involves development of a Catchment Pollutant Export Model and Ecological Response Model to quantify pollutant sources from the catchment and identify the potential waterway response. This project will lead to the identification of additional opportunities for managing stormwater that will improve the quality of discharges to the Parramatta River estuary.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Areas of Contamination

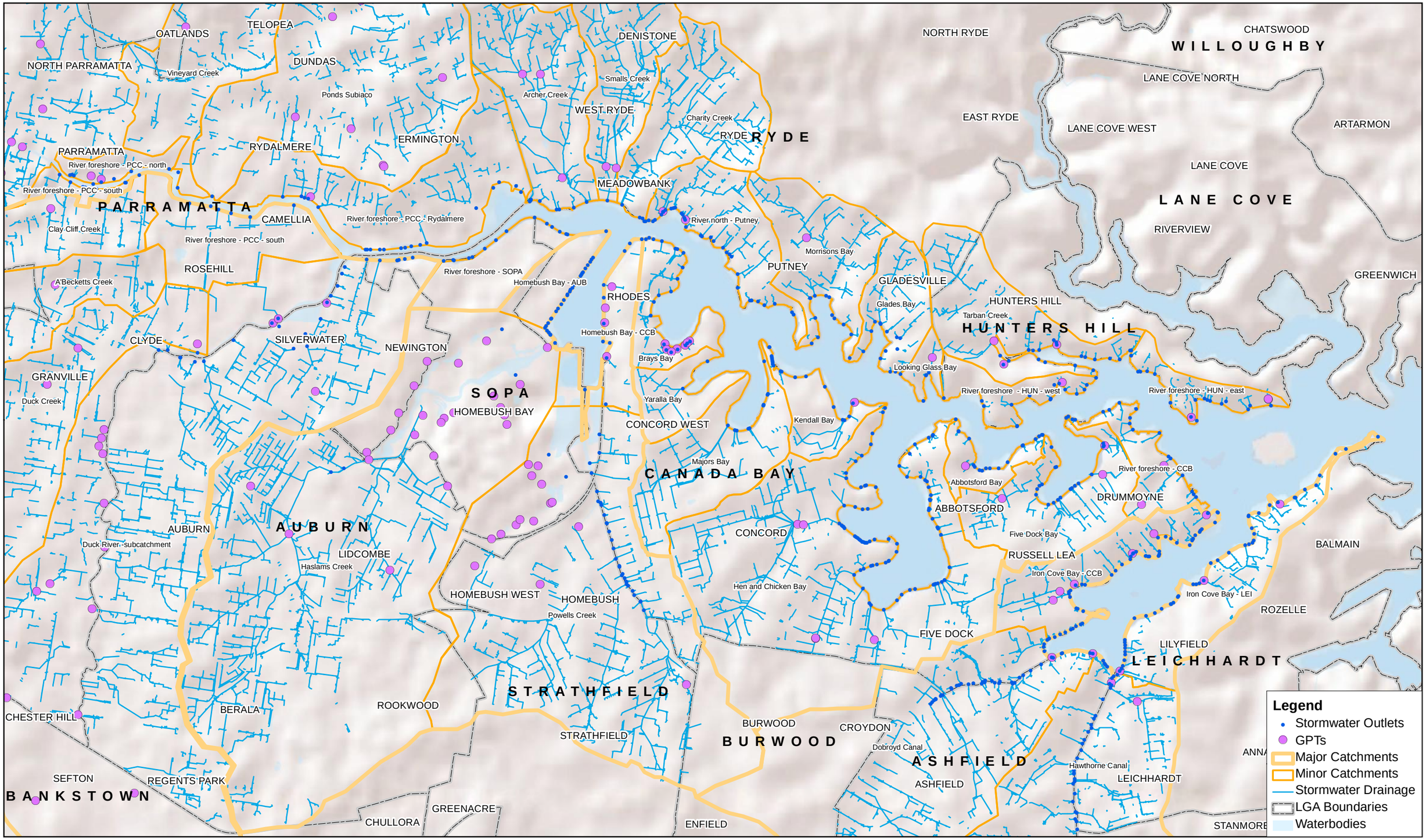
PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.5

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2005_ContaminatedLand 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Google and associated third party suppliers.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Stormwater Network and Water Quality Controls

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.6

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2006_StormwaterNetworkAndWaterQual 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.

a) Litter boom, Hawthorne Canal.

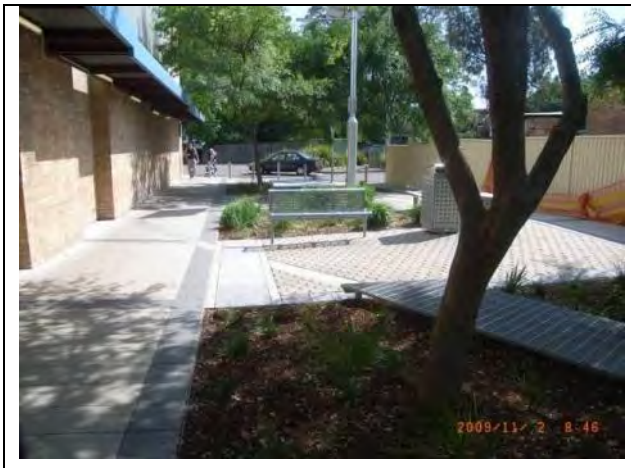
b) Continuous deflection separation device, Clarkes Point.

Figure 2.7: Example SQIDs / GPTs

a) Organic matter and rubbish captured in a GPT, Meadowbank Park.

b) Sedimentation, scour and organic matter around outlet, Kissing Point Bay (source: AECOM, 2010).

Figure 2.8: Examples of Stormwater Impacts on the Parramatta River Estuary



a) Pervious pavers and rain garden, Guildford Lane, Guildford.

b) Rain garden, Meadowbank Park.

Figure 2.9: Examples of Water Sensitive Urban Design (WSUD) Features

Sedimentation

Progressive infilling of estuaries with catchment-derived sediments is a natural process, due to ongoing erosion and sedimentation associated with rainfall events, as well as the mobilisation of larger quantities of sediments from either the banks or the estuary bed during flood events. However, much higher sediment loads are currently entering the Parramatta River estuary compared with pre-European times, exacerbated by urban development, causing significant sedimentation within the estuary. The *Data Compilation and Review Study* (Cardno, 2008) found that there was limited information on rates of sedimentation in the estuary. Investigation of this issue is also complicated by the history of dredging and reclamation works that have been conducted in the estuary. Historical accounts suggest very high rates of sedimentation during the early development of the catchment (e.g. McLoughlin, 2000), but more recent analysis of sediment cores suggests a rate of sedimentation of between 1.5-3.5mm/yr over the last 150-200 years, which is generally en par with other similar estuaries types of a less disturbed nature, in NSW (Geoscience Australia, 2012).

With respect to sedimentation, it is likely that some locations in the estuary were significantly affected by sedimentation due to catchment development or flooding in the past. In more recent years erosion and sedimentation is subject to tight control at development sites and a range of measures have been implemented to reduce sediment inputs (e.g. SQIDs). In addition, the construction of canals, weirs and similar features has probably reduced the amount of sediment that can reach the estuary from the lower catchment. However, erosion and sedimentation may continue to occur from the upper catchment or from natural creek lines. As previously discussed, sediments introduced to the waterway can impact negatively on local water quality and estuarine habitats (e.g. seagrass).

2.2 Physical and Water Quality Processes

2.2.1 Water and Sediments

Hydrodynamic Processes

Key hydrodynamic processes in the Parramatta River estuary include ocean tides (tidal flushing), freshwater inflows, and wind and wave driven flows. These hydrodynamic processes are also influenced by the system bathymetry (bed form of the estuary). The Parramatta River estuary is constantly open to the ocean and as such the water level within the estuary is primarily driven by the ocean water level and the tidal prism. During large catchment inflow events water levels within the estuary would temporarily be elevated (Cardno, 2008).

The tidal limit currently extends to the Charles Street Weir in Parramatta (Figure 2.10), which restricts further tidal influence upstream. Prior to construction of the weir the tidal limit extended further upstream to near Marsden Street at Parramatta. Alterations to and channelisation of previously natural creek lines in the catchment (Figure 2.11) have also changed the tidal limit in other locations. For example, in Duck River and Duck Creek, the tidal range has been limited by weirs at the Clyde Railway Bridge and Martha Street, respectively.

a) Looking upstream towards the weir.

b) Looking downstream from the weir.

Figure 2.10: Charles Street Weir

a) Powells Creek near Mason Park.

b) Tarban Creek, Riverglade Reserve.

Figure 2.11: Channelised Creek Lines

Tidal flushing is a vital mechanism for maintaining water quality within the estuary, particularly as the estuary receives high volumes of stormwater runoff which has potential to contain a range of pollutants. Extensive alteration of the estuary foreshore and its tributaries (reclamation, etc.) has limited tidal flushing in some areas, which can lead to significant impacts on local water quality and the ecological characteristics of the estuary. As the tidal waters of the estuary rise and fall, intertidal vegetation and fauna becomes alternately submerged and exposed with high and low tides. Maintenance of tidal inundation is an important factor in the function of these intertidal habitats and their associated flora and fauna.

Estuarine water levels may also become elevated beyond the typical tidal range due to factors such as king tides, storm surge and freshwater flood flows. At such times the elevated estuarine water levels can present a hazard to human users and assets along the foreshore. A number of foreshore parks are inundated during spring high tides, such as Kissing Point Park and Riverglade Reserve. Some coastal hazards will be exacerbated by climate change, particularly extreme estuarine water levels, which will result in an increase in risk for foreshore users and assets over time (see Section 2.5).

It should be noted that catchment flood hazard is managed under the Floodplain Management Process, and is not subject to management under this Plan. Foreshore inundation due to elevated estuarine water levels would be managed under the coastal and estuary management program.

Sedimentary Contamination

Sediment quality in and around the Parramatta River estuary has a major influence on the overall water quality and aquatic biodiversity. A review of the available literature presented in Cardno (2008) highlighted that the sediments of the Parramatta River estuary are significantly contaminated. Birch and Taylor (2004) provide a summary of the analytical methods and extent of contamination in the Parramatta River estuary, and have prioritised Duck River, the eastern shore of Homebush Bay, Fairmile Cove and the upper reaches of Hen and Chicken Bay, Five Dock Bay and Iron Cove Bay for remediation (Figure 2.5). Sources of these contaminants include reclaimed lands (which were commonly filled with contaminated or waste materials), contaminated lands, industrial activities, and traffic and roadways. Contaminants associated with sediments typically make their way to the estuary either attached to sedimentary particles or via groundwater leachates.

Benthic sediments of the Parramatta River estuary also contain stores of nutrients (Nitrogen, Phosphorous and Organic Carbon) which may be available for mobilisation to the water column, although the mechanisms that control the uptake and release of nutrients are not well understood (Birch *et al.,* 1999). These nutrients are likely derived from stormwater inputs from residential areas, green waste and leaf litter. Sewage overflows can also introduce significant amounts of nutrients into the estuary.

Hydrodynamic and biogeochemically mediated processes are important for regulating the mobilisation of these contaminants/nutrients between the sediments and the water column. Factors such as bioturbation, changes in water chemistry (e.g. pH and/or DO concentrations), uptake and release by organisms, and physical disturbance can contribute to the flux of pollutants between the water column and sediments.

Contaminants in the water column or surficial sediments can have a significant impact on estuarine biota. In their synthesis of the literature relating to possible biological effects of sedimentary contamination Birch and Taylor (2004) state that the spatial extent of the study area within which adverse effects on biota may be anticipated are highly variable dependent upon the contaminant in question, however, almost all of the Parramatta River estuary sediments exceed the ISQG-L (Interim Sediment Quality Guidelines – Low) values for at least one heavy metal, representing the level above which effects on biota may occur. There have been a number of ecotoxicology and bioaccumulation studies in the Parramatta River estuary (see Cardno, 2008), however, the full effects on estuarine ecology are not well understood. Dioxin levels in fish species are elevated to the point where a commercial fishing ban was placed on Sydney Harbour and its tributaries, including the Parramatta River in 2006, and it is prohibited to consume fish caught west of the Harbour Bridge.

Catchment management, particularly for stormwater and contaminated sites, are the primary mechanisms used to regulate the introduction of these pollutants into the estuary. There is, however, a legacy of contaminated sediments from historical activities that may only be addressed by remediation (Figure 2.12), capping or removal of the affected sediments from the estuary. These activities can in themselves have significant impacts on the environment and may increase the risk of mobilisation of contaminants to the water column. Contaminated sites, including those in the estuary, are regulated by the Environment Protection and Regulation Division of OEH.

a) Contaminated site rehabilitation, Rhodes (source: D. Wiecek, OEH, date unknown).

b) Remediation works, Homebush Bay (source: M. Campanelli, NSW Maritime, date unknown).

Figure 2.12: Remediation Works

Water Quality

In-estuary water quality processes are complex and involve biological, physical and chemical processes. These processes mediate the way water moves around the estuary, the exchange between estuarine waters and sediments, and estuarine waters and the atmosphere. In general, in-estuary processes are strongly influenced by climatic and hydrodynamic processes and can significantly impact on local water and sediment quality issues.

Poor water and sediment quality can impact on ecological processes and human recreation. Key water quality parameters of concern for management are:

- Dissolved oxygen (DO);
- pH;
- Turbidity or Total Suspended Solids (TSS);
- Nutrient concentrations (Nitrogen and Phosphorous);
- Algal concentrations; and
- Pathogens (faecal coliforms (FC) and Enterococci).

Heavy metals and other pollutants are discussed previously in relation to sedimentary contamination.

With regards to human recreation, poor water quality has impacted on recreational usage of the estuary for activities such as swimming and fishing. Based on data collected under OEH's Harbourwatch program, water quality in the estuary is often unsuitable for primary contact recreation due to high FC counts (Cardno, 2008). This is believed to result from FCs entering the estuary in stormwater runoff from the catchment or sewer overflows, which can result in water quality issues in certain bays where rates of tidal flushing are low. Overall there are only limited areas of the Parramatta River estuary that are considered suitable for primary and secondary contact recreational activities (Cardno, 2008).

A review of the available information on water quality in the Parramatta River estuary can be found in Cardno (2008) and WRL (2011). Water quality data collected by Sydney Water from the Parramatta River estuary includes monitoring of the following parameters:

- DO;
- pH;
- Nitrogen (TN and biological available forms: ammonia, nitrates/nitrites);
- Phosphorous (TP and biologically available Filterable Reactive Phosphorous);
- Chlorophyll a; and
- FC and Enterococci.

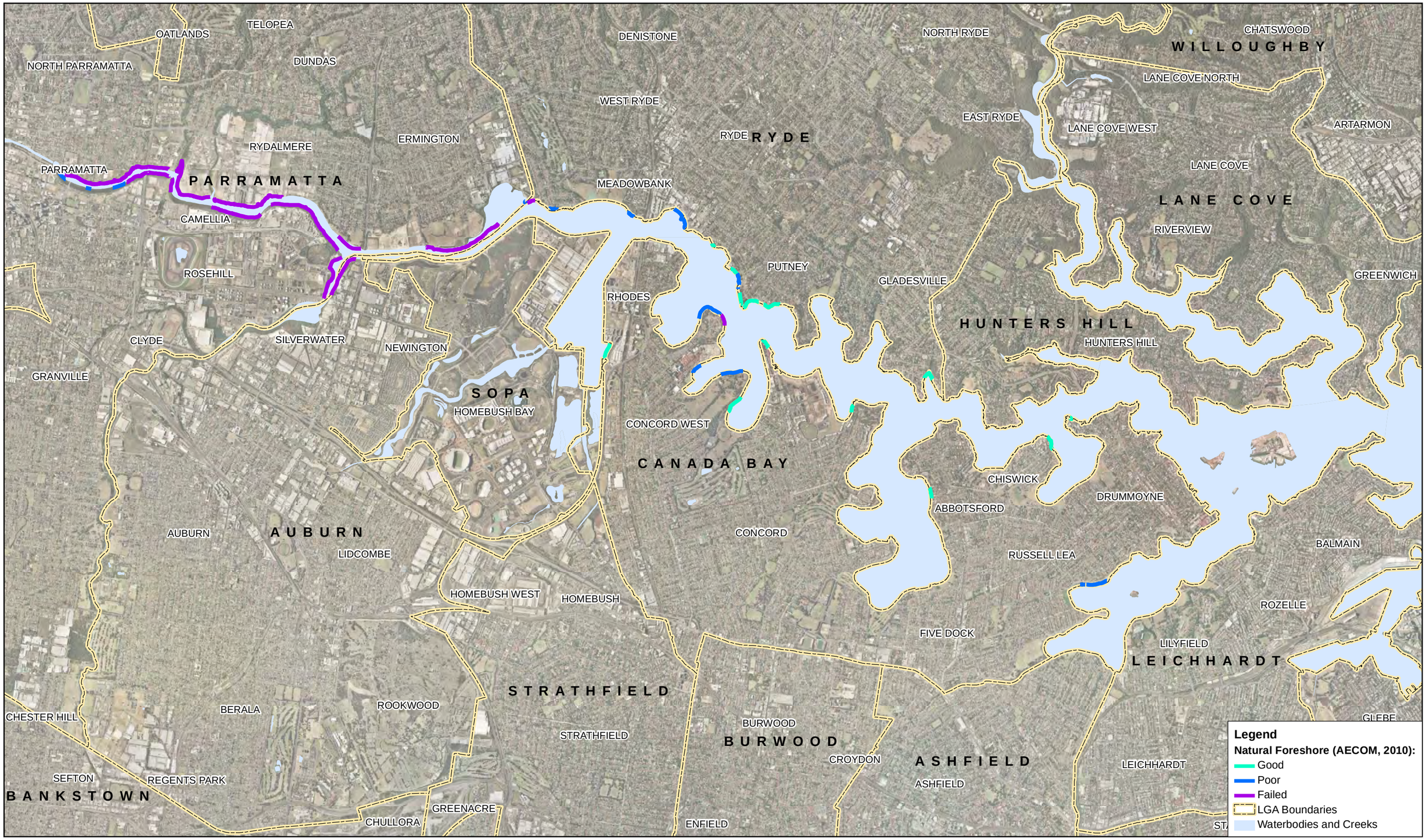
As discussed in WRL (2011), an analysis of the data indicates that average concentrations of these water quality parameters are in excess of the ANZECC (2000) aquatic ecosystem health guidelines for south-east Australian estuaries. The exception is for pH, for which the average values are in the acceptable range. Particular hotspots include Duck River and the Silverwater Bridge area. Based on a review of the data presented in WRL (2011), it is considered likely that these locations are impacted by sewer overflows, due to the high concentrations of nutrients, FC and Enterococci, along with the low DO values. The high levels of nutrients at all sampling sites indicate that stormwater quality is a key issue for estuary management and there is potential for algal blooms.

2.2.2 Bank Condition

According to AECOM (2010) the study area contains approximately 135km of foreshore, including all tidal areas of the estuary's tributaries and canals. AECOM (2010) inspected approximately 36km of seawalls and 21km of canals along the shoreline, with foreshore and marine facilities and structures also located along the foreshore for human usage and recreation. Approximately 45% of the foreshore is no longer natural (AECOM, 2010). The current condition of natural shoreline and seawalls reaches was also recently assessed by AECOM (2010) (see Figure 2.13).

Several of the submissions received during the public exhibition of the Draft CZMP considered that the findings of AECOM (2010) were either not entirely accurate for specific locations, or that conditions had changed since the field survey was conducted. This may be the case, noting that three or four years has passed since the AECOM (2010) survey was conducted, and conditions may have changed since that time.

The section of shoreline between Wharf Road in Ryde and Kissing Point was identified in a submission as experiencing erosion issues. This generally concurs with the findings of AECOM (2010), which found several sections of natural shoreline in poor condition through this area (Figure 2.13), and a number of sections of seawall in poor or failed condition. These issues are thought to be due to boat wake and the submission expressed concern about the RiverCat specifically, and more generally the exceedences of boat speed limits in that section of the river.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Foreshore Condition

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.13

N
W E
S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2013_ForeshoreCondition 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Google and associated third party suppliers.

Natural Shoreline

Natural foreshore areas within the study area (74km or 55% of the total shoreline surveyed by AECOM (2010)) typically comprise beaches, rock platforms, vegetated and non-vegetated natural shoreline (e.g. mudflats) (Figure 2.14). Natural shoreline occurs predominantly west of the Silverwater Bridge, where significant areas of erosion occur (Figure 2.13, after AECOM, 2010). East of Concord Road there are some isolated sections of natural shoreline in Meadowbank, Putney, Yaralla and Majors Bays, and Iron Cove Bay.

a) Hen and Chicken Bay, City of Canada Bay

b) Iron Cove Bay, City of Canada Bay.

Figure 2.14: Natural Shoreline

Areas of natural foreshore may be vulnerable to short duration or episodic erosion events (severe storms, vessel wash, flooding, high tides and informal public access), or longer term recession or accretion (caused by changes to mean sea level, sediment availability, and changes in river hydrodynamics due to foreshore and channel realignment and dredging). AECOM (2010) located 44 areas of foreshore erosion in the study area, which equates to approximately 13km of shoreline (18% of the total natural shoreline) (Figure 2.13).

Approximately 70% (9.2km) of natural shoreline exhibiting erosion is located upstream of Silverwater Bridge in the Auburn and Parramatta LGAs, with the most extensive foreshore erosion occurring in the Parramatta LGA (approximately 8.6km). This section of the river is characterised by a narrow channel, shallow water depths, banks vegetated with mangroves, and is subject to long period waves from RiverCat movements. RiverCat wash is thought to be the primary source of erosion in this area, causing bank slumping and loss of mangrove vegetation, and must be managed as a priority prior to expenditure of significant funds to rehabilitate these sections of natural foreshore and seawalls. This issue is apparent to the community, and whilst they support the provision of alternative forms of public transport, they have expressed a high level of concern about the impact the RiverCat service is having on the estuary (Appendix B). There were 28,000 individual trips to and from Parramatta, in 2011-12 financial year (Sydney Ferries, 2012), which will inevitably result in a level of damage to the natural foreshore. A key management issue for these upper areas of eroding natural shoreline is instigating modifications to or replacement of the RiverCat with another vessel that generates less wash to reduce further erosion caused by its wash, and subsequently to allocate funding towards remediation of these foreshore areas.

Foreshore erosion can have negative impacts on estuarine water quality as sediments are mobilised and washed into the waterway. This can release nutrients and contaminants into the water column and acts to destabilise foreshore vegetation, leaving it vulnerable to further erosion and subsidence. Nearby seagrass beds can also

become smothered by sedimentation as a result of foreshore erosion. The presence and maintenance of riparian and estuarine foreshore vegetation is very important for the stabilisation of soils to minimise erosion potential.

Seawalls

Seawalls have been constructed extensively along the study area's shoreline to protect foreshore assets, guard against inundation and support reclaimed parklands. The poor condition of many seawalls in the study area was raised by community members in the Community Information Session (Appendix B) as a prominent issue in their locality (particularly the City of Canada Bay). In the community survey the issue of protecting public and private property from coastal hazards was highly ranked by 75% of respondents, which suggests support for the maintenance of seawalls.

The most common functions of seawalls in the study area are the provision of support for other foreshore structures and reclaimed land. Failure of seawalls that structurally support other foreshore facilities (e.g. pathways, jetties) may result in replacement costs of more than just the seawall, and also impact on aesthetics and public amenity, access and safety. Where seawalls protect reclaimed land, seawall failure may result in the liberation of potentially contaminated landfill into the waterway. Furthermore, the potential for loss of land to the estuary may result where unconsolidated landfill is no longer supported (AECOM, 2010).

The majority of seawalls in the study area were inspected and assessed by AECOM as part of the *Estuary Processes Study* (2010), which covered approximately 36km of seawall and 21km of canals. The seawalls have a mixture of public and private ownership, in addition to which some of the canals are owned and maintained by Sydney Water. Types of seawalls in the study area typically include solid concrete, sandstone blocks and loose rubble revetments.

The City of Canada Bay has the greatest extent of seawalls, followed by Auburn and Parramatta LGAs (Table 2.1). A total of 84 seawall sections were either categorised as in 'poor' or 'failed' condition by AECOM (2010), requiring replacement or upgrading due to visual signs of degradation (e.g. cracking, landward subsidence, collapse), which equates to approximately 17.7km of seawalls in total or about half the seawalls in the study area. See Figures 2.15 and 2.16 for examples of failing and failed seawalls.

a) Iron Cove Bay, City of Canada Bay.

b) Waste materials used to stabilise the shoreline, Silverwater (source: M. Campanelli, date unknown).

Figure 2.15: Examples of Failing Seawalls

Failed seawall, Leichardt (source: D. Wiecek, OEH, date unknown).

Figure 2.16: Example of Failed Seawalls

The key constraints on upgrading/replacing certain seawalls include:

- Heritage status, if the seawall is heritage listed under local or state heritage registers, such as the historic seawall at Queens Wharf Reserve in the Parramatta LGA;
- Ongoing erosion potential, particularly in areas where the current RiverCat wash would continue to act to erode or undercut the new seawall; and
- Funding, replacing or upgrading seawall sections can be very costly.

These seawalls and other marine structures provide surfaces for colonisation by benthic organisms and have the potential to supplement natural habitat by supporting natural species assemblages. More recently there has been a move to reintroduce intertidal habitat to urbanised estuaries and the Estuary Processes Study lists the 20 highest priority seawall sections which are considered the most appropriate locations for habitat creation in the Parramatta River estuary (AECOM, 2010).

Wherever seawalls need to be rehabilitated or replaced in the study area this should be undertaken in accordance with the Environmentally Friendly Seawalls Guidelines (DECC and SMCMA, 2009). The guidelines advocate the incorporation of estuarine habitats into seawall and other marine support structures wherever possible, which will provide habitat and help support biodiversity and species abundance at the same time as providing structural support (see Figure 2.17 for examples). Incorporating estuarine habitat into these structures will provide improved ecological value through the upgrading of seawalls.

a) Seawall with low sill and saltmarsh, Ermington (source: D. Wiecek, OEH, date unknown).

c) Artificial intertidal habitat within a seawall, McMahons Point (source: http://cristinabump.wordpress.com/).

Figure 2.17: Examples of Environmentally Friendly Seawalls

2.3 Ecological Processes

Although much of the native habitat along the foreshores of the Parramatta River estuary has been removed for development purposes or has been subject to degradation, the estuary foreshore and its tributaries still support a range of native flora and fauna, including a number of threatened species that are important on a state and national level. The remaining natural vegetation in the catchment is generally associated with creek lines (Cardno, 2008).

The community recognises the need to maintain the ecological health of the estuary, with some of the key threatening processes, such as managing stormwater pollution, ranking very high in importance in the community survey (Appendix B).

Key ongoing management issues regarding ecology include:

- Habitat loss, degradation and fragmentation;
- Poor ecological connectivity along the foreshores;
- Introduced species;
- Stormwater impacts and sewer overflows;
- Changes to natural patterns of tidal inundation;
- Channelisation of natural waterways;
- Loss of foreshore vegetation via mowing or deliberate vandalism; and
- Damage from recreational activities (e.g. from swing moorings, dingy storage or trampling).

2.3.1 Estuarine Vegetation

Estuarine vegetation is vegetation found in the sub-tidal zone and intertidal zones of an estuary. Also of importance for ecological processes is riparian vegetation contiguous with these zones. A high proportion of

vegetation within the riparian zone or supra-tidal zone has tolerance to salinity from sea spray but not from tidal inundation. Estuarine vegetation communities present in the study area include seagrasses, saltmarsh and mangroves (Figure 2.18). Each one of these communities can tolerate a particular range of salinities and regular or permanent inundation. Riparian vegetation communities in the study area include Swamp-oak Floodplain Forest, Sydney Turpentine-ironbark Forest, Coastal Sandstone Gully Forest and Coastal Sandstone Ridgetop Woodland (AECOM, 2010). Swamp-oak Floodplain Forest and Sydney Turpentine-ironbark Forest are considered significant riparian vegetation as they are both Endangered Ecological Communities (EECs). Table 2.2 summarises available information on the condition and extent of significant riparian and estuarine vegetation in the study area.

Table 2.2: Extent and Condition of Significant Riparian and Estuarine Vegetation (After: AECOM, 2010)

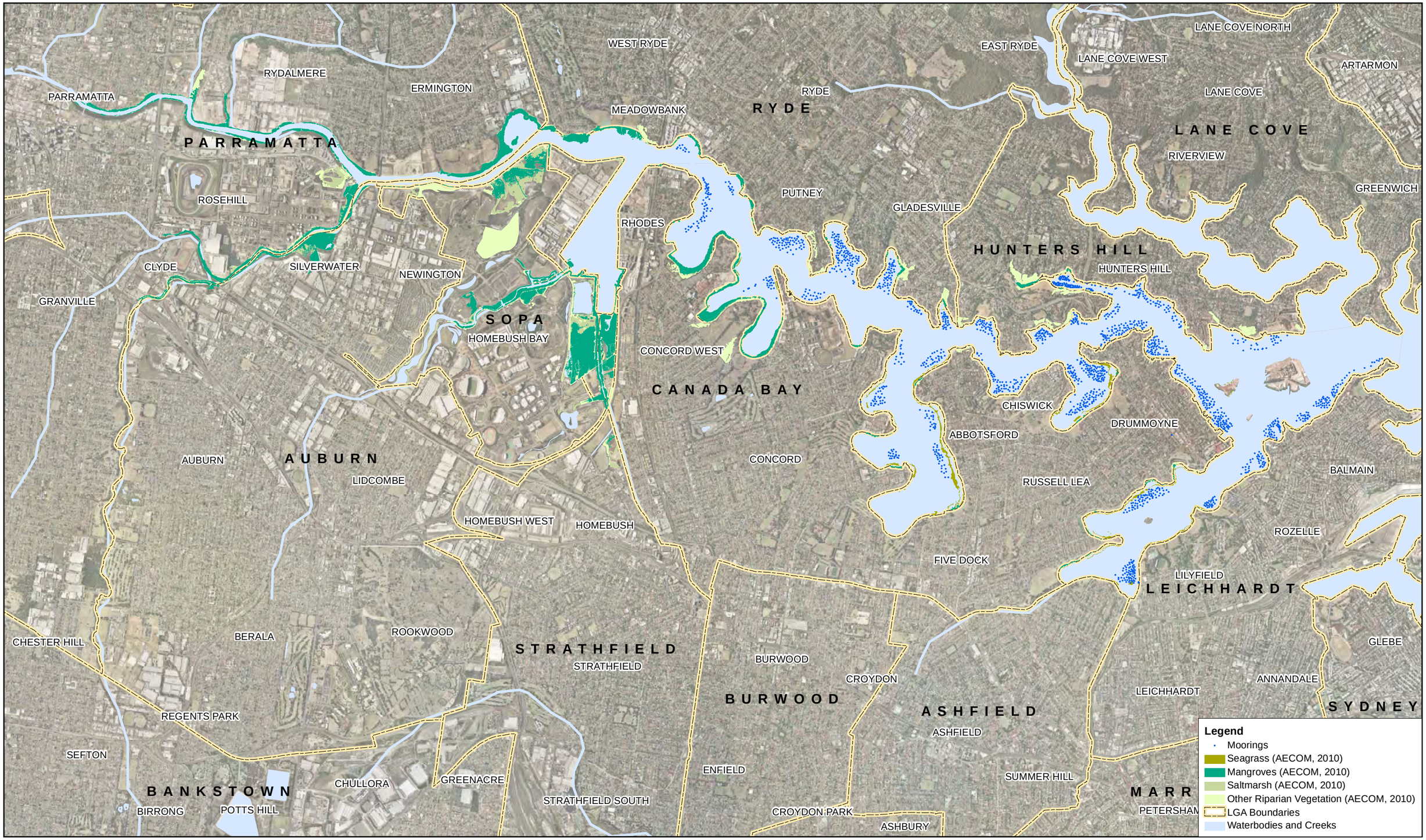
Estimated Total Extent	Extent	Threats	Trends in Extent & Condition
Seagrasses (Figure 2.19)			
10.3ha	Confirmed areas (based on field verification, AECOM, 2010) total 9.26ha, including: ▪ 8.58ha within waterways adjacent to the City of Canada Bay, ▪ 0.62ha adjacent to Leichhardt LGA, and ▪ 0.06ha adjacent to the City of Ryde.	Poor water quality, smothering by sediments, erosion of beds through changed water movements and damage from water-based recreational activities (i.e. boat propellers and moorings).	Seagrass cover has declined since mapping was first produced in the 1970's (West et al., 1985; West *et al.*, 2004; West and Williams, 2008).
Saltmarsh (EEC) (Figure 2.21)			
23ha	▪ The largest area is in Homebush Bay (18.6ha in Sydney Olympic Park); ▪ 1.32ha in Mason Park Wetlands in Strathfield LGA; ▪ 1.31ha in Duck River and Wentworth Point Homebush Bay; and ▪ 0.89ha in Parramatta LGA.	Inter-specific competition (e.g. with mangroves), poor water quality, changes to the hydrological regime, weed infestations and trampling at more locations.	There has been both a historical and a contemporary loss of saltmarsh habitat recorded in the study area.
Mangroves (Figure 2.22)			
149ha	▪ 63.8ha in Homebush Bay and its tributaries (within the Sydney Olympic Park); ▪ 40.0ha in the Parramatta LGA;	Illegal clearing by residents and for development activities, bank subsidence in locations affected by RiverCat wash, informal dinghy storage and trampling at some locations.	Mangroves are believed to be more widely distributed and abundant in comparison to pre-European settlement along the Parramatta River (McLoughlin, 2000). Mangroves previously would have

Estimated Total Extent	Extent	Threats	Trends in Extent & Condition
	▪ 19.8ha in the City of Canada Bay; ▪ 13.2ha in the Auburn LGA; and ▪ 10.2ha in the City of Ryde.		formed a ring around the river and bays. Sedimentation that has occurred since European settlement has assisted mangroves to grow on the sedimentation deltas. However, connectivity of mangrove habitats in the catchment still needs to be improved.
Riparian Vegetation			
Swamp-oak Floodplain Forest 30ha): ▪ 18.2ha in Sydney Olympic Park; ▪ 5.5ha in Parramatta LGA; and ▪ 4.1ha in the City of Canada Bay. Sydney Turpentine-Ironbark Forest (22 ha): ▪ 15.8ha in Sydney Olympic Park; ▪ 1.6ha in the City of Ryde; and ▪ 4.5ha in the City of Canada Bay.		Infestations of introduced species and trampling at some locations, which is exacerbated by their degraded and highly fragmented condition.	Historically these EECs have been cleared or reclaimed for industrial, residential or open space requirements. Subsequently remnant communities are highly fragmented and restricted to narrow bands of growth fringing the intertidal zone within the highly urbanised environment.

Seagrasses, saltmarshes and mangroves are highly productive and support a wide range of estuarine fauna, including fish, avifauna, and macroinvertebrates such as crabs and snails. Estuarine vegetation is used as a shelter, food source, breeding ground and/or nursery ground by many animals, including commercially and recreationally important species. Other ecosystem functions performed by estuarine vegetation may include:

- Buffering water quality;
- Stabilising sediments and buffering wave action;
- Sediment trapping;
- Nutrient cycling;
- Regulating hydrological flows;
- Acting as an indicator for environmental change; and
- Acting as sinks of organic carbon.

Non-vegetated habitats such as mudflats and rock platforms are also important habitats. It is likely that significant areas of these two habitats have been lost due to reclamation, dredging and the construction of seawalls.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Estuarine Vegetation

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.18

N W E S

Cardno

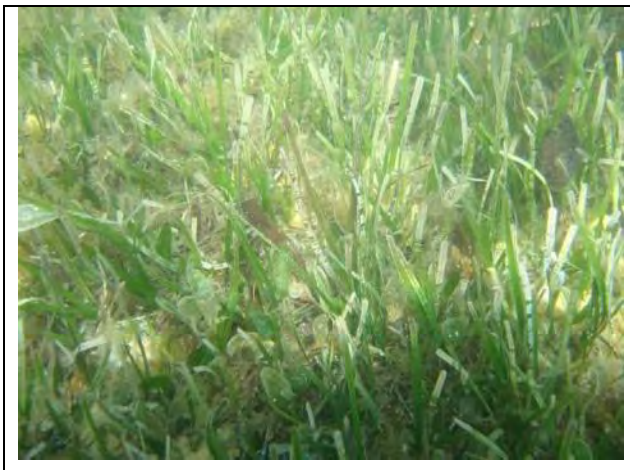
Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2018_EstuarineVeg 03.mxd
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.

Water and sediment quality can also have significant impacts on estuarine vegetation. Poor water and sediment quality can impact saltmarsh and mangrove communities mainly through growth inhibition. High velocity stormwater entering the estuary also erodes these areas of vegetation, with a significant amount of fine material being lost from between Mangrove pneumatophores due to stormwater scour and also vessel wash.

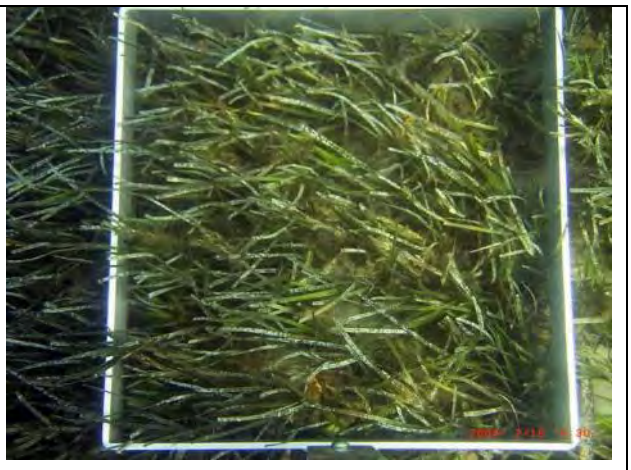
Seagrass is the estuarine community most acutely affected by poor water quality. Seagrass beds in the study area are particularly affected by excessive quantities of gross pollutants (organic materials) smothering seagrass beds and reducing light penetration, which inhibits seagrass growth. Excessive nutrients and sediments leading to algal blooms and high turbidity levels in the water column can also reduce light penetration to seagrass beds, as does shading from jetties and wharves. Other impacts on seagrass beds include damage by boat propellers, anchors, moorings (see Figure 2.20) and launching of watercraft. These issues are particularly evident in the southern end of embayments, including Iron Cove Bay, Hen and Chicken Bay and Five Dock Bay (AECOM, 2010).

Saltmarsh and mangroves in the study area are commonly impacted by trampling as people create informal access routes along the foreshore, and in some locations store their non-motorised watercraft (e.g. dinghies) informally on vegetated areas. Saltmarsh is often also impacted by mowing of residential and public open space areas, when saltmarsh itself is mowed (either purposefully or inadvertently).

Illegal clearing of mangroves is a particular issue where they front private residences, as many councils have noted residents deliberately lop off tree limbs or poison the mangroves where such growth is impinging on their views of the waterway (Figure 2.23). Stormwater impacts, including pollution and changes to the hydrological regime (both freshwater inflows and tidal inundation) have also resulted in degradation and loss of these communities.



a) Seagrass bed of Zostera and Halophila.



b) Healthy, dense bed of Zostera.

Figure 2.19: Estuarine Vegetation - Seagrass

Scouring by swing mooring.

Figure 2.20: Observed Impacts on Seagrass

a) Saltmarsh (low groundcover), Iron Cove Bay.

b) *Sarcocornia quinqueflora*.

Figure 2.21: Estuarine Vegetation - Saltmarsh

a) Mangroves lining the upper Parramatta River estuary.

b) Mangrove forest, Bicentennial Park.

Figure 2.22: Estuarine Vegetation – Mangroves

a) Mangroves subsidence due to bank erosion (source: D. Wiecek, OEH).

b) Evidence of illegal mangrove clearing, Five Dock Bay (source: D. Wiecek, OEH).

Figure 2.23: Observed Impacts on Intertidal Estuarine Vegetation

2.3.2 Conservation Significant Communities, Flora and Fauna

Seagrasses, saltmarsh, mangroves and macroalgae are protected under the *Fisheries Management Act 1994*. Coastal Saltmarsh, Swamp-oak Floodplain Forest and Sydney Turpentine-ironbark Forest which is also present in the study area, are listed as EECs under the *Threatened Species Conservation Act 1995*. Sydney Turpentine-ironbark Forest is one of the communities that form the nationally significant Turpentine-ironbark Forest, which is listed as a critically endangered ecological community under the EPBC Act. Hence the ecological communities present in the study are significant on both a local, NSW state-wide and national scale as indicated by the legislation.

Habitat restoration and/or enhancement works will be a valuable exercise for enhancing existing vegetation and re-establishing areas of habitat that have been lost (Figure 2.24). This is a particular challenge for diminished intertidal communities, such as rock platforms and mudflats and channelised drainage lines. Consideration should be given to naturalising these concreted drainage lines and shorelines when the structures come to the end of their design life, to improve the ecological value of the estuary and extend biodiversity corridors. Protecting areas consisting of EECs and threatened flora and fauna species should be considered a priority. Management actions should also focus on creating biodiversity corridors throughout the catchment and along foreshore areas, to connect existing fragmented areas of vegetation.

The study area contains nine nationally significant wetlands which together form an extensive wetland system bordering the Parramatta River estuary, including Brays Bay, Ermington Bay, Haslams Creek, Homebush Bay, Lower Duck River, Majors Bay, Mason Park, Meadowbank Park Foreshore and Yaralla Bay Wetlands and Silverwater Saltmarsh. In particular, the mangroves lining the Parramatta River represent a significant proportion of those remaining in the Sydney region and those in the Lower Duck River represent the oldest known stand of mangroves in NSW. The Silverwater Saltmarsh complex incorporates highly significant saltmarsh species that do not commonly occur in the Sydney region. This saltmarsh complex is in excellent health and comprises a small intact ecosystem that is representative of pre-European vegetation that can no longer be found in the study area. The Bicentennial Park and Newington Nature Reserve Wetland are also listed as nationally significant wetland sites, and support a wide range of fauna.

a) Mangrove planting, Homebush Bay (source: D. Wiecek, OEH).

b) Riparian revegetation behind a seawall (source: D. Wiecek, OEH).

Figure 2.24: Examples of Habitat Restoration Works

The Parramatta River estuary provides habitat to a variety of shorebirds, waterbirds, wader birds and forest birds. The estuary is on the route of the East Asian-Australasian Flyway which is used by shorebirds to move between Australia / New Zealand, East Asia and the Arctic region of the northern hemisphere. Key habitat areas of mangroves and saltmarsh in the estuary such as Sydney Olympic Parklands and the Mason Park Wetlands provide important and vital stopover areas for these migratory birds to rest and feed. Australia is party to international conventions and agreements to protect many migratory species, such as the China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

a) Ibis (*Threskiornis molucca*) in the mangroves in Bicentennial Park.

b) Pied Stilt (*Himantopus himantopus*), Homebush (source: D. Wiecek, OEH).

Figure 2.25: Wading Birds

2.3.3 Impacts on Estuarine Ecology

The study area also contains locally and regionally significant fauna species (Figure 2.25). For example, a number of regionally rare bird species, including the White-fronted Chat, Red-rumped Parrot, Osprey, White-bellied Sea Eagle, Marsh Harrier and Peregrine Falcon have been found in Homebush Bay. Human-induced threats to avifauna in the study area include significant loss of habitat through vegetation removal and predation by domestic animals, with off-leash dog walking being an issue in certain areas of the foreshore. It is understood that there are also concerns about bioaccumulation of toxins affecting the health of birds living around the estuary.

In 1972, a survey failed to catch a single fish upstream of Silverwater Bridge (Paxton and Collett, 1975). However, more recent data would suggest that fish populations have been making a recovery in recent decades due to improvements in water quality associated with improved catchment management practices, better regulation of industry and a decrease in the intensity of industrial activity along the estuary foreshores. A review of the available literature on fish populations in the estuary presented in Cardno (2008) suggests that the estuary currently supports a diverse fish fauna, despite evidence of poor water quality and pollution impacting on fish.

Nonetheless, the bioaccumulation of toxins from contaminated sediments remains an issue, and the true impact on estuarine ecology is unknown. Recreational fishing is still allowed in the Parramatta River estuary, although limited consumption of fish caught in the estuary is recommended due to elevated dioxin levels in fish (Figure 2.26). In addition, weirs and other structures that change flow regimes or prohibit fish passage have also impacted fish populations.

a) Recreational fishing dietary advice signage in the catchment (source: P. Hackney, PCC).

b) Signage indicating total fishing ban in Duck Creek (source: P. Hackney, PCC).

Figure 2.26: Recreational Fishing Restrictions

Estuarine ecology in the study area has been seriously degraded and fragmented over time due to extensive clearing of foreshore and catchment vegetation for residential, industrial, commercial and open space

development purposes since European settlement. This has resulted in a loss of biodiversity and fragmentation of the remaining habitat, leaving the ecology vulnerable to natural and human induced stressors, such as infestations by introduced species, inter-specific competition and climate change. Nevertheless, biodiversity in Sydney, the Parramatta River estuary catchment included, is still high compared to many other parts of Australia and the world and hence biodiversity conservation is a key management issue. Estuarine hydrodynamic processes, in particular tidal inundation, are vital to the maintenance and functioning of estuarine ecosystems. Alteration to natural flow regimes of waterways, and their floodplains and wetlands, is recognised as a major factor contributing to the loss of biological diversity and ecological function in aquatic ecosystems.

A significant long term threat to the ecology of the study area is climate change and SLR in particular. As mean sea levels rise, this will reduce light penetration to seagrass beds in deeper areas of the estuary, potentially resulting in their loss, although it is noted that there may also be gains elsewhere. Intertidal vegetation such as mangroves and saltmarsh may have potential to migrate landward to higher elevations, provided infrastructure and other land uses are not currently occupying suitable areas for colonisation. In order to facilitate landward migration in priority areas management interventions may be required, such as vegetation management and/or the relocation/decommissioning of infrastructure. AECOM (2010) identified priority areas where vegetation enhancement efforts should be focused by quantifying the potential for landward migration of intertidal vegetation with SLR in the catchment as follows:

- An estimated 65% of existing saltmarsh communities have some potential for landward migration, of which a large proportion is located within Newington Nature Reserve Wetland (Sydney Olympic Park); and
- An estimated 22% of existing mangrove communities have some potential for landward migration, based on the presence of obvious impediments to landward migration for the remaining 78%. Of further concern, is that areas in which mangroves have some potential to migrate landwards are presently occupied by EECs such as saltmarsh and Swamp-oak Floodplain Forest, thereby forcing competition between and loss within these communities.

2.4 Human Usage and Recreation

2.4.1 Recreation

Public access along the foreshore, via cycle paths and walking tracks, was identified by the community as being the second most important issue in the community survey undertaken in the preparation of this CZMP (Appendix B). The availability of recreational facilities and infrastructure, including BBQ areas, seating, public toilets, jetties and boat ramps along the foreshore was also raised by the community as a high priority management issue, with 64% of the community surveyed ranking this of high importance. A key issue for the estuary is the inconsistency of accessibility to the foreshore as well as the availability and suitability of recreational facilities throughout the catchment.

As the study area has developed and moved away from its industrial past, the foreshore has been increasingly reclaimed for recreational uses with considerable investment at both the state and local government levels. However, a large proportion of the foreshore is still in the hands of industry and individuals as private residences. As part of the Parramatta River Foreshores Improvement Program an audit of the estuary foreshore was

undertaken. This audit reported that approximately 46.6km of foreshore in the study area is publicly owned, while 24.9km is privately owned, not including tidal tributaries (Cardno, 2008).

Over the last decade significant works have been undertaken around the Parramatta River estuary foreshore to improve public access to the waterway, as part of DIPNR's (2003) *Sharing Sydney Harbour Regional Action Plan*. Significant funding for the Parramatta River estuary was also provided in 2007 under the *Sharing Sydney Harbour Access Program*, a NSW government initiative to improve public access to and enhance the recreational enjoyment of Sydney Harbour and its tributaries. Many projects across the eight foreshore LGAs have been undertaken to date under this program, providing access and recreational improvements (Cardno, 2008). In 2007 the NSW Government also announced the provision of additional funding to extend its support for public walking and cycling tracks, and recreational boating facilities around Sydney Harbour to at least 2013 (Cardno, 2008). However, certain cycleway/walkway facilities, such as the Parramatta Valley Cycleway Shared Path, are discontinuous in sections and still require further work to complete and improve connectivity throughout the study area and across LGAs (Figure 2.27).

a) Shared cycleway/walkway in the catchment.

b) Dedicated bike lanes along the estuary foreshore.

Figure 2.27: Examples of Public Access

The open space areas and recreational infrastructure are mapped in Figure 2.31. There are six major foreshore parks in the study area that primarily provide for passive recreation opportunities:

- Sydney Olympic Park (Auburn LGA);
- George Kendall Riverside Park (Parramatta LGA);
- Meadowbank Park (City of Ryde);
- Kissing Point Park (City of Ryde);
- Putney Park (City of Ryde); and
- Cabarita Park (City of Canada Bay).

These major foreshore parks and other reserves have significant recreational value as they service the passive recreational needs of the approximately 561,200 people living in the foreshore LGAs (according to ABS statistics from the 2011 census), as well as visitors to the area (Cardno, 2008). The largest areas of foreshore parks and reserves are found in Auburn LGA, followed by the Cities of Ryde and Canada Bay. Foreshore recreational activities include walking, jogging, fishing, family gatherings and picnics undertaken in foreshore parks.

A number of capital works projects have been funded under the Parramatta River Foreshores Improvement and Metropolitan Greenspace Programs, including foreshore parks, cycle and pedestrian paths and foreshore access points; however, further works are still required in order to provide adequate facilities to service demand, particularly in foreshore sites that are proposed for medium to high density residential development.

The Parramatta River estuary is an important recreational waterway, particularly for the western suburbs of Sydney. Water-based recreational activities in designated areas of the estuary include power boating, sailing, sail-boarding and rowing, as evidenced by a number of active, long-term sailing and yachting clubs in the study area. The estuary has a long historical association with sailing and in particular with rowing, as evidenced by the large number of boat sheds and club houses along the river. Several local schools and universities also row along the Parramatta River for sport. In September 2007 the Parramatta River estuary hosted the World Dragon Boat Racing Championships (Cardno, 2008). RMS (Maritime) produced a boating guide that identifies rules and regulations (e.g. speed zones) and shows the location of boating infrastructure.

Many planning policies, such as the *Sydney Regional Environment Plan (Sydney Harbour Catchment) 2005* are in place that cover the Parramatta River estuary and aim to establish a balance between maintaining a healthy and ecologically sustainable estuary, and promoting recreational access to the foreshore and waterways.

The Parramatta River estuary is used as a public transport link by ferries and the RiverCat (Figure 2.28), linking Sydney and Parramatta. Many commercial businesses, such as marinas, restaurants, cafes, slipway services, and activities are also located along the foreshore, servicing the local and wider community and also visitors to the area i.e. the tourism industry. Issues caused by the RiverCat's wash have been discussed previously in Section 2.2.2.

a) RiverCat in the estuary, Parramatta.

b) RiverCat in the estuary, Parramatta.

Figure 2.28: RiverCat

Associated with the development of the estuary foreshore has been the construction of waterway recreational assets along the foreshore, including boat ramps, wharves, jetties, landings, informal and formal dinghy storage areas and temporary mooring facilities. There may also be opportunities to improve connectivity between the waterway and the foreshore, and to better service the boating community. However, there are concerns amongst the community that this would lead to overcrowding of the waterway and increased conflicts between users (Appendix B). There is also potential for impacts on estuarine ecology and water quality if not properly managed. Some of the ongoing impacts of human activities have been identified in previous sections (Sections 2.1, 2.2 and 2.3).

One of the most prominent issues associated with waterway recreation facilities is the lack of formal dinghy storage facilities. Dinghies are scattered along the foreshore (Figure 2.29), leaning against walls, rock shelves and trees and such informal access and informal storage at these locations is resulting in the degradation of foreshore vegetation, primarily by trampling (AECOM, 2010).

a) Private jetties accessing the estuary waterway.

b) Informal dinghy storage along the estuary foreshores.

Figure 2.29: Boating Infrastructure

There may be opportunities to improve recreational amenity/facilities through the process of re-development of foreshore lands. However, in some cases it may be more appropriate to de-commission infrastructure and/or relocate it to a more suitable location where impacts on the environment can be minimised.

Waterway recreational facilities are prone to deterioration over time due to the physical and chemical stresses they are under, including exposure to saline waters, waves and changes in water levels (e.g. for structures with a connection to the foreshore). A total of 84 facilities were inspected by ACEOM (2010) and their locations are mapped in Figure 2.31. The highest concentration was in the City of Canada Bay (28), followed by the City of Ryde (17) and Hunters Hill LGA (16). The condition assessment found that there were a number of facilities in poor condition or subject to failure (AECOM, 2010), which represents a risk to public safety and the environment (Figure 2.30).

Climate change and the projected increases in estuarine water levels are also of concern for management of recreation and public access across the estuary. Foreshore assets, particularly those located on the waterway but with a fixed connection to the foreshore, may require modification and/or relocation with rising sea levels, as some locations are already subject to inundation during king tides.

Management actions proposed to address the recreational needs of the estuary users must aim to achieve a harmony between the competing demands of meeting the community's needs for recreational access and amenity, and providing for conservation and enhancement of estuarine ecosystems. Achieving this balance was raised as one of the most important issues for the Parramatta River estuary in the community survey undertaken for this Study (Appendix B).

a) Failing pylons in the estuary.

b) Failing wall along the estuary foreshores (source: P. Hackney, PCC).

Figure 2.30: Failing Foreshore Infrastructure

2.4.2 Cultural Heritage

With regards to Non-Aboriginal cultural heritage, the Parramatta River estuary is considered to be culturally the most significant waterway in Sydney and has been critical in the development of Sydney from the first settlement. The River acted as a crucial communication and transport link between Sydney and Parramatta. Initially settlement followed the river and then spread into the surrounding districts. Hence, the Parramatta River estuary foreshores contain some of Australia's earliest Non-Aboriginal historical monuments and features (Cardno, 2008).

There are a significant number of commonwealth, state and local heritage listed items located within the eight foreshore LGAs, and there is also a sizeable volume of literature relating to the heritage and cultural values of the Parramatta River estuary and its foreshores (Cardno, 2008).

Cockatoo Island represents a highly significant heritage site located within the Lower Parramatta River estuary, relating to its maritime heritage and history, and it also contributes to the visual character of the estuary. Both Cockatoo Island itself and a number of features located on the Island are protected under the EPBC Act as Commonwealth Heritage Listed sites. Cockatoo Island also has enormous cultural heritage significance as a shipbuilding facility, operating for 134 years until 1991 as the nation's primary shipbuilding facility (Cardno, 2008).

The Parramatta River estuary lies within some of the most developed and urbanised areas of Australia. As such, the Aboriginal cultural heritage of the area has been under severe pressure since the settlement and subsequent development of the area by Non-Aboriginals. Aboriginal groups in the study area today include the Darug Tribal Aboriginal Corporation and the Deerubbin LALC (Cardno, 2008).

A number of Aboriginal heritage sites and places of significance are located within the estuary and foreshore areas, which highlights both the size of the study area and also the importance of the study area for Aboriginal people. It is also recognised that there is significant potential for previously unrecorded Aboriginal heritage items to occur in the study area.

One of the most culturally significant sites in the study area is the Parklands at Sydney Olympic Park, which covers 432ha. The Parklands contain stands of remnant woodlands, rare saltmarshes and mangroves alongside

constructed places of historical significance. The Parklands are also a place of Aboriginal significance and are of historic naval importance.

The community survey results indicated that cultural and heritage values associated with the estuary and its foreshores were ranked as being of high importance to 64% of respondents and of medium importance to 33% of respondents (Appendix B). Hence, the community largely recognises the need to protect and promote the cultural values and significance associated with the Parramatta River estuary.

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:40,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Recreational Assets

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.31

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2031_RecreationAreas 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)

2.5 Climate Change

2.5.1 Climate Change Science and Policy

It is generally accepted amongst the scientific community that global warming of the Earth's atmosphere will lead to a rise in mean sea level due to the Greenhouse effect. The most recent climate change projections indicate increased temperature and evaporation rates for coastal NSW, along with changes to seasonal rainfall patterns, runoff and therefore subsequent impacts on bushfire regimes, biodiversity, soils, erosion and flooding (DoP, 2010). It is predicted that current weather patterns will be altered; leading to more frequent extreme weather events (i.e. floods, droughts, tropical cyclones, etc.). SLR projections of 0.4 m by 2050 and 0.9 m by 2100 were previously adopted by the NSW Government for planning purposes (DECCW, 2009), and although the formal endorsement by the government has now been repealed, it is noted that these values are still considered to represent the best available science (CSE, 2012) and have been adopted in this study.

Coastal communities and environments are particularly vulnerable to climate change due to the potential for permanent coastal inundation and increasing coastal hazards associated with changing weather patterns and extreme weather events. Costal hazards include risks from coastal erosion, tidal inundation and coastal flooding, including the impacts of SLR.

Water level analyses have been conducted on tide gauge water level data collected over a 122 year period at Fort Denison, Sydney Harbour (You *et al*., 2009). An analysis of the full data set from 1886 to 2007 identified a rate of rise in water levels in Sydney Harbour of 0.63±1.4 mm/yr. However, where the analysis was limited to the more reliable data collected from 1950 to 2007, the rate of rise was determined as 0.58±0.38 mm/yr (You *et al*., 2009).

2.5.2 Potential Impacts of Climate Change on Estuary Processes

A brief overview of the key potential implications of climate change on estuary processes is outlined below, as identified by Cardno (2008) and AECOM (2010):

- *Increased water levels:* SLR would lead to higher estuarine water levels and may also result in changes to the tidal prism. This would have the effect of increasing tidal penetration of tributary creeks and canals, provided that the tidal flows are not impeded by physical infrastructure;
- *More frequent or permanent inundation of foreshore areas:* Some facilities and foreshore areas along the Parramatta River estuary may be inundated more frequently or permanently as the elevated water level events of today will become more common in the future. Seawalls have been used extensively in the study area to support the foreshore and reclaimed lands; however, where these seawalls are not high enough to combat rising sea levels, they may be overtopped and the assets they protect may become inundated. Frequent overtopping or permanent inundation would compromise the function of these seawalls or other affected infrastructure, potentially leading to economic damage of public and private assets and further water quality issues, such as leachate from contaminated reclaimed lands may be released into the estuary;
- *Changes to rainfall patterns:* Extreme weather events, in particular more frequent flood and drought periods, may impact on catchment processes and there is potential for a wider range of water quality

conditions to occur in the estuary. Changes in rainfall patterns could change the water balance of the estuary tributaries;

- *Erosion of unconsolidated foreshores:* Increased water levels could contribute to the erosion of unconsolidated shorelines. Where there is sufficient fetch, changes in wind patterns could result in increased erosion of affected shorelines by wind waves;
- *Impacts on estuarine ecology:* The impacts of climate change on estuarine ecology will be complex and are difficult to predict. Changes to the intertidal zone due to SLR will significantly limit the present extent of intertidal estuarine vegetation in many locations, as potential areas for landward migration are limited by existing infrastructure. For example, AECOM (2010) estimated that 78% of existing mangrove communities will potentially be impacted upon by SLR based on impediments to landward migration. This will also impact on other intertidal habitats, such as mudflats and rock platforms, which have already been significantly reduced in extent. A rise in mean sea level would also result in a gradual shift in the locations where seagrasses could survive.

2.5.3 Coastal Hazard Assessment

A Coastal Hazard Assessment (CHA) was recently undertaken by Cardno to assess the potential impacts of elevated estuarine water levels in both the present day and under SLR conditions in the Parramatta River. The assessment was conducted in accordance with the *Coastal Risk Management Guide* (DECCW, 2010d) and adopting SLR projections of 0.4m by 2050 and 0.9m by 2100. The CHA report is provided in Appendix C.

The CHA provides a series of maps to depict the projected impacts of SLR on ocean still water levels in the estuary, for higher water level events due to storm surge (1-year and 100-years ARI). Three scenarios were investigated (existing, 0.4m SLR and 0.9m SLR), and the results indicate that, as anticipated, the effects of inundation on the estuary foreshores will increase under SLR conditions. Based on the mapping, several key areas have been identified as being subject to risk from coastal hazards in the future and a discussion of these areas has been provided for each scenario (Appendix C). A range of land uses are likely to be affected including residential, commercial/industrial, road infrastructure and open space/parkland.

Protecting public and private property in relation to wave inundation, flooding, erosion and/or SLR (e.g. via seawalls or flood control works) was ranked as an issue of high importance by 75% of the community surveyed (Appendix B). The Parramatta River estuary foreshore is subject to a number of coastal hazards, including tidal and wave inundation, flooding, shoreline erosion and SLR. The co-occurrence of a number of these factors at the same time significantly increases hazard. As discussed above, coastal hazards such as inundation due to storm surge represent a potential threat to public and private assets and human users of the foreshore and will be exacerbated with climate change and SLR.

In the long term, permanent tidal inundation due to SLR will become a significant challenge. There are limited locations around the foreshore where increased tidal inundation can be accommodated without risk to public and private assets, and the management authorities will need to consider an appropriate management response. Under climate change conditions, rising groundwater levels, salinisation of groundwater and soils, and changes in rainfall intensities will also impact on the functioning and maintenance regimes of the stormwater network as well as other services and utilities. Alternatives involve relocation of assets out of the impacted area, or increasing levels of protection. In many instances this may involve raising the crest height of seawalls to combat future SLR as seawalls require repair and/or replacement. It may be desirable to seek opportunities to build

resilience or adapt to these impacts during the course of regular capital works (e.g. by increasing the hydraulic capacity of stormwater pipes). Planning for coastal hazards should consider both current and future levels of risk. The most effective means of managing risk from coastal hazards is via strategic land use planning.

It is anticipated that the results of the CHA can be utilised in various strategic land use planning and management frameworks for the estuary. Action 39_COM21 of the Parramatta River Estuary CZMP specifies the consideration of the implications of the CHA when updating the CZMP in the future.

2.6 Estuarine Health, Monitoring and Community Awareness

Monitoring of estuarine health is necessary to track positive and/or negative trends and locations or issues that require active management. Development of an estuarine monitoring program consistent with the NSW MER Strategy (DECCW, 2010c) is a requirement of CZMPs. Further discussion on proposed future monitoring is provided in Section 6.2.

A large number of existing studies have been conducted in the study area to investigate key issues such as water and sediment quality, and the extent, condition and composition of estuarine flora and fauna. However, many of these are limited in spatio-temporal scale. Generally these studies have had a variety of aims (often for development approvals, as opposed to estuarine health assessments), have used a variety of methodologies and techniques, and have occurred in an ad hoc manner across the study area. As such these studies are very limited in their ability to provide accurate baseline information on estuary health. AECOM (2010) also highlighted data deficiencies and inconsistent approaches to data collection and reporting in relation to stormwater management activities/devices, which makes comparison of data across the catchment difficult. Further review of available monitoring data has been undertaken in relation to development of an estuarine health monitoring program (Section 6.2 and Appendix I).

Commensurate with monitoring, the community and the Committee have also identified that communication with the community and raising awareness on estuarine management is a high priority. As previously indicated, there is potential for improved catchment management and compliance with regulations as a result of community education. Lot-based water cycle management (e.g. through the use of rainwater tanks, water conservation and re-use), weed management by 'looking after your own lot', littering and inappropriate disposal of waste products represent opportunities for individuals to reduce their impacts on the estuarine environment, provided they have support from local authorities. Raising awareness, particularly amongst the community in the study area, about the importance of estuary management and why the estuary needs to be conserved will be an important part of this process. The community has a high level of awareness and concern about environmental degradation and pollution of the Parramatta River estuary, and it would be beneficial to communicate to them trends in estuarine health. It is recommended that the Committee seek means to address this issue by improving direct communication with the community, and involving them in the implementation of the Plan.

2.7 Summary of Estuary Values and Significance

Sections 2.1 to 2.6 have discussed the significance of the Parramatta River estuary based on the key findings of the *Data Compilation and Review Study* (Cardno, 2008) and the *Estuary Processes Study* (AECOM, 2010).

Feedback on estuary values was obtained and complied as part of the community survey to establish the current view on which attributes of the estuary are most valued (Appendix B).

A summary of the local, regional, national and international significance of the Parramatta River estuary and values identified by the community are detailed in Table 2.3.

Table 2.3: Values and Significance of the Parramatta River Estuary

Scale	Significance of the Parramatta River Estuary
Local	▪ Significant for the local Aboriginal people and traditional owners, with over 250 known Aboriginal places or objects recorded in or near the study area. ▪ Extensive usage of the estuary and foreshores by local people on a regular basis for passive recreation. ▪ Provides a place for activities for various water-based clubs and organisations. In particular, the estuary is, and has been, used by local sailing and rowing recreation clubs. ▪ Native habitat in the study area supports local biodiversity including fish, birds and invertebrate fauna.
Regional	▪ Most culturally significant waterway in Sydney, critical in the development of Sydney from the first settlement. ▪ High State heritage significance with over 130 listings under the NSW *Heritage Act 1977* within the eight foreshore LGAs. ▪ The study area contains regionally significant fauna species, in particular regionally rare bird species in Homebush Bay. ▪ In terms of NSW state significance, the study area contains seagrasses and mangroves, which are protected under the *Fisheries Management Act 1994* and Coastal Saltmarsh, Swamp-oak Floodplain Forest and Sydney Turpentine-ironbark Forest, which are listed as EECs under the TSC Act.
National	▪ High national heritage significance with over 500 listings on the Register of the National Estate and Commonwealth Heritage List within the eight foreshore LGAs. ▪ The study area contains a number of nationally significant wetlands listed on the Directory of Important Wetlands in Australia, and Turpentine-ironbark Forest, which is listed as a critically Endangered Ecological Community under the EPBC Act.
International	▪ Migratory birds listed under bilateral and multilateral agreements (e.g. JAMBA, CAMBA and ROKAMBA) use the wetlands in the study area as important stopover areas. ▪ Important international sporting competitions have been held in the study area, the most prominent being the Sydney Olympics in 2000. The World Dragon Boat Regatta was also held in the study area.
Values Identified by the Community	
▪ Public access to and along the foreshore. ▪ Connectivity between the waterway, foreshore and surrounding areas. ▪ Being able to enjoy the public open space areas. ▪ Being able to engage in a range of passive and active recreational activities. ▪ Water quality suitable for recreational usage. ▪ Harmony between different recreational user groups. ▪ The presence of native animals and vegetation. ▪ Enjoyment of the natural environment. ▪ The promotion of environmental education. ▪ The recognition of Aboriginal and European cultural heritage. ▪ Sustainable approaches to managing the estuary. ▪ Opportunities to understand how the estuary functions and hear about trends in estuarine health.	

2.8 Summary of Key Estuary Issues

Through the estuary management process the *Data Compilation and Review Study* (Cardno, 2008) and *Estuary Processes Study* (AECOM, 2010) identified a comprehensive list of 107 management issues associated with the Parramatta River estuary, many of which have been discussed in Sections 2.1 to 2.6. The issues identified in these studies were collated and consolidated to 70 issues for discussion and review with the Committee during Committee Workshop 1 (see Table D.1 in Appendix D).

One of the aims of Committee Workshop 1 (held on 2 March 2011) was to identify the top 10 key management issues to guide the management framework in the CZMP. These top 10 management issues have been identified as follows:

1. Increased pressure is being put on the estuary due to large foreshore developments and land use changes as industrial areas are re-developed;
2. Water and sediment quality within the estuary is generally poor;
3. Much higher sediment loads are entering the estuary than in pre-European times;
4. There have been historic and ongoing declines in ecological values due to a range of threatening processes;
5. Erosion is impacting on bank stability and estuarine and riparian vegetation in a number of locations;
6. Seawalls line a substantial proportion of the Parramatta River estuary and have led to a significant loss of foreshore habitat. Much of this infrastructure is dated and the need for maintenance and repair is likely to further increase with SLR;
7. Accessibility of the foreshore, as well as the availability and suitability of recreational facilities is not consistent across the estuary, particularly in the context of residential development of former industrial sites along the foreshores;
8. There is currently no baseline information on estuary health, or any coordinated monitoring programs within the Parramatta River estuary;
9. There is a need for improved education of the community and other stakeholders in relation to estuary processes and their linkages to catchment processes. There is also a need to improve communication and reporting on estuary management initiatives; and
10. The Parramatta River estuary foreshore is subject to coastal hazards such as storm surge that will increase with climate change and have the potential to negatively impact on public and private assets.

Detailed discussion of the management issues facing the Parramatta River estuary (including the 10 key issues listed above) has been provided in Sections 2.1 to 2.6.

3 MANAGEMENT AIMS AND OBJECTIVES

In order to guide the development and implementation of the Parramatta River Estuary CZMP, the Committee developed a series of management aims and objectives. In accordance with the *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010b), the aims and objectives were formulated with a focus on estuarine health, and the sustainable use and enjoyment of the estuary by the community. Human uses of the estuary waterway and foreshore are considered primarily with respect to how they impact on estuarine health.

These management aims and objectives constitute the framework of the Plan. Any options or actions considered as part of the Plan are required to work towards the attainment of these aims and objectives. The process of developing the management aims and objectives is, therefore, important in focussing the direction of the Plan.

3.1 Determining Management Aims and Objectives

Two workshops were held with the Committee to develop the management aims and objectives (see Section 1.4). The approach adopted was to develop a single broad aim for each of the ten key management issues identified in Section 2.8. For each of the ten aims, a series of more specific management objectives were then developed.

Prior to the first Committee Workshop, draft aims and objectives were developed by the Cardno study team based on the *Data Compilation and Review Study* (Cardno, 2008) and *Estuary Processes Study* (AECOM, 2010) for discussion with the Committee members. The Committee broke into two groups and engaged in discussion on priorities for management and how the aims and objectives should be phrased. The original intention was that the management objectives would be fairly specific and directly measurable. However, the Committee considered that it would be beneficial to find a balance between outlining more specific outcomes within the objective wording, while at the same keeping them sufficiently flexible to enable the development of a wide range of management options. The outcome of this discussion was a final list of management aims and objectives. After the workshop, the comments on the aims and objectives were compiled and collated by the study team.

At the second Committee Workshop the Committee members confirmed the final management aims and objectives (Table 3.1). The Committee members were also asked to provide input on the objectives prioritisation. This involved each Committee member allocating a “high”, “medium” or “low” priority against each objective. The results were then averaged by the Cardno study team, and are presented in the final column of Table 3.1. The prioritisations reflect the relative importance of the different management objectives in the first period of implementation. For example, water quality was viewed by all Committee members as being a key management issue that requires immediate attention, and as a result, four of the six objectives relating to water quality were consistently rated as having a high priority by the Committee members. The prioritisation of the objectives was also used to rank the management options (see Section 4.1.3).

Table 3.1: Management Aims and Objectives

Key Management Issues	Management Aim	Objective ID	Management Objective(s)	Objective Prioritisation
Land Use Planning and Development				
Increased pressure is being put on the estuary due to large foreshore developments and land use changes as industrial areas are re-developed.	Foreshore development and land use planning incorporates the principles of ecologically sustainable development.	1A	Ensure integration of the Parramatta River Estuary CZMP aims and objectives into other strategic planning and natural resource management activities, instruments and policies (e.g. regional strategies, and council DCPs and LEPs).	High
Water and Sediments				
Water and sediment quality within the estuary is generally poor.	To improve water quality in the estuary such that it is suitable for a range of environmental functions and recreational uses.	2A	Minimise incidences of illegal dumping of waste into the estuary.	Medium
		2B	Reduce the level of contaminated sediment and other pollutant loads entering the estuary from catchment runoff.	High
		2C	Reduce the incidence of sewer overflows affecting the estuary and improve compliance with recreational water quality guidelines for all sites monitored under the Harbourwatch program.	High
		2D	Limit the mobilisation of pollutants from contaminated foreshore areas and bed sediments into the water column through minimising their disturbance.	Medium
		2E	Ensure all new developments do not have a negative impact on estuarine water quality.	High
Much higher sediment loads are entering the estuary than in pre-European times.	To reduce the environmental damage caused by sedimentation.	3A	Reduce sediments entering the estuary, particularly where sedimentation affects vulnerable ecological communities such as seagrass.	High
Estuarine Ecology				
There have been historic and ongoing declines in ecological values due to a range of threatening processes.	To maintain and enhance the ecological values associated with the estuary, both aquatic and terrestrial.	4A	Protect and enhance estuarine habitats (both aquatic and foreshore habitats), with a focus on providing ecological connectivity between core habitats.	High
		4B	Naturalise existing concrete lined and highly modified creeks as opportunities arise.	Medium
		4C	Reduce the occurrence of weeds and pests in aquatic and terrestrial habitats in and around the estuary.	Medium
		4D	Incorporate additional aquatic habitat opportunities into existing areas of limited habitat.	Low

Key Management Issues	Management Aim	Objective ID	Management Objective(s)	Objective Prioritisation
Bank Condition				
Erosion is impacting on bank stability and estuarine and riparian vegetation in a number of locations.	Manage bank erosion to reduce its environmental impacts and improve the social amenity of the estuary.	5A	Actively encourage the replacement of the current RiverCat with another vessel that has a lower environmental impact (i.e. particularly with respect to bank erosion).	Medium
		5B	Rehabilitate high priority sections (AECOM, 2010) of eroding shorelines.	High
Seawalls line a substantial proportion of the Parramatta River estuary and have led to a significant loss of foreshore habitat. Much of this infrastructure is dated and the need for maintenance and repair is likely to further increase with SLR.	The foreshore is managed to protect existing assets while maximising environmental values.	6A	Remove seawalls where feasible and restore a natural intertidal zone.	Medium
		6B	All seawalls, including those that are to be retained and new seawalls that are proposed, should where feasible, incorporate the principals of environmentally friendly design features (after DECC and SMCMA, 2009).	Medium
Human Usage and Recreation				
Accessibility of the foreshore, as well as the availability and suitability of recreational facilities is not consistent across the estuary, particularly in the context of residential development of former industrial sites along the foreshores.	Enhance access to the estuary and its foreshores for a wide range of user groups, while ensuring estuary health is not compromised.	7A	Maintain and improve public access along the estuary foreshores and waterway, without compromising estuarine health.	High
		7B	Ensure that recreational facilities continue to be provided for a range of different user groups at strategic locations.	High
		7C	Achieve recognition of the iconic status of the Parramatta River and capitalise on foreshore and waterway linkages.	High
Monitoring, Evaluation and Reporting				
There is currently no baseline information on estuary health, or any coordinated monitoring programs within the Parramatta River estuary.	Adopt coordinated monitoring programs for the Parramatta River estuary that provide information on estuarine health and also monitor the effectiveness of implementation of the Plan in working to continually improve the management of the estuary.	8A	Implement a coordinated estuary health monitoring program in line with the NSW MER Strategy. This program should incorporate elements that assist in assessing the effectiveness of implementation of the Plan in achieving the stated aims and objectives. The program should also incorporate a reporting function to provide information to the community and key stakeholders.	High
There is a need for improved education of the community and other stakeholders in relation to estuary processes and their linkages to catchment processes. There is also a need to improve communication and reporting on estuary management initiatives.	To increase community awareness about the Parramatta River estuary.	9A	Promote public awareness of cultural heritage in and around the estuary.	Low
		9B	Provide information to the community on the potential impacts of climate change on the Parramatta River.	Low

Key Management Issues	Management Aim	Objective ID	Management Objective(s)	Objective Prioritisation
Coastal Hazards				
The Parramatta River estuary foreshore is subject to coastal hazards such as storm surge that will increase with climate change and have the potential to negatively impact on public and private assets.	Risks from coastal hazards affecting the estuary are appropriately managed.	10A	Plan for and mitigate (or increase the capacity to adapt to) the impacts of climate change and SLR on foreshore-based public infrastructure and ecological communities.	Medium

3.2 Integration with Existing Plans

There are currently in place two pre-existing Plans with which the aims and objectives of the Parramatta River Estuary CZMP are required to be consistent:

- The *Sydney Metropolitan Catchment Action Plan* (SMCMA, 2009); and
- The *Parramatta River Foreshore Plan 2009-2016* (PCC, 2009).

The *Catchment Action Plan* (SMCMA, 2009) is discussed briefly in Appendix A. The CAP includes Catchment Targets that correspond to aims for management which take as their focus ecological conservation, waterway health, strategic land use management, improved community awareness and involvement in natural resource management, and monitoring and evaluation. It is noted that, over the last 12 months, the SMCMA has been reviewing the CAP and it has been exhibited as the *Draft Catchment Action Plan 2012 A Plan for Sydney's Liveability* (SMCMA, 2012b). As the SMCMA and HNCMA have now been amalgamated, the status of the current CAP and draft CAP is not clear.

The *Parramatta River Foreshore Plan* (PCC, 2009) articulates a series of management principles under the categories of habitat, water management, landscape, visual quality and future urban form, access, recreation, and cultural heritage.

A review of the aims and objectives presented in Table 3.1 indicates that they are wholly consistent with those presented in the CAP (SMCMA, 2009), draft CAP (SMCMA, 2012b) and the *Foreshore Plan* (PCC, 2009).

4 MANAGEMENT OPTIONS AND ACTIONS

The aims and objectives established in Section 3 describe what the Committee and community members would like to achieve through implementation of the Parramatta River Estuary CZMP. The management options and actions articulate how the Committee intends to go about this process. For the purposes of this study, the management options describe the general activities to be undertaken under the Plan, whereas the actions detail the specific activities that are to be undertaken to progress that management option.

As previously discussed, early on in the project it was identified that there was a need to focus the Parramatta River Estuary CZMP. This desire to focus the Plan stems from:

- The need to target key management issues affecting the whole estuary where the Committee can do something to improve the current situation;
- The need to target those key management issues that are currently impacting on estuarine health (Section 2.8);
- The need to ensure all the actions and options are reasonable, feasible and achievable;
- Recognition that there are finite resources for implementation of any actions identified in the Plan, and that these should be directed to the highest priority areas; and
- An understanding that the Plan is required to be updated every 5 to 10 years in accordance with the Guidelines (DECCW, 2010b).

For these reasons, the Committee agreed to develop an implementation strategy (Section 5) that targets priority activities within the first phase of implementation. When the Plan is updated in 5 to 10 years' time the actions listed within the implementation strategy may be updated to address any emerging issues or to include additional activities to replace those actions that have been completed in the preceding implementation phase. This is considered appropriate within the context of adaptive management.

Therefore, there was a need to prioritise the management options and actions in order to identify those activities that would provide the greatest net benefit for the first phase of implementation. The process of developing and prioritising management options is discussed in Section 4.1 and management actions are discussed in Section 4.2. Section 5 details the implementation strategy and provides the Action Plans.

4.1 Developing and Prioritising Management Options

4.1.1 Options Development Process

A total of 40 management options were developed, each of which addresses one or more of the management objectives listed in Table 3.1. The process by which the options were developed is outlined below:

- *Preliminary Options List:* Once the management aims and objectives had been identified, Cardno prepared a preliminary list of 49 management options for discussion with the Committee.
- *Committee Workshop 2:* The preliminary options list was then presented to the Committee for discussion on 18 May 2011. The Committee broke into two groups, each of which discussed a

subset of the full list of preliminary options. As a result of these discussions, the options list was revised to a list of 63 options.

- *Post Workshop Feedback:* Committee members were also provided with an opportunity after the workshop to provide comment on the revised list of 63 management options, and any further amendments to the list of options were made as required based on any further feedback received after the workshop. This resulted in further revision of the management options to a list of 50 management options, resulting from:
  - Two or more overlapping options being combined into a single option,
  - Duplicate options being deleted, and
  - The removal from the list of options that are already being implemented by a local or State authority.

  At this stage, the list of management options were assessed and prioritised in accordance with the methodology outlined in Section 4.1.2.
- *Committee Workshop 3:* Each of the 50 management options was also discussed with the Committee at the third and final workshop on 9 June 2011. At this time, each individual management option was discussed and the Committee agreed on the final option wording and prioritisation. A number of options were re-worded, and in some instances options were combined such that the list was further reduced. At the conclusion of the workshop, the Committee had reached a consensus on a final list of 40 management options, of which 23 were identified as having a high priority.

General feedback provided by the attendees at the Community Information Session on 21 July 2011 was that the options developed addressed what were perceived to be the main issues in the estuary (Appendix B).

4.1.2 Options Assessment and Prioritisation

The goal of the options assessment and prioritisation process was to identify which options would provide the greatest net benefit for the first 5 to 10 year phase of implementation. Once the priority options were identified, more specific management actions were developed (Section 4.2), and these form the implementation strategy in the Plan (Section 5).

The options assessment process included consideration of how the proposed option would impact on the estuary values and how well it would achieve the management objectives and the priority objectives in particular. The assessment criteria against which the management options were assessed included:

- Public access;
- Recreational amenity;
- Cultural heritage;
- Economics;

Socio-economic criteria

- Water and sediments;
- Estuarine ecology; and
- Climate change.

Environmental criteria

Each management option was scored to assess how well it performed against each of the assessment criteria in accordance with the methodology described in Table E.1 of Appendix E. These scores were then summed to calculate a preliminary benefit index with possible values between -27 and +27. The preliminary benefit index was adjusted to account for the objective prioritisations shown in Table 3.1, by summing the preliminary benefit index and the objective prioritisation score to give an adjusted benefit index (to enable this a numerical value was assigned to the objective prioritisation, with High scoring 3, Medium scoring 2 and Low scoring 1). The adjusted benefit index was used to rank the options. The results are presented in Section 4.1.3.

This approach effectively provides a triple-bottom line assessment of the options through the inclusion of environmental, social and economic criteria. It also considers how well each option addresses the management objectives, and whether it addresses a high priority objective.

Further assessment was undertaken of the management actions falling under each option, as outlined in Section 4.2.2, with a view to prioritising the works proposed by each management authority.

4.1.3 Options Assessment Outcomes

Table 4.1 presents the final list of 40 management options, and identifies the 23 high priority options. Tables E.3 and E.4 of Appendix E include the full details of the assessment for each management option, including:

- The option ID number;
- A description of what the option entails;
- The primary management objective addressed by the option;
- Any other management objectives also addressed;
- A score corresponding to the objective prioritisation value allocated to the primary management objective (Table 3.1);
- Scores against the seven assessment criteria (see Section 4.1.2);
- Preliminary benefit index, representing the unadjusted sum of the scores;
- Comments on the potential impacts of not implementing the option (i.e. business as usual);
- Comments on the key advantages of implementation;
- An adjusted benefit index; and
- The resultant overall ranking of the management option.

Some brief notes are also provided in Tables E.3 and E.4 of Appendix E for each option in relation to the main advantages/disadvantages of implementation, and the potential consequences of not implementing the option (i.e. 'business as usual approach').

Table 4.1: Ranked Management Options

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
Land Use Planning and Development					
1	New and revised Plans of Management should be compatible and consistent with the recommendations of the Parramatta River Estuary CZMP.	1A	Increased pressure is being put on the estuary due to large foreshore developments and land use changes as industrial areas are re-developed.	7	Promotes good governance and coordinated and holistic management, which will assist in addressing the currently disjointed management approach across the large catchment area.
2	When undertaking reviews of planning instruments or engaging in strategic land use planning, seek consistency with the Parramatta River Estuary CZMP and, where possible, update the relevant instrument as required.	1A		1	Specific planning controls that promote estuarine health can be incorporated into revised planning instruments. For example, WSUD policies can be updated and/or generated by councils to enforce the application of WSUD principles into planning for all new developments or redevelopments in their LGA.
3	Work with relevant Aboriginal community groups along the Parramatta River to determine management options for identified Aboriginal heritage sites.	1A		24	-
4	Develop provisions under Development Control Plans that provide for the incorporation of best practice WSUD and ecological connectivity along the estuary foreshores for sites subject to redevelopment.	2E	Water and sediment quality within the estuary is generally poor.	2	Provides an avenue to develop biodiversity corridors throughout the estuary, improving connectivity and biodiversity values of the estuary. Similarly for WSUD which will address stormwater management within the catchment. Considering large areas of the foreshore could be subject to redevelopment from industrial to residential land use in the future (similar to Rhodes in the City of Canada Bay), this could improve conditions for a large proportion of the estuary. See Figure 2.3 for current industrial land use locations along the foreshore and historical land use change patterns throughout the estuary.
Water and Sediments					
5	Promote the reporting and enforcement of penalties for illegal dumping on the estuary foreshores and waterway.	2A	Water and sediment quality within the estuary is generally poor.	36	-

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
6	Ensure the prompt removal of waste materials dumped in the estuary or along its foreshores for disposal at a suitably licensed waste management facility.	2A	Much higher sediment loads are entering the estuary than in pre-European times.	36	-
7	Retrofit appropriate WSUD features in existing urban areas of the catchment targeting locations upstream from where stormwater runoff and associated pollutants are impacting sensitive estuary locations.	3A		7	Provides an opportunity to promote good catchment management and to reduce the magnitude of stormwater impacts on the estuary and its tributaries, targeting high priority sensitive estuary locations in the first instance. Examples of WSUD features are shown in Figure 2.9.
8	Modify, upgrade or repair existing SQIDs, stormwater infrastructure and management practices as required to maintain or improve their effectiveness. This should include development of maintenance schedules for existing infrastructure where they are not currently in place.	2B		7	Has the potential to improve water quality in the estuary and its tributaries and to reduce stormwater impacts on bank condition, or where stormwater is causing erosion (e.g. Figure 2.8). Photos of existing SQIDs within the catchment are shown in Figure 2.7.
9	Work with Sydney Water to prioritise maintenance and upgrade of the sewerage network within the catchment on an ongoing basis to reduce sewage overflows. This activity should include investigations into the incidence of illegal private connections to the sewerage and / or stormwater network.	2C		24	-
10	Reduce sediment inputs through bank stabilisation works in estuary tributaries.	2B		14	Would reduce the risk of erosion occurring from the banks of the estuary and its tributaries, and consequently reduce the level of threat to estuarine water quality and ecology due to sedimentation.

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
Estuarine Ecology					
11	Develop and implement a strategy for the coordinated management of estuarine and riparian biodiversity across administrative boundaries for the estuary as a whole. The strategy should incorporate biodiversity corridors and SLR consideration, to ensure the ongoing provision of habitat and connectivity between habitat areas.	4A	There have been historic and ongoing declines in ecological values due to a range of threatening processes.	4	Provides opportunity to undertake strategic planning as an investment in both current and future biodiversity. The option also provides an improved capacity for ecological adaptation throughout the estuary by considering areas where landward migration of vegetation/habitat is viable (see Section 2.3).
12	Minimise impacts of moorings and boating on seagrass.	4A		31	-
13	Manage public access at environmentally sensitive foreshore locations. Priority areas may include key habitat and vegetation communities located in areas that are frequented by the public.	4A		14	This would reduce the risk of impacts on foreshore ecology, with added benefits where public access is also compromising bank condition or causing erosion and sedimentation.
14	Reduce the unauthorised clearing of riparian and estuarine vegetation.	4A		24	-
15	Work with private landholders and bush care groups to encourage and assist in the re-vegetation of foreshore areas, and the management and conservation of existing vegetation. As a priority, target landholders with ecologically significant vegetation present on their land.	4A		24	-
16	Undertake improvements to foreshore infrastructure, where possible, to reduce their impacts on aquatic habitats. Consider the need, where feasible, to relocate or decommission infrastructure where it is impacting on environmentally sensitive locations.	4A		4	Provides an opportunity to strategically manage recreational infrastructure throughout the catchment, while at the same time improving the condition of the natural environment. Failing foreshore infrastructure should be targeted as a priority (e.g. Figure 2.30), especially where this infrastructure currently presents a risk to public safety.

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
17	Undertake works to provide for the ongoing preservation of estuarine and riparian habitats under climate change conditions. This should include the enhancement of existing habitats where there is possibility of retreat, or establishing additional habitat areas as required, to maximise habitat under SLR conditions.	4A		7	These options provide a long term benefit in maintaining and potentially improving the extent of estuarine vegetation. Provides for maintenance of estuarine biodiversity and ecosystem services into the future by considering the potential for landward migration, as discussed in Section 2.3. Examples of habitat restoration works are shown in Figure 2.24.
18	Manage identified public foreshore areas where they are required for the retreat of estuarine vegetation in response to SLR.	4A		7	
19	Undertake creek naturalisation works of existing channelised creeks, focusing as a priority on channels coming to the end of their design life.	4B		14	Provides an opportunity to provide improved ecological value within estuary creeks and to potentially incorporate WSUD features into creek naturalisation works.
20	Undertake ongoing monitoring and management of aquatic and terrestrial weeds (incl. noxious weeds) and introduced species (both flora and fauna).	4C		14	This would reduce the risk to estuarine biodiversity throughout the catchment by reducing the threats associated with introduced species. Also has the potential to increase the extent and condition of existing habitat areas.
21	Improve the environmental value of existing seawalls through the addition of habitat, where feasible.	4D		14	This option has the potential to increase the extent of estuarine habitat by incorporating the principles of the *Environmentally Friendly Seawalls Guidelines* (DECC and SMCMA, 2009) when retrofitting and/or replacing seawalls (e.g. Figure 2.17).
Bank Condition					
22	Formally negotiate with Harbour City Ferries for a change in vessel (from the RiverCat) that would have less wake impacts.	5A	Erosion is impacting on bank stability and riparian vegetation in a number of locations.	14	This option would assist in reducing the extent/magnitude of bank erosion caused by the RiverCat wake, resulting in improved bank condition. It would also reduce the rate of loss/damage to intertidal vegetation and seawalls caused by the RiverCat wake.
23	Encourage bank and foreshore erosion control techniques that maximise the use of riparian and estuarine vegetation.	5B		14	Provides the potential to improve the condition and increase the extent of estuarine vegetation, improving ecological connectivity throughout the catchment.

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
24	All management authorities involved in the building, design and approval of new seawalls, or major upgrades of existing seawalls, should promote their compliance with the *Environmentally Friendly Seawalls Guidelines* (DECC and SMCMA, 2009) within legislative constraints.	6B	Seawalls line a substantial proportion of the Parramatta River estuary and have led to a significant loss of foreshore habitat. Much of this infrastructure is dated and the need for maintenance and repair is likely to further increase with SLR.	14	Potential to increase the extent of estuarine habitat, or at least reduce the rate of loss of intertidal habitat, through incorporation of the principles of *Environmentally Friendly Seawalls Guidelines* (DECC and SMCMA, 2009) when retrofitting and/or replacing seawalls (e.g. Figure 2.17).
Human Usage and Recreation					
25	Maintain and improve existing public access (i.e. bike and walking paths) for the Parramatta River estuary to provide transport linkages throughout the LGAs, giving consideration to sensitive environmental locations.	7A	Accessibility of the foreshore, as well as the availability and suitability of recreational facilities is not consistent across the estuary, particularly in the context of residential development of former industrial sites along the foreshores.	14	The primary benefit is in providing improved connectivity, public access and recreational amenity throughout the estuary. Value added benefits include reduced vehicle emissions and improved public health within the catchment.
26	Repair or upgrade existing foreshore facilities identified as failing or as being in poor condition in the *Estuary Processes Study* (AECOM, 2010) as funding opportunities allow.	7B		31	-
27	Continue to conduct surveillance and compliance monitoring with a view of removing or regulating unauthorised foreshore structures / uses.	7B		41	-
28	Strategically provide foreshore infrastructure to support boating in the Parramatta River estuary, with due consideration of any potential impacts on the estuary.	7B		24	-
29	Develop and implement an integrated approach to the provision of recreational amenity for the estuary as a whole.	7B		14	Provides the potential to improve recreational amenity throughout the estuary, while also reducing any negative impacts on the environment.
30	Provide viewing points and interpretive signage at appropriate locations to promote an appreciation of the estuary and enhance the visitor experience.	7B		24	-

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
31	Work with the key stakeholders to develop and implement a vision for the Parramatta River estuary that delivers world-class facilities for both residents and visitors. The vision should recognise the regional, State and Federal significance of the Parramatta River as an iconic waterway.	7C		31	-
32	Work together to develop and implement a program for industry and the community to raise awareness of issues relating to estuary management and estuarine health. Key elements of the program could include: - Good catchment management practices; - The heritage significance of the estuary and its foreshores; - The types of activities that are permitted, or are not permitted, in different parts of the foreshore or waterway; - The use of vegetation for bank and foreshore protection works; - The potential impacts of climate change on the estuary; and - How individuals can reduce their impact on the estuary.	2B	Water and sediment quality within the estuary is generally poor.	2	Provides opportunity to raise community awareness and promote good catchment management practices to reverse the decline in ecological values of the estuary due to human activities. Also provides the potential to improve overall estuarine health with a whole-of-community effort.
Monitoring, Evaluation and Reporting					
33	Develop and implement a communication strategy for the implementation stage of the Parramatta River Estuary CZMP.	8A	There is currently no baseline information on estuary health, nor are there coordinated monitoring programs within the Parramatta River estuary.	7	Provides the opportunity to promote estuary management, educate the community about estuary issues, and attract people to the estuary.
34	Develop and implement a holistic and rigorous monitoring program that coordinates the efforts of the various stakeholders responsible for management of the Parramatta River estuary and includes monitoring of climate change impacts.	8A		4	Provides the opportunity to establish standardised baseline information and track trends in estuarine health. This may also enable comparison against similar estuaries in NSW. This option promotes holistic and coordinated adaptive management, addressing the currently disjointed management approach.

Option ID	Option Description	Primary Objective Addressed	Corresponding Management Issue(s)	Option Ranking (Blue = HIGH PRIORITY)	Additional Comments (High Priority Options Only)
35	Encourage DPI (Fisheries) to periodically map the distribution of estuarine vegetation (seagrass, saltmarsh and mangroves) for the estuary.	8A		34	-
Coastal Hazards					
36	Within the regular program of upgrades, provide additional capacity in the stormwater network to account for changes in rainfall patterns and elevated estuary water levels under climate change conditions.	10A	The Parramatta River estuary foreshore is subject to coastal hazards such as storm surge that will increase with climate change and have the potential to negatively impact on public and private assets.	36	-
37	Restrict new foreshore developments in areas where tidal inundation hazards under current and future SLR scenarios are quantified.	10A		36	-
38	Manage foreshore infrastructure with likely tidal inundation risk in such a way as to allow adaptation to SLR.	10A		36	-
39	Assess the potential impacts of SLR on the estuary foreshores.	10A		7	Provides information to assist strategic, long term planning of the estuary foreshores and waterway as existing risks due to coastal hazards may increase under climate change conditions.
40	Identify cultural heritage sites that are currently affected by coastal hazards or that may be affected by coastal hazards under climate change conditions, and develop appropriate management responses to address these issues.	9A	There is a need for improved education of the community and other stakeholders in relation to estuary processes and their linkages to catchment processes. There is also a need to improve communication and reporting on estuary management initiatives.	34	-

4.2 Detailed Management Actions

The options assessment process identified which options would provide the greatest net benefit for the first phase of implementation of the Parramatta River Estuary CZMP. The Committee then developed a series of more detailed management actions that addressed the high priority management options, representing the individual activities that are undertaken by the various Committee members to implement that option. These actions form the implementation strategy in the Plan (Section 5).

4.2.1 Actions Development Process

A preliminary list of management actions was developed by the Cardno study team to stimulate discussion at the third Committee workshop held on 9 June 2011. Initially the study team and the Committee discussed the following key points for consideration when developing actions:

- Does the action address one (or more) of the high priority management options?
- Is the proposed action realistic, technically feasible and achievable? Is it likely that there are sufficient resources available for commencement within the first period of implementation (next 5 to 10 years)?
- How does the proposed action fit in with existing plans, strategic documents or other initiatives being undertaken by the Committee members?
- What specific actions proposed within the *Estuary Processes Study* (AECOM, 2010) would be appropriate for inclusion in the Plan?
- Who should be responsible for implementation of the action? Where a single authority is taking primary responsibility, is any support or information required from other Committee members?
- Is the action location specific?
- Is there a need for any ground-truthing or other investigations required to develop the action? Alternatively, does this need to be noted for further consideration at the implementation stage?

The Committee then worked through those preliminary draft management actions proposed by Cardno that were identified for implementation by the Committee as a whole, and suggested any amendments required. A number of new actions for the Committee were also proposed. This was a useful discussion for the purpose of identifying related initiatives being conducted by the various attendees. After the conclusion of the workshop, Cardno circulated the list of actions for implementation by the Committee for further comment by the members and amendment as required.

At the workshop the attendees were also encouraged to develop a list of up to five management actions for their own agency or authority. This was considered to be a reasonable and realistic number of activities for the first period of implementation. It was suggested that the various local councils and other authorities refer in the first instance to the actions proposed within the *Parramatta River Estuary Processes Study* (AECOM, 2010). After the workshop, Cardno supported the Committee members in developing suitable management actions for implementation by their organisation. This involved a number of emails, telephone conversations and, in some cases, a meeting with the organisation.

Most authorities included within their list of management actions some of those suggested in the *Estuary Processes Study* (AECOM, 2010), and where necessary built on these by including additional management

actions that either aligned well with other initiatives being conducted by their organisation or that they otherwise considered a priority. In other cases, a management action was developed to assist in implementation of the Plan or to address a knowledge gap. There were also a number of instances in which the action was developed to ensure the aims and objectives of the Plan are communicated through their organisation, or are progressed via initiatives undertaken by other organisations.

Technical feasibility was considered in a qualitative fashion at the actions development stage. Based on the information provided, it was considered that none of the management actions developed were technically infeasible, noting that in some instances more detailed, quantitative investigations would be required to confirm that this is the case.

The community was provided with opportunity to comment on the draft management actions proposed for their local area at the information session held on 21 July 2011. The feedback received indicated that they were supportive of the proposed actions and felt that they addressed the key management issues they had observed in their local areas.

4.2.2 Action Descriptions and Prioritisation

Actions Description

A total of 67 management actions were developed, including 21 actions for implementation by the Committee as a whole. Appendix F contains the full list of unranked management actions grouped under their relevant options. The following information is provided for each management action in Appendix F (Tables F.1 and F.2) and Section 5:

- A unique identification number;
- A description of the action;
- Primary responsibility for implementation and supporting organisations (where relevant);
- Location for implementation (where relevant);
- Management category (see below);
- Notes on implementation and decommissioning (as required);
- A brief summary of the key anticipated environmental and social impacts (both positive and negative) of the actions;
- Scores against the three action assessment criteria (see Table E.2 in Appendix E);
- Relevant management options score;
- Benefit index, representing the unadjusted sum of the scores and the management option score;
- Indicative cost of implementation (capital and ongoing costs);
- Net present value for each action;
- Cost:benefit ratio for each action; and
- The resultant overall ranking of the management action (from 1 to 67).

In addition to these 67 prioritised actions a further 16 management actions were identified as generic actions of significant benefit or high priority that may be implemented by any council or authority in the event the necessary resources become available. These generic actions have been provided as a stand-alone list as they cannot be costed or prioritised along with the other actions in the strategy.

Management Categories

As indicated above, each action was also assigned a management category corresponding roughly to the general organisational structure found within local councils and those other organisations responsible for implementation. They include:

- *Planning* – These actions provide for development of a planning instrument, regulation, policy or guideline, plan of management, or similar;
- *Investigations* – Actions falling under this category relate to further studies, surveys or investigations. This includes actions that may then lead on to specific works or other activities;
- *Works* – These actions involve maintenance or actual on the grounds works (e.g. construction of a footpath or WSUD feature). This includes actions that may be phrased as investigations, but that are likely to be implemented or for which sufficient detail was available to cost construction;
- *Monitoring* – Actions falling within this category provide for some type of monitoring activity; and
- *Communications/Education* – Relevant actions relate to information dissemination or awareness raising on estuary management issues, activities or the results of monitoring. This category may also include actions that relate to liaison with other authorities to progress specific programs or activities.

Indicative Cost of Implementation

Preliminary indicative costs of implementation were also developed for each management action, including a capital cost and annually recurrent costs (e.g. for maintenance or ongoing implementation). A Net Present Value is then calculated based on these costings, representing a cost of implementation over the first period of implementation. The Net Present Value has assumed a 10 year period of implementation and has adopted a discount rate of 7%.

The costings were calculated based on experience on similar projects and/or information provided by the Committee members. Where possible, brief notes have been provided as to the factors considered in developing the costings (Section 5.1). It is noted that these costings are indicative only and further detailed costings should be prepared prior to implementation of an action. Further information may become available over time that would change the costings significantly.

Actions Prioritisation

The options assessment and prioritisation process (Section 4.1) considered how well each management option addressed the management objectives (Section 3) based on consideration of the potential environmental and socio-economic impacts of the option. This allowed the Committee to objectively prioritise the management options, and identify areas on which to focus management initiatives in the first period of implementation that would provide the greatest net benefit to estuarine condition/health.

However, the management actions provide a higher level of detail, and it was considered that it would be useful to further consider the specific constraints and opportunities associated with each action in order to assist the

implementation process. Furthermore, it was recommended that the management actions be prioritised to assist the Committee members in allocating resources for implementation.

The actions prioritisation was based on a cost:benefit index calculated based on a function of the cost of implementation (represented by the Net Present Value) and the benefit index. The benefit index is based on the sum of scores provided in relation to:

- The likely compatibility of the management action with the statutory and non-statutory framework;
- The potential for the land tenure status of the subject site (where known) to necessitate landowner consent or require additional consultation;
- The likely community acceptance, which has been assessed by the study team based on the feedback provided by the community during the course of the project; and
- The ranking of the corresponding management option under which the action falls (see Tables F1 and F2 in Appendix F for full details).

The scores applied to each of these criteria and data sources used to inform the scoring are identified in Table E.2 in Appendix E.

The cost:benefit index was then used to prioritise the management actions for each responsible group/authority; the higher the cost:benefit index, the higher the priority. The outcomes of this process are presented as an implementation strategy in Section 5.

5 IMPLEMENTATION STRATEGY AND ACTION PLANS

5.1 Implementation Strategy

The full list of prioritised management actions has been developed into an implementation strategy that forms the basis of the Parramatta River Estuary CZMP. There are a total of 67 management actions in the strategy, of which 21 are to be progressed by the Committee as a whole. The remaining 46 management actions are the responsibility of individual authorities. It should be noted that implementation of these actions are dependent on suitable funding and internal resources being available within the individual organisations. In addition, a further 16 management actions were identified as generic actions of significant benefit or high priority that may be implemented by any council or authority in the event the necessary resources become available. These generic actions have been provided as a stand-alone list as they cannot be coasted or prioritised along with the other actions in the strategy.

Where possible, the management actions have also been mapped and the corresponding GIS (Geographic Information System) file provided to the relevant authority responsible for implementation. The locations of management actions have been mapped using GIS layers prepared for the *Estuary Processes Study* (AECOM, 2010) where relevant, and also GIS layers created by Cardno.

5.1.1 Cost of Implementation

The estimated capital cost of implementation of the Plan is $19.4 million, with an estimated $1.6 million in annually recurrent costs over an assumed ten year period of implementation (corresponding to the first period of implementation). The cost of implementation has been broken down for the different authorities in Table 5.1.

For some actions, the capital cost relates to preparation of a plan, an investigation or time for a staff member to progress an activity (project management). In other cases, the capital cost involves on the ground works, which is highly variable depending upon the specific project. The annually recurrent costs may relate to ongoing project management, maintenance or an annual budget for implementation of a staged strategy.

Table 5.1: Preliminary Indicative Cost of Implementation of the Implementation Strategy

Authority	Estimated Capital Cost	Estimated Annually Recurrent Cost
Ashfield Council	$ 300,000	$ 4,000
Auburn City Council	$ 78,750	$ 10,525
City of Canada Bay	$ 4,193,375	$ 20,900
City of Ryde	$ 1,312,918	$ 15,686
Hunters Hill Council	$ 395,000	$ 416,125
Leichhardt Municipal Council	$ 2,218,150	$ 45,700
Parramatta City Council	$ 575,000	$ 97,000
Strathfield Council	$ 5,237,250	$ 125,876
RMS (Maritime)	$ 290,000	$ 7,000
SOPA	$ 10,000	$ 134,500
Sydney Water	$ 2,289,275	$ 163,063
Committee	$ 2,473,000	$ 516,500
TOTAL	$19,372,838	$1,556,875

As of 11 April 2013, the OEH website states that projects which can be subsidised under the coastal and estuary management programs include:

- Preparation (or updating) of CZMPs and associated technical studies (including coastal hazard assessments);
- Action to manage the risks from coastal hazards;
- Action to implement environmental repairs, including habitat restoration and conservation projects;
- Pre-construction activities for projects that are eligible and are likely to proceed to construction; and
- Development of management tools (such as education projects).

Funding of up to 50% of a project's costs may be provided to successful grant applicants.

Other sources of grant funding include:

- NSW Government Environment Trust and Heritage Grants Program;
- NSW DP&I's Metropolitan Greenspace Program, Planning Reform Fund, and Sharing Sydney Harbour Access Program;
- NSW DPI Habitat Action Grants;
- RMS (Maritime)'s Better Boating Program; and
- Australian Government's Caring for Our Country Program and Stormwater Harvesting and Reuse grants.

Organisations like the HNCMA also play a role in working with local councils and community groups to undertake natural resource management projects.

5.1.2 Sub-Plans

In order to support the implementation strategy and identify where activities are proposed, a series of sub-plans have been developed, including Action Plans and 'Process' Sub-Plans. The Action Plans developed are discussed further and provided in Section 5.2.

A series of A3 'Process' Sub-Plans (provided in Appendix G) have been developed to map those management actions for each of the processes listed below. These Sub-Plans are useful for showing in a more holistic fashion the spatial distribution of different types of activities across the study area:

- Land Use Planning and Development (Figures F.1A and B),
- Water and Sediments (Figures F.2A to D),
- Estuarine Ecology (Figures F.3A to C),
- Bank Condition (Figures F.4A and B), and
- Human Usage and Recreation (Figures F.5A and B).

5.2 Action Plans

In order to support the implementation strategy and identify where activities are proposed, a series of Action Plans have been developed as sub-plans.

An Action Plan has been prepared for each authority consisting of a table listing the actions for implementation and capital and annually recurrent costs. Where possible, an A3 sized plan has also been provided that maps any location specific actions. The Action Plans can be easily separated out from the main report and used to progress implementation of each authority's management actions. One Action Plan has been developed for each of the 11 authorities as well as the Committee:

- Ashfield Municipal Council (2 actions);
- Auburn Council (2 actions);
- City of Canada Bay (5 actions);
- City of Ryde (5 actions);
- Hunters Hill Council (5 actions);
- Leichhardt Municipal Council (5 actions);
- Parramatta City Council (5 actions);
- Strathfield Council (5 actions);
- RMS (Maritime) (4 actions);
- SOPA (4 actions);
- Sydney Water (4 actions); and
- Committee (21 actions).

Action Plan tables for the above-listed authorities are provided in Tables 5.2 to 5.13, respectively, while Action Plan maps are provided in Figures 5.1 to 5.10, with the exception of RMS (Maritime) and the Committee where no map has been prepared due to a lack of site-specific actions.

Note that the Committee has an overarching responsibility to progress the Plan and support its members in implementing actions for which they are responsible.

In addition a further 16 management actions were identified as generic actions. As previously discussed, these generic actions have been provided as a stand-alone list. The Action Plans for the additional 16 General Actions are provided in Table 5.14.

Table 5.2: Ashfield Municipal Council Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
21_ASH2	Utilise data collected for all seawalls, including referenced site photographs, as a benchmark for ongoing monitoring and in particular continue to monitor the seawall identified in AECOM (2010) as ASH_S03 for any decrease in structural stability. Include intertidal habitat, such as artificial reefs, in the eventual repair and / or replacement of seawalls.	Ashfield Council	Haberfield	Monitoring and Works	For purposes of costing, assume replacement seawalls identified as being in poor condition in AECOM (2010) in addition to monitoring.	$260,000	Design, EIA, tender, project management, site establishment. Develop monitoring framework & systems.	$4,000	Annual maintenance of seawalls, plus regular monitoring.	$288,094	0.37	1
8_ASH1	In conjunction with Leichhardt Municipal Council, City of Canada Bay and Sydney Water, undertake a critical review of existing stormwater management practices to determine: - The efficacy of maintenance regimes of existing GPTs, and - Identify locations where additional gross pollutant trapping is required. Include a review of current street sweeping activities in catchment areas draining to Iron Cove Bay, given that the dominant gross pollutant evident is leaf litter. Reference should be made to AECOM (2010) for further discussion of the issues relevant to this action.	Ashfield Council Leichhardt Municipal Council, City of Canada Bay, Sydney Water	Iron Cove Catchment	Investigation		$40,000		$ -		$40,000	0.87	2

Action Plan - Ashfield Municipal Council

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

CONCORD
CANADA BAY
CANADA BAY
FIVE DOCK
RODD POINT
Iron Cove Bay
Haberfield Foreshore
LILYFIELD
BURWOOD
BURWOOD
CROYDON
LEICHHARDT
Iron Cove Catchment
ASHFIELD
ASHFIELD
BURWOOD HEIGHTS
SUMMER HILL
STANMORE
STANMORE
PETERSHAM
LEWISHAM
CROYDON PARK
ASHBURY
CANTERBURY
DULWICH
CAMPSIE
CANTERBURY
HURLSTONE PARK

Action 21_ASH2

Utilise data collected for all seawalls, including referenced site photographs, as a benchmark for ongoing monitoring and in particular continue to monitor the seawall identified in AECOM (2010) as ASH_S03 for any decrease in structural stability. Include intertidal habitat, such as artificial reefs,in the eventual repair and / or replacement of seawalls.

Action 8_ASH1

Undertake a critical review of existing stormwater management practices to determine:
- The efficacy of maintenance regimes of existing GPTs, and
- Locations where additional gross pollutant trapping is required.

Include a review of current street sweeping activities in catchment areas draining to Iron Cove Bay, given that the dominant gross pollutant evident is leaf litter.
Undertake in conjunction with Leichhardt Municipal Council, City of Canada Bay and Sydney Water.

Legend

- Ashfield LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.1

N
W E
S

1:16,000 Scale at A3

Metres
0 200 400 600 800

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5001_ActionsAshfield 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial Imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers.

Table 5.3: Auburn Council Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
10_AUB2	Undertake bank stabilisation works with natural materials and vegetation in Duck River, along approximately a 20-30m reach adjacent to the Auburn Botanic Gardens and approximately a 50m reach adjacent to Mona Park.	Auburn City Council	Duck River	Works		$26,250	Design, EIA, tender, project management, site establishment. Install sandstone bank protection (200mm high, 50m long retaining wall) including footings, and restoration as required to surrounding area.	$525		$29,937	0.89	1
7_AUB1	Investigate the installation of a GPT or WSUD feature within Mona Park, Auburn, to treat stormwater discharging into Duck River.	Auburn City Council	Auburn	Works	For purposes of including a realistic budgetary estimate within the Plan, this has been costed assuming installation of a GPT.	$52,500	Feasibility, design, EIA, tender, project management, site establishment. Supply and install GPT, including connection to existing drainage, and discharge erosion protection as required.	$10,000	Annual maintenance of GPT.	$122,736	0.79	2

Action Plan - Auburn City Council

PARRAMATTA RIVER ESTUARY COASTAL ZONE MANAGEMENT PLAN

Legend

- Auburn LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.2

N
W E
S

1:28,000 Scale at A3

Metres

0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5002_ActionsAuburn 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial Imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers.

Table 5.4: City of Canada Bay Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
17_CAN3	Undertake enhancement of estuarine vegetation as a stabilisation method in areas of erosion, and to protect existing seawalls from further erosion. Locations as identified in the *Estuary Processes Study* (AECOM, 2010) include: Hen and Chicken Bay, Sisters Bay, Half Moon Bay, Five Dock Bay and Iron Cove Bay.	City of Canada Bay	City of Canada Bay	Works		$ -		$2,500	Annual budget for vegetation management (noting that the effort will decrease over time as the vegetation becomes established).	$17,559	1.18	1
2_CAN1	Liaise with the NSW Government to progress the remediation of Kendall Bay and others and seek appropriate rezoning to W2 - Environmental Protection Zone.	City of Canada Bay	Kendall Bay	Comms		$ -		$400	Assumes 0.05 FTE hours per week for 6 months.	$2,809	1.16	2
8_CAN2*	Develop and commence a staged implementation program from the City of Canada Bay Stormwater Drainage Asset Management Plan. The implementation program should incorporate activities that aim to reduce the potential impacts of climate change and SLR on stormwater drainage.	City of Canada Bay	City of Canada Bay	Planning	Opportunities to reduce vulnerability of the stormwater drainage system to climate change impacts may be achieved more cost effectively in a progressive fashion, although some activities may be more suitable for implementation once a trigger has been reached.	$50,000		$ -		$50,000	1.06	3
21_CAN4	Develop and commence a staged implementation program from the *City of Canada Bay Estuary Foreshore Management Strategy* to include environmentally friendly seawalls as key options for seawall and foreshore management, where reasonable and feasible. Continue to monitor the condition of seawall sections identified in the *Estuary Processes Study* (AECOM, 2010) and prioritise in accordance with the *City of Canada Bay Asset Management Plan* (2010) to ensure structural integrity. As a priority, repair and/or upgrade existing seawall sections along Abbotsford Bay (CAN_S28) and Five Dock Bay (CAN_S23).	City of Canada Bay	City of Canada Bay	Planning, Works and Monitoring	For purposes of costing, assumes replacement the two seawall sections identified.	$3,265,875	Design, EIA, tender, project management, site establishment. Upgrade seawalls.	$16,000	Assume 0.2 FTE hours.	$3,378,252	0.46	4
23_CAN5	Repair and/or upgrade sections of seawall, natural shoreline and adjacent affected infrastructure around Iron Cove, including the following sections identified in the *Estuary Processes Study* (AECOM, 2010), avoiding the use of artificial structures where reasonable and feasible: CAN_S03, CAN_S04, CAN_S06, CAN_NS01 and CAN_NS02. Seawall upgrades should, where possible, be designed in accordance with the DECC and SMCMA (2009) *Guidelines for Environmentally Friendly Seawalls*.	City of Canada Bay	Iron Cove Bay	Works		$877,500	Design, EIA, tender, project management, site establishment. Upgrade seawalls.	$2,000		$891,547	0.67	5

Action 8_CAN2

Develop and commence a staged implementation program from the City of Canada Bay Stormwater Drainage Asset Management Plan. The implementation program should incorporate activities that aim to reduce the potential impacts of climate change and sea level rise on stormwater drainage.

Action 17_CAN3

Undertake enhancement of estuarine vegetation as a stabilisation method in areas of erosion, and to protect existing seawalls from further erosion. Locations as identified by AECOM (2010) include: Hen and Chicken Bay, Sisters Bay, Half Moon Bay, Five Dock Bay and Iron Cove Bay.

Action 23_CAN5

Repair and/or upgrade sections of seawall, natural shoreline and adjacent affected infrastructure around Iron Cove, including those sections identified by AECOM (2010) CAN_S03, CAN_S04, CAN_S06, CAN_NS01 and CAN_NS02), avoiding the use of artificial structures where reasonable and feasible. Seawall upgrades should, where possible, be designed in accordance with the DECC (2009) Guidelines for Environmentally Friendly Seawalls.

Action 2_CAN1

Liaise with the NSW Government to progress the remediation of Kendall Bay and seek appropriate rezoning to W2 - Environmental Protection Zone.

Action 21_CAN4

Develop and commence a staged implementation program from the City of Canada Bay Estuary Foreshore Management Strategy to include environmentally friendly seawalls as key options for seawall and foreshore management. Continue to monitor the condition of seawall sections identified in AECOM (2010) and prioritise in accordance with the City of Canada Bay Asset Management Plan (2010) to ensure structural integrity. As a priority, repair and/or upgrade existing seawall sections along Abbotsford Bay (CAN_S28) and Five Dock Bay (CAN_S23).

EAST RYDE
LANE COVE WEST
LANE COVE
RYDE
LANE COVE
RIVERVIEW
AUBURN
HOMEBUSH BAY
PUTNEY
GLADESVILLE
LINLEY POINT
RHODES
LONGUEVILLE
HUNTLEYS
MORTLAKE
Kendall Bay and Breakfast Point
HENLEY
LIBERTY GROVE
BREAKFAST POINT
CONCORD WEST
SOPA
CABARITA
CAN_S28
Five Dock Bay
ABBOTSFORD
CHISWICK
CAN_S23
DRUMMOYNE
Hen and Chicken Bay
CONCORD
WAREEMBA
Sisters Bay
NORTH STRATHFIELD
RUSSELL LEA
CAN_NS02
Half Moon Bay
CAN_S04
ROZELLE
HOMEBUSH
Iron Cove Bay
CANADA BAY
RODD POINT
STRATHFIE
FIVE DOCK
LEICHHARDT
LILYFIELD
CROYDON
ASHFIELD
ASHFIELD
LEICHHARDT
LEICHHARDT

Action Plan - City of Canada Bay Council

PARRAMATTA RIVER ESTUARY COASTAL ZONE MANAGEMENT PLAN

Legend

- Canada Bay LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.3

N
W E
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1:25,000 Scale at A3

Metres
0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (COE)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5003_ActionsCanadaBay 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers

Table 5.5: City of Ryde Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
7_RYD3	Investigate the potential for installing a SQID at Meadowbank Lane, Meadowbank.	City of Ryde	Meadowbank	Works	Works would be subject to available funding. Potential treatment area of 40,000m^2.	$220,000	Design, EIA, tender, project management, site establishment, construction.	$3,000	Annual maintenance	$241,071	1.11	1
7_RYD2	Investigate the potential for installing irrigation and bioretention systems at Peel Park in Gladesville to provide improved treatment of stormwater flows entering the estuary from the site.	City of Ryde	Gladesville	Works	Works would be subject to feasibility studies and available funding. Peel Park has a potential treatment area of 150m^2.	$114,375	Feasibility, design, EIA, tender, project management, site establishment, construct bioretention treatment area.	$4,575	Annual maintenance of features.	$146,508	0.97	2
23_RYD5	Rehabilitate the following two sections of eroding foreshore identified as being of a high priority and in poor condition in the *Estuary Processes Study* (AECOM, 2010), subject to available funding: - RYD-NS07 (Kissing Point Park, Putney), and - RYD-NS13 (Meadowbank, adjacent to rail bridge).	City of Ryde	City of Ryde	Works		$55,125	Design, EIA, tender, project management, site establishment. Rehabilitate foreshore.	$1,103		$62,872	0.83	3
7_RYD1	Investigate the potential for installing irrigation and bioretention systems at Anzac Park in West Ryde to provide improved treatment of stormwater flows entering the estuary from the site.	City of Ryde	West Ryde	Works	Works would be subject to feasibility studies and available funding. Anzac Park has a potential bioretention system catchment area of 3,100m^2 and treatment area of 67m^2. There is also a potential underground tank catchment area of 14,000m^2 and treatment area of 20m^2 for irrigation purposes.	$83,438	Feasibility, design, EIA, tender, project management, site establishment, construction bioretention treatment area, excavate and construct below ground tank.	$3,008	Annual maintenance of features.	$104,565	0.80	4
21_RYD4	Upgrade and / or repair the following four sections of seawall identified as being in poor condition and of a high priority in the *Estuary Processes Study* (AECOM, 2010) and seek to incorporate additional vegetated habitat in the design, subject to available funding: RYD-S06, RYD-S11, RYDS03 & RYD-S23. Continue to monitor the condition of other seawall sections identified in the *Estuary Processes Study* (AECOM, 2010) for any decrease in structural stability.	City of Ryde	City of Ryde	Works and Monitoring	For purposes of costing, assumes replacement the two seawall sections identified, as well as monitoring.	$840,000	Design, EIA, tender, project management, site establishment, upgrade seawalls. Develop monitoring framework and systems.	$4,000	Annual maintenance of seawalls, plus regular monitoring.	$868,094	0.34	5

Action 7_RYD3
Investigate the potential for installing a SQID at Meadowbank Lane, Meadowbank.

Action 7_RYD1
Investigate the potential for installing irrigation and bioretention systems at Anzac Park in West Ryde to provide improved treatment of stormwater flows entering the estuary from the site.

Action 21_RYD4
Upgrade or repair the four sections of seawall (RYD-S06, RYD-S11, RYDS03 and RYD-S23) identified as being in poor condition and of a high priority in the Estuary Processes Study (AECOM, 2010). Seek to incorporate additional vegetated habitat in the design, subject to available funding. Continue to monitor the condition of other seawall sections identified in the Estuary Processes Study for any decrease in structural stability.

Action 7_RYD2
Investigate the potential for installing irrigation and bioretention systems at Peel Park, Gladesville to provide improved treatment of stormwater flows entering the estuary from the site.

Action 23_RYD5
Rehabilitate the following two sections of eroding foreshore identified as being of a high priority and in poor condition in the Estuary Processes Study (AECOM, 2010), subject to available funding:
- RYD-NS07 (Kissing Point Park, Putney), and
- RYD-NS13 (Meadowbank, adjacent to rail bridge).

DENISTONE
DENISTONE WEST
NORTH RYDE
Anzac Park
WEST RYDE
EAST RYDE
RYDE
RYDE
MELROSE PARK
PARRAMATTA
MEADOWBANK
RYD-NS13
RYD-S23
RYD-S11
PUTNEY
HUNTERS HILL
GLADESVILLE
RYD-NS07
Peel Park
RHODES
RYD-S06
TENNYSON POINT
HUNTERS HILL
HOMEBUSH BAY
AUBURN
HUNTLEYS COVE
SOPA
CONCORD WEST
MORTLAKE
HENLEY
BREAKFAST POINT
CANADA BAY
CABARITA
RYD-S03
ABBOTSFORD
CANADA BAY
CONCORD
CHISWICK

Action Plan - City of Ryde

PARRAMATTA RIVER ESTUARY COASTAL ZONE MANAGEMENT PLAN

Legend
- Ryde LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.4

N
W E
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1:20,000 Scale at A3

Metres
0 250 500 750 1,000

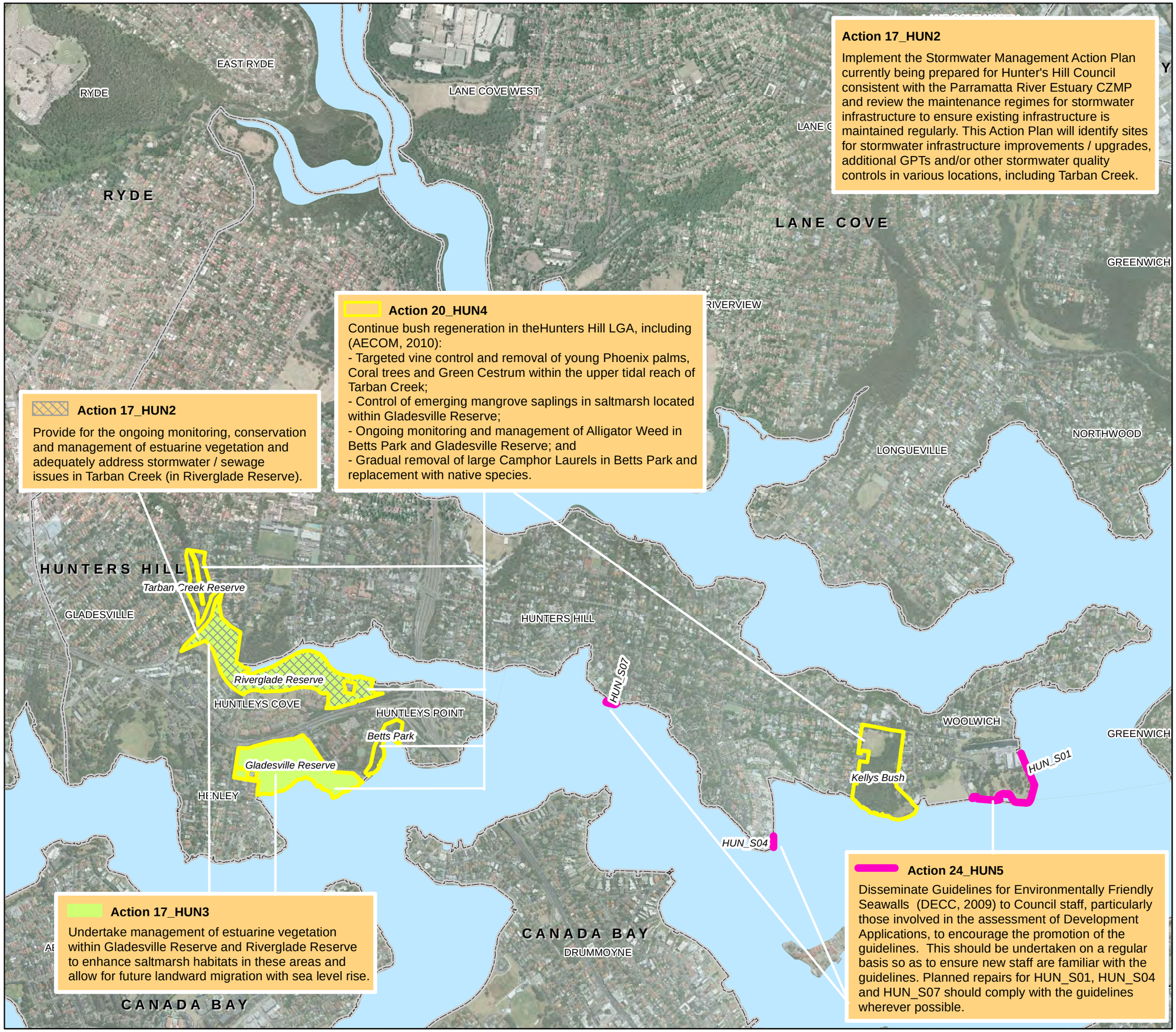
Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5004_ActionsRyde 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers

Table 5.6: Hunters Hill Council Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
1_HUN1	Implement the *Stormwater Management Action Plan* currently being prepared for Council consistent with the CZMP and review the maintenance regimes for stormwater infrastructure to ensure existing infrastructure is maintained regularly and adequately. This Action Plan will identify sites for stormwater infrastructure improvements / upgrades, additional GPTs and/or other stormwater quality controls in various locations, including Tarban Creek.	Hunters Hill Council	Hunters Hill LGA	Planning and Works	Relies on completion of the Action Plan for implementation.	$50,000	For review of existing maintenance regimes.	$250,000	Budget for implementation will depend on the strategy defined in the Action Plan. Current costings provide an indicative annual budget for implementation.	$1,805,895	0.80	1
24_HUN5	Disseminate the *Guidelines for Environmentally Friendly Seawalls* (DECC and SMCMA, 2009) to council staff, particularly those involved in the assessment of DAs, to encourage the promotion of the guidelines. This should be undertaken on a regular basis so as to ensure new staff are familiar with the guidelines. Make sure the planned repairs to the following seawalls comply with the guidelines wherever possible: HUN_S01, HUN_S04 & HUN_S07.	Hunters Hill Council OEH	Hunters Hill LGA	Comms	Costing assumes internal communication only.	$ -		$1,500	Assume one week of staff members time for liaison with internal staff.	$10,535	0.75	2
17_HUN3	Undertake management of estuarine vegetation within Gladesville Reserve and Riverglade Reserve to enhance saltmarsh habitats in these areas and allow for future landward migration with SLR.	Hunters Hill Council	Gladesville Reserve, Riverglade Reserve	Works	May require assessment of potential SLR impacts on the Reserves. Reference is made to linked actions 34_COM22 & 39_COM23.	$ -		$50,000	Assumed annual budget for implementation of activities identified in the relevant Estuary Vegetation Rehabilitation & Management Plans.	$351,179	0.72	3
20_HUN4	Continue bush regeneration in all reserves of the Parramatta River estuary catchment located within Hunters Hill LGA, including undertaking the following recommendations made in the *Estuary Processes Study* (AECOM, 2010): - Targeted vine control and removal of young Phoenix palms, Coral trees and Green Cestrum within the upper tidal reach of Tarban Creek; - Control of emerging mangrove saplings in saltmarsh located within Gladesville Reserve; - Ongoing monitoring and management of Alligator Weed in Betts Park and Gladesville Reserve; and - Gradual removal of large Camphor Laurels in Betts Park and replacement with native species.	Hunters Hill Council	Hunters Hill LGA	Works		$ -		$50,000	Assumes annual salary for 0.4 FTE hours for Bushcare coordinator & budget for materials as required.	$351,179	0.72	3

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
17_HUN2	Provide for the ongoing monitoring, conservation and management of estuarine vegetation and adequately address stormwater / sewage issues in Tarban Creek (in Riverglade Reserve).	Hunters Hill Council	Tarban Creek	Monitoring and Works	Reference is made to AECOM (2010) for a discussion on issues currently impacting Tarban Creek & management recommendations.	$345,000	Design, EIA, tender, project management, site establishment. Install leaf traps & GPTs, provide erosion protection. Bank rehabilitation upstream of pedestrian bridge. Remediation of weir controlling flows to the wetland.	$64,625	Includes 0.05 FTE hours for one staff member & annual maintenance /monitoring / works costs.	$798,899	0.68	4



Action Plan - Hunters Hill Council

PARRAMATTA RIVER ESTUARY COASTAL ZONE MANAGEMENT PLAN

Legend

- Hunters Hill LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.5

N W E S

1:16,000 Scale at A3

Metres

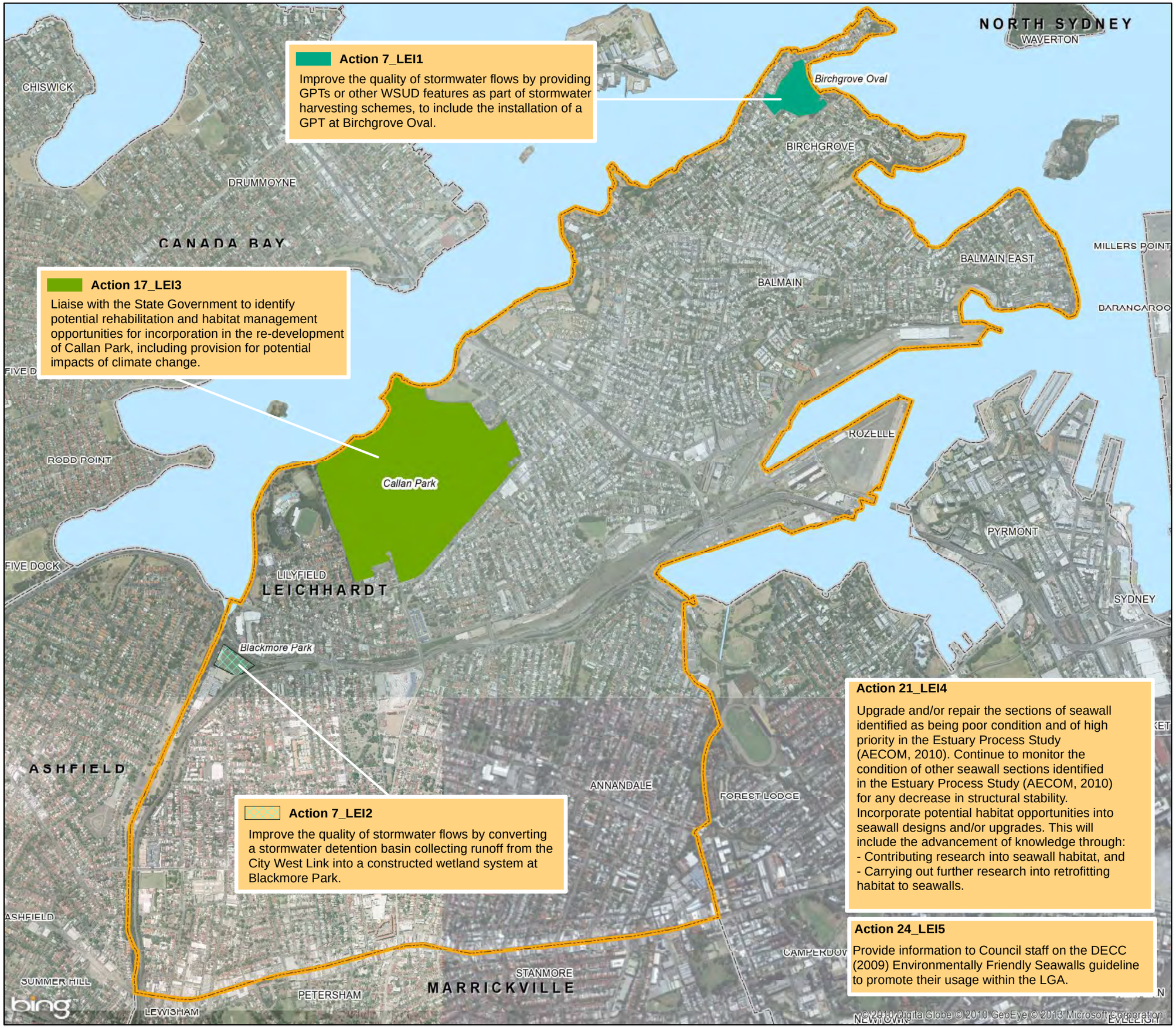
0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5005_ActionsHuntersHill 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial Imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers.

Table 5.7: Leichhardt Municipal Council Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
17_LEI3	Liaise with the State Government to identify potential rehabilitation and habitat management opportunities for incorporation in the re-development of Callan Park, including provision for potential impacts of climate change.	Leichhardt Municipal Council	Callan Park	Comms	May include the incorporation of habitat features within seawalls proposed for upgrading, as well as other activities relating to management of open space.	$ -		$4,000	Assume 0.1 FTE hours for a staff member for five years.	$28,094	1.12	1
24_LEI5	Provide information to Council staff on the DECC and SMCMA (2009) *Guidelines for Environmentally Friendly Seawalls* to promote their usage within the LGA.	Leichhardt Municipal Council OEH, HNCMA	Leichhardt LGA	Comms		$ -		$1,500	Assume one week of staff members time for liaison with internal staff.	$10,535	0.99	2
7_LEI2	Improve the quality of stormwater flows by converting a stormwater detention basin collecting runoff from the City West Link into a constructed wetland system at Blackmore Park.	Leichhardt Municipal Council	Leichhardt LGA	Works	Works located on RMS Land. Approval and MOUs required. RMS have provided in principle support.	$283,150	Detailed design and construction.	$10,000	Annual maintenance	$353,386	0.72	3
7_LEI1	Improve the quality of stormwater flows by providing GPTs or other WSUD features as part of stormwater harvesting schemes, to include the installation of a GPT at Birchgrove Oval.	Leichhardt Municipal Council	Leichhardt LGA	Works	Based on an average project cost as reported for the Sustaining the Parramatta River project.	$705,000	Investigation into options, design, EIA, tender, project management, site establishment, implement water quality system.	$28,200	Annual maintenance of features.	$903,065	0.67	4
21_LEI4	Upgrade and/or repair the sections of seawall identified as being poor condition and of high priority in the *Estuary Process Study* (AECOM, 2010). Continue to monitor the condition of other seawall sections identified in the *Estuary Process Study* (AECOM, 2010) for any decrease in structural stability. Incorporate potential habitat opportunities into seawall designs and/or upgrades. This will include the advancement of knowledge through: - Contributing research into seawall habitat and - Carrying out further research into retrofitting habitat to seawalls.	Leichhardt Municipal Council	Leichhardt LGA	Works	For purposes of costing, assume replacement seawalls identified as being in poor condition or failing in AECOM (2010).	$1,230,000	Design, EIA, tender, project management, site establishment. Upgrade seawalls.	$2,000		$1,244,047	0.33	5



Action Plan - Leichhardt Municipal Council

PARRAMATTA RIVER ESTUARY COASTAL ZONE MANAGEMENT PLAN

Legend

- Leichhardt LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.6

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1:18,000 Scale at A3

Metres
0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5006_ActionsLeichhardt 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial Imagery supplied by Sydney Metropolitan Catchment Management Authority, Bing and associated third party suppliers.

Table 5.8: Parramatta City Council Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
8_PAR1	Investigate the efficacy of existing water quality controls and review maintenance regimes for stormwater infrastructure across the Parramatta LGA.	Parramatta City Council	Parramatta LGA	Investigation	This action is likely to require the collation of data and potentially the acquisition of additional data. It is recommended that the analysis and reporting be linked to mapping in GIS.	$75,000		$ -		$75,000	1.03	1
25_PAR5	Facilitate the incorporation of public access into new and existing developments with due consideration of sensitive estuarine environments and ecological values.	Parramatta City Council	Parramatta LGA	Planning	Will likely involve both internal communications & adoption of a collaborative approach with developers through the DA/master planning process.	$ -		$8,000	Assume 0.1 FTE hours. Note: Cost to be born as part of normal operations under existing council budget.	$56,189	0.63	2
18_PAR2	If possible, purchase land upslope of the Baludarri Wetlands and Eric Primrose Reserve, to allow for landward migration of the ecosystems at this location caused by the long term effects of SLR.	Parramatta City Council	Parramatta LGA	Planning	Potential for migration should be confirmed prior to implementation via ground-truthing and supported by SLR mapping.	$400,000		$ -		$400,000	0.54	3
25_PAR4	Improve public access along the foreshore by investigating the feasibility of Shared Paths. A shared pedestrian and cycle bridge connecting Morton St and Alfred St, Parramatta, and a Shared Path from Pike St to South St have been previously identified as being high priority.	Parramatta City Council	Parramatta LGA	Works		$100,000	For investigations & design work.	$39,000		$373,920	0.36	4
21_PAR3	As seawalls in the Parramatta LGA need to be repaired or upgraded this should be done in compliance with the DECC and SMCMA (2009) *Guidelines for Environmentally Friendly Seawalls* and should incorporate habitat creation opportunities wherever possible. Note: at the time of writing of this report all Parramatta Council owned seawalls have been repaired to "good" standard. However, some funds will be required annually to inspect and repair these seawalls into the future.	Parramatta City Council	Parramatta LGA	Works	For purposes of costing, assume replacement seawalls identified as being in poor condition in AECOM (2010).	$ -		$50,000		$351,179	0.36	4

Action Plan - Parramatta City Council

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

Action 18_PAR2

If possible, purchase land upslope of the Baludarri Wetlands and Eric Primrose Reserve, to allow for landward migration of the ecosystems at this location caused by the long term effects of sea level rise.

Action 8_PAR1

Investigate the efficacy of existing water quality controls and review maintenance regimes for stormwater infrastructure across the Parramatta LGA. (LGA-wide, not mapped).

Action 21_PAR3

As seawalls in the Parramatta LGA need to be repaired or upgraded this should be done in compliance with the DECC (2009) Guidelines for Environmentally Friendly Seawalls and should incorporate habitat creation opportunities wherever possible. Note: at the time of writing of this report all Parramatta Council owned seawalls have been repaired to "good" standard. However, some funds will be required annually to inspect and repair these seawalls into the future. (LGA-wide, not mapped).

Action 25_PAR5

Facilitate the incorporation of public access into new and existing developments with due consideration of sensitive estuarine environments and ecological values. (LGA-wide, not mapped). Note: The cost of implementation is provided for under Councils existing budget.

Action 25_PAR4

Improve public access along the foreshore by investigating the feasibility of Shared Paths.
A shared pedestrian and cycle bridge connecting Morton St and Alfred St, Parramatta,and a Shared Path from Pike St to South St have been previously identified as being high priority.

Legend

- Parramatta LGA
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.7

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W E
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1:44,000 Scale at A3

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Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5007_ActionsParramatta 03.mxd 02
Data Source: LPMA (LGAs, suburbs, waterways)
Imagery supplied by Bing and associated third party suppliers.

Table 5.9: Strathfield Council Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
1_STR1	Review and update the Plans of Management for Mason and Bressington Park to incorporate consideration of the impacts of SLR on vegetation.	Strathfield Council	Strathfield LGA	Planning	Outcomes of implementation will be dependent on ongoing commitment over a longer period of time. Those elements of the Plans relating to accommodating SLR should provide some capacity to adapt to changes in SLR projections/observations.	$26,000	Assumes GIS based analysis of potential inundation extents & review of action plans / lists.	$ -		$26,000	0.91	1
17_STR3	Provide for the ongoing monitoring, conservation and management of saltmarsh, swamp oak floodplain forest and mangrove communities in the Mason Park wetlands to enhance estuarine habitats in these areas and allow for their future landward migration with SLR (e.g. weed control).	Strathfield Council	Mason Park	Planning	It has been assumed that this action provides for strategic support & management planning to support the existing works program. Reference should be made to AECOM (2010) for a discussion on vegetation management relating to Mason Park.	$ -		$50,000	Assumed annual budget based on allowance for control of weeds & mangrove seedlings, monitoring vegetation extents, propagation & transplantation of saltmarsh species.	$351,179	0.90	2
25_STR5	Seek to improve public access linkages to and along the estuary foreshores by preparing a draft pedestrian / cycleway plan that takes into consideration existing and proposed infrastructure in the Strathfield LGA. As a priority activity under the CZMP, undertake works along Powells Creek to improve cycleway connectivity with public transport.	Strathfield Council	Strathfield LGA	Planning and Works	Implementation should consider the need to link in with existing transport services & other pathways both within the Strathfield LGA & beyond. Reference is made to the Powells Creek Masterplan.	$3,820,000	For purposes of costing incl. development of a strategy and construction of up to 5km cycleway across 5 sites.	$50,000	Cycleway maintenance, review plan regularly.	$4,171,179	0.30	3
19_STR4	Undertake naturalisation of approximately 150m of the western wall of Boundary Creek, south from the end of Mandemar Avenue, Homebush West, if investigations indicate this is feasible.	Strathfield Council	Homebush West	Works	Detailed design should consider potential flood impacts. Ongoing maintenance will be critical to the long term success of these projects.	$101,250	Design, EIA, tender, project management, site establishment. Naturalisation of creek incl. removal of existing channel if required, weed control, preparation or soil for planting, planting & establishment of selected species.	$3,375		$124,955	0.59	4
13_STR2	Manage public access and/or off-leash dog walking near the Mason Park wetlands. Managing public access may involve formalising a walking trail, prohibiting access or installing signage to indicate appropriate activities.	Strathfield Council	Mason Park	Works	Consultation with the community may be required as to selection of a preferred option.	$1,290,000	Design, EIA, tender, project management, site establishment. Construct path, reinstating surrounding disturbed area as required. Install fencing as required around sensitive areas to prevent access. Provide signage.	$22,501		$1,448,038	0.49	5

Action Plan - Strathfield Council

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

SILVERWATER
NEWINGTON
LIBERTY GROVE
SOPA
HOMEBUSH BAY
CONCORD WEST
AUBURN
Bressington Park
Powells Creek
Mason Park
CONCORD
LIDCOMBE
NORTH
Boundary Creek
HOMEBUSH
STRATHFIELD
BURWOOD
STRATHFIELD
BURWOOD

Action 1_STR1

Review and update the Plans of Management for Mason and Bressington Park to incorporate consideration of the impacts of sea level rise on vegetation.

Action 25_STR5

Seek to improve public access linkages to and along the estuary foreshores by preparing a draft pedestrian / cycleway plan that takes into consideration existing and proposed infrastructure in the Strathfield LGA. As a priority activity under the CZMP, undertake works along Powells Creek to improve cycleway connectivity with public transport.

Action 13_STR2

Manage public access and/or off-leash dog walking near the Mason Park wetlands. Managing public access may involve formalising a walking trail, prohibiting access or installing signage to indicate appropriate activities.

Action 17_STR3

Provide for the ongoing monitoring, conservation and management of saltmarsh, swamp oak floodplain forest and mangrove communities in the Mason Park wetlands to enhance estuarine habitats in these areas and allow for their future landward migration with sea level rise (e.g. weed control).

Action 19_STR4

Undertake naturalisation of approximately 150m of the western wall of Boundary Creek, south from the end of Mandemar Avenue, Homebush West, if investigations indicate this is feasible.

Legend

- Strathfield LGA
- LGA Boundaries
- Waterways

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS dataprovided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.8

N
W E
S

1:15,000 Scale at A3

Metres
0 200 400 600

Cardno

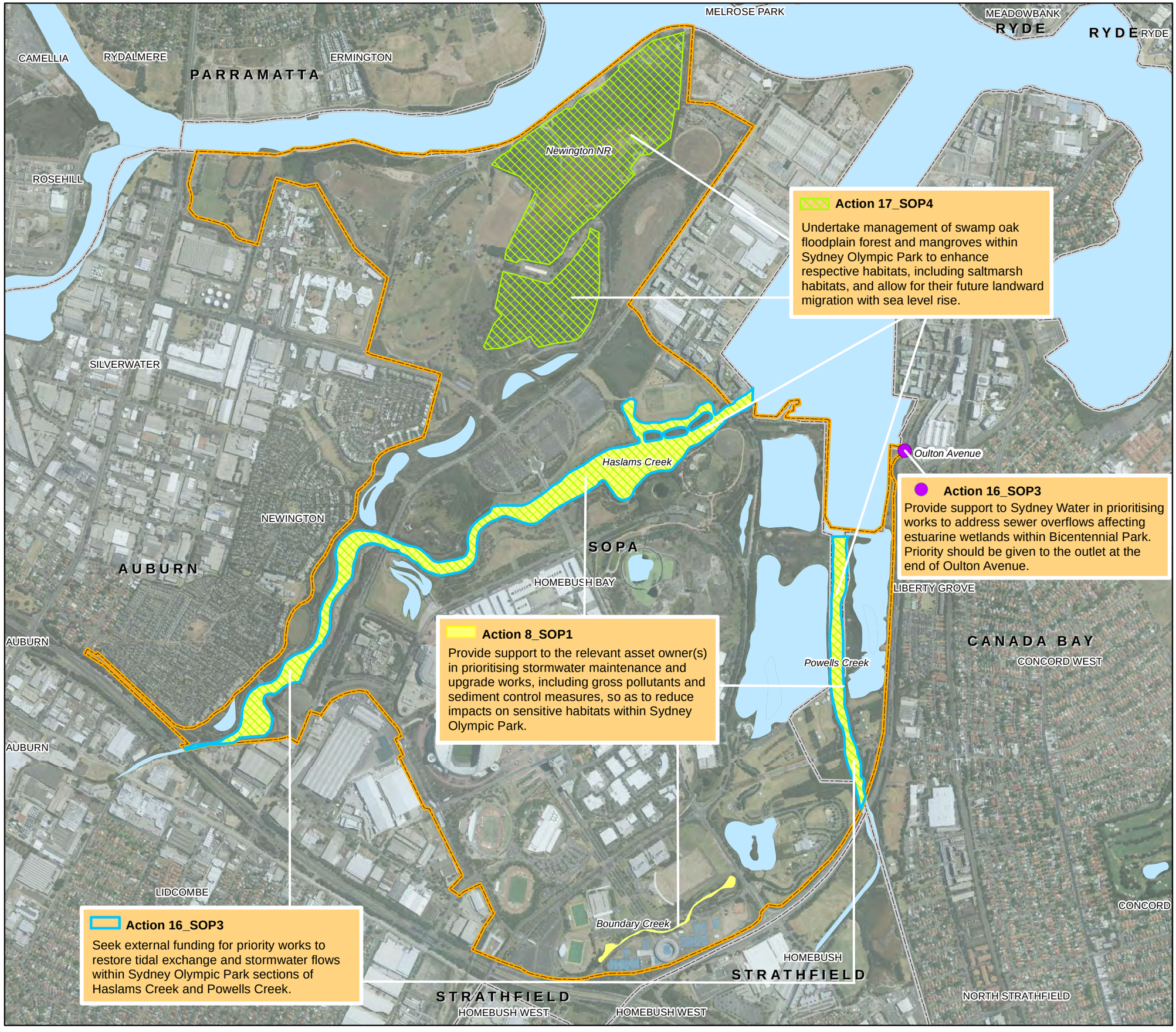
Map Produced by Cardno NSW/ACT Pty Ltd (COE)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5008_ActionsStrathfield 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers

Table 5.10: RMS (Maritime) Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
16_MAR2	Endorse the use of environmentally friendly moorings in the Parramatta River estuary.	RMS (Maritime)	Waterway-wide	Comms	This action will likely require some internal communications/education activities to ensure implementation.	$5,000	Develop a guidance note.	$1,500	Assumes total of one week of a staff member's time over a year to promote seagrass friendly moorings.	$15,535	0.95	1
29_MAR4	Continue to encourage infrastructure improvements for recreational boating facilities through the Better Boating Program.	RMS (Maritime)	Waterway-wide	Planning	This action should also consider environmentally friendly features or approaches to providing facilities.	$ -		$4,000	Assume 0.05 FTE hours.	$28,094	0.45	2
12_MAR1*	Subject to further investigation, consider the reconfiguration of moorings where they are impacting on (or have the potential to impact on) seagrass beds. This action should be informed by the Estuary Processes Study (AECOM, 2010).	RMS (Maritime)	Waterway-wide	Works	This action may be undertaken opportunistically or in a targeted fashion.	$285,000	Identification, project management, site establishment, relocate moorings. Assumes 5% of 1,764 moorings require relocation.	$ -		$285,000	0.73	3
24_MAR3	Liaise with the Department of Planning and Infrastructure to include reference to the *Guidelines for Environmentally Friendly Seawalls* (DECC and SMCMA, 2009) as part of the *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* review.	RMS (Maritime) OEH	Waterway-wide	Planning		$ -		$1,500		$10,535	1.24	4

Table 5.11: Sydney Olympic Park Authority Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
8_SOP1	Provide support to the relevant asset owner(s) in prioritising stormwater maintenance and upgrade works, including gross pollutants and sediment control measures, so as to reduce impacts on sensitive habitats within Sydney Olympic Park.	SOPA	Sydney Olympic Park	Comms		$ -		$ 3,000	Assumes total of two weeks of a staff member's time over a year.	$21,071	1.16	1
17_SOP4	Undertake management of swamp oak floodplain forest and mangroves within Sydney Olympic Park to enhance respective habitats, including saltmarsh habitats, and allow for their future landward migration with SLR.	SOPA	Sydney Olympic Park	Planning	It has been assumed that this action provides for strategic support and management planning to support the existing works program.	$ -		$130,000	Assume 1.0 FTE staff member & operational budget of $50,000 p.a.	$913,066	0.84	2
16_SOP3	Seek external funding for priority works to restore tidal exchange and stormwater flows within Sydney Olympic Park sections of Haslams Creek and Powells Creek.	SOPA	Sydney Olympic Park	Works	Feasibility investigations should consider impacts on catchment flooding and potential future SLR impacts.	$10,000	Prepare funding applications, liaison with relevant organisations.	$ -		$10,000	1.00	3
9_SOP2	Provide support to Sydney Water in prioritising works to address sewer overflows affecting estuarine wetlands within Bicentennial Park.	SOPA Sydney Water	Bicentennial Wetlands	Comms		$ -		$1,500	Assumes total of one week of a staff member's time over a year.	$10,535	1.24	4



Action Plan - Sydney Olympic Park Authority

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

Legend

- SOPA Boundary
- LGA Boundaries
- Waterway

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

FIGURE 5.9

N
W E
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1:15,000 Scale at A3

Metres

0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (COE)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5009_ActionsSOPA 03.mxd 02
Data source: NSW Land and Property Information (LPI)
Aerial Imagery supplied by Sydney Metropolitan Catchment Management Authority and associated third party suppliers.

Table 5.12: Sydney Water Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
19_SYD3	Investigate the potential for channel naturalisation of the following five channels as they require asset renewal and/or replacement: - SWC 50 Powells Creek - SWC 18 Brickfield Creek - SWC 53 Dobroyd - SWC 90 St Lukes Park - SWC 95 Whites Creek. Any future channel naturalisation projects would be subject to feasibility studies and landowner consent.	Sydney Water	Catchment-wide	Works	Detailed design should consider potential flood impacts. Ongoing maintenance will be critical to the long term success of these projects.	$1,426,875	Design, EIA, tender, project management, site establishment. Removal of existing channel if required, removal of foreign species, preparation or soil for planting, planting of selected species, & upkeep & protection during establishment.	$47,563		$1,760,938	0.64	1
16_SYD2	Ensure that new stormwater infrastructure is designed to appropriately mitigate the impacts of scour on estuarine habitats.	Sydney Water	Catchment-wide	Comms	This action will likely require some internal communications / education activities to ensure implementation.	$5,000	Develop an internal guidance note.	$3,000	Review of designs, assume 2 weeks of a staff member's time per year.	$26,071	1.13	2
7_SYD1	Investigate the potential for installing additional stormwater quality improvement devices (SQIDs) to provide improved treatment of stormwater flows entering the estuary at the 11 locations indicated, within the following stormwater channels: - SWC 92 Tarban Creek - SWC 55 Johnsons Creek - SWC 62 Hawthorne Canal - SWC 53 Dobroyd - SWC 50 Powells Creek - SWC 13 Haslams Creek - SWC 86 Sefton Park - SWC 27 Clay Cliff Creek - SWC 42 Finalysons Creek.	Sydney Water	Catchment-wide	Works	The installation of any future SQIDs would be subject to feasibility studies and landowner consent.	$457,500	Investigation into options, design, EIA, tender, project management, site establishment, buy & install SQID, site restoration.	$110,000	Annual maintenance of structure.	$1,230,094	0.82	3
19_SYD4	In consultation with Strathfield Council and the City of Canada Bay, consider the addition of tide gates along Powells Creek to increase the flushing of the Mason Park wetlands, subject to feasibility studies. If Powells Creek stormwater channel (SWC 50) is to be naturalised these works should occur concurrently, if possible and subject to feasibility studies.	Sydney Water Strathfield Council, City of Canada Bay	Mason Park	Works	Feasibility investigations should consider impacts on catchment flooding and potential future SLR impacts.	$ 400,000	Design, EIA, tender, project management, site establishment, installation of a tide gate. See also cost as listed in Mason Park PoM.	$2,500		$417,559	0.53	4

Action 19_SYD4
In consultation with Strathfield Council and the City of Canada Bay, consider the addition of tide gates along Powells Creek to increase the flushing of the Mason Park wetlands, subject to feasibility studies. If Powells Creek stormwater channel (SWC 50) is to be naturalised these works should occur concurrently, if possible and subject to feasibility studies.

Action 7_SYD1
Investigate the potential for installing additional stormwater quality improvement devices (SQIDs) to provide improved treatment of stormwater flows entering the estuary at the 11 locations indicated, within the following stormwater channels:
- SWC 92 Tarban Creek
- SWC 55 Johnsons Creek
- SWC 62 Hawthorne Canal
- SWC 53 Dobroyd
- SWC 50 Powells Creek
- SWC 13 Haslams Creek
- SWC 86 Sefton Park
- SWC 27 Clay Cliff Creek
- SWC 42 Finalysons Creek

Action 19_SYD3
Investigate the potential for channel naturalisation of the following five channels as they require asset renewal and/or replacement:
- SWC 50 Powells Creek
- SWC 18 Brickfield Creek
- SWC 53 Dobroyd
- SWC 90 St Lukes Park
- SWC 95 Whites Creek

Any future channel naturalisation projects would be subject to feasibility studies and landowner consent.

Action 16_SYD2
Ensure that new stormwater infrastructure is designed to appropriately mitigate the impacts of scour on estuarine habitats. (Catchment-wide)

Legend
- LGA Boundaries
- Parramatta River

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:50,000 Scale at A3

Kilometers
0 1 2 3 4

Action Plan - Sydney Water

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 5.10

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G5010_ActionsSydneyWater 03.mxd 01
Data Source: LPMA (LGAs, suburbs, waterways)
Imagery supplied by Bing and associated third party suppliers.

Table 5.13: Committee Action Plan

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
8_COM04	Liaise with RMS (Maritime) to encourage the ongoing collection of gross pollutants from the estuary waterway.	Committee	Waterway-wide	Comms		$ -		$1,500	Assumes total of one week of a staff member's time per year.	$10,535	1.49	1
2_COM02	Consult with the NSW Department of Planning and Infrastructure to develop a model LEP clause for inclusion into the statutory planning framework that provides for consideration of issues such as foreshore building lines, riparian setbacks and public access. Encourage inclusion by Councils into their standard instrument LEPs.	Committee	Catchment-wide	Planning		$ -		$1,200	Assumes 0.05 FTE hours / week over 3 years.	$8,428	1.27	2
4_COM03	In consultation with the NSW Department of Planning and Infrastructure, develop model DCP clauses for more specific aspects of estuarine management, such as: - Environmentally friendly seawalls; - Site-based WSUD; - Stormwater retention, harvesting and re-use; - Foreshore inundation/flooding (including from SLR); - Biodiversity corridors and habitat conservation; - Public access; and - Riparian setbacks. Encourage inclusion by local Councils in their DCPs.	Committee OEH, HNCMA	Catchment-wide	Planning		$ -		$ 1,200	Assumes 0.05 FTE hours / week over 3 years.	$8,428	1.27	3
22_COM08	In order to mitigate the impacts of the RiverCat on seawalls, bank condition and fringing vegetation along large sections of the shoreline, open the dialogue and formally negotiate with Harbour City Ferries for a change in vessel that has lower vessel wake impacts.	Committee	Waterway-wide	Comms	Refer to linked action 22_COM09.	$ -		$1,600	Assume 0.1 FTE staff member over 2 years.	$11,238	1.23	4
33_COM16	Develop and implement a communication strategy utilising the PRCG website for the implementation stage of the Parramatta River Estuary CZMP to update the general public each time an action is being progressed or is completed. Encourage all organisations on the Committee to provide links on their web pages and in regular publications (i.e. newsletters) to the PRCG website, with a view to promoting the estuary and disseminating information about the progress of the CZMP.	Committee	N/A	Comms	Refer to Section 6 of the CZMP on KPIs and reporting.	$ 5,000	Develop strategy.	$10,000	Assume 2 week of a staff members time per year, plus graphic design as required.	$75,236	1.23	5

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
17_COM07	Work with local Councils and other land managers that are responsible for developing and implementing Plans of Management to ensure that they provide for the landward retreat (where feasible) of all significant saltmarsh, swamp oak floodplain forest and mangrove communities. Issues to be addressed in the Plans of Management include the protection and enhancement of the communities, and provision for areas for landward retreat.	Committee	Catchment-wide	Planning	The Committee's role in implementation will likely involve technical advice and review, and should be supported by HNCMA and OEH.	$ -		$4,000	Assumes 0.05 FTE hours for staff member per year	$28,094	1.12	6
34_COM18	Undertake annual reporting to the PRCG and the community on trends in estuarine health for the Parramatta River estuary. Estuarine health report cards should be prepared quarterly and published on the PRCG website. Reporting on trends in estuarine health should be undertaken in accordance with the recommendations made with respect to monitoring and evaluation within the Parramatta River Estuary CZMP.	Committee OEH	N/A	Monitoring	Refer to Section 6 of the CZMP.	$ -		$50,000	Annual reporting, including both an annual report & quarterly report cards.	$351,179	1.08	7
32_COM14	Develop and implement an education strategy targeting key groups, such as school groups and foreshore landowners. Where possible use existing educational materials, such as the: - PRCG's program *Growers for Greenspace*, which aims to promote the protection and enhancement of biodiversity corridors; or the - Environmentally friendly seawalls guideline (DECC and SMCMA, 2009), which could be provided to foreshore landowners submitting applications for new seawalls or seawall upgrades.	Committee	Catchment-wide	Comms	It is recommended that this action target these key groups in the first instance.	$15,000	Develop strategy, collate existing materials.	$6,000	Printing and distribution of brochures & liaison; assume 0.05 FTE hours per year.	$57,141	1.05	8
11_COM06	Support the PRCG Biodiversity Sub-Committee to develop a biodiversity corridors strategy for the Parramatta River catchment area. Work with State agencies and other stakeholders for this Strategy to be recognised within planning and development frameworks including LEPs and DCPs, DA assessments and Plans of Management. Encourage on-ground rehabilitation works undertaken within these areas to support the biodiversity corridors concept.	Committee	Catchment-wide	Planning	This action will require consultation with the NSW Department of Planning and Infrastructure on development of standard clauses for LEPs and DCPs. Reference should be made to linked actions 2_COM02 and 4_COM04.	$ -		$8,000	Assume 0.1 FTE hours for staff member per year.	$56,189	1.05	9

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
34_COM20	Liaise with OEH about opportunities for installation and operation of permanent automatic water level gauges on the Parramatta River estuary.	Committee OEH	Waterway-wide	Monitoring	This is an important activity for improving our understanding of how tidal and flood flows impact on estuarine hydrodynamics, and also in terms of monitoring for the potential impacts of climate change. With respect to the latter, a long term data set would be required, and therefore it is recommended that the gauges be installed as a priority activity.	$60,000	Design, EIA, tender, project management, site establishment. Install 3 gauges.	$4,500		$91,606	1.01	10
25_COM11	Liaise with Harbour City Ferries and the RMS to encourage them to incorporate environmentally friendly features into their designs for new (or upgraded) ferry wharf access ways and bike paths (respectively). As part of the design and site selection process, due consideration should be given to the protection and enhancement of riparian zones, biodiversity corridors and estuarine vegetation.	Committee	Catchment-wide	Comms	Existing guideline documents and other supporting materials should be used where possible.	$ -		$1,500	Assume one week of staff members time per year for liaison with internal staff.	$10,535	0.99	11
1_COM01	Encourage the development or review of Plans of Management for all fresh water and saltwater wetlands in the PRCG area, focusing initially on high and medium priority wetlands identified in the HNCMA Wetlands Prioritisation process in the PRCG area, specifically: - Newington Nature Reserve Wetland (*Plan of Management for Newington Nature Reserve*, 2003), - Bicentennial Park (*Plan of Management for The Parklands at Sydney Olympic Park*, 2010), and - Upper Duck River 1 and 2 (*Upper Duck River Riparian and Wetland Plan of Management* - funded by HNCMA and to be completed 2012).	Committee SOPA, Auburn City Council	Catchment-wide	Planning		$88,000		$4,000	Encourage councils to undertake/update PoMs for wetlands in the PRCG area.	$116,094	0.99	12
34_COM17	Implement an estuarine health monitoring program for the Parramatta River estuary in accordance with the recommendations of the CZMP, and the requirements of the NSW MER Strategy, that coordinates the monitoring activities undertaken by the various stakeholders, including the *Sydney Harbour Catchment Water Quality Improvement Plan* data coordinated by the HNCMA.	Committee OEH	Catchment-wide	Monitoring	Refer to the recommendations on monitoring and evaluation in Section 6 of the CZMP. Linked actions include 32_COM16 and 34_COM20.	$50,000	Detailed design of monitoring program, establish frameworks.	$200,000	Based on cost of implementation of the Georges River monitoring program, relies on substantial volunteer support.	$1,454,716	0.97	13
34_COM19	Undertake a review of the Parramatta River Estuary CZMP every 5 to 10 years.	Committee	N/A	Planning	Refer to Sections 6 and 7 of the CZMP.	$ -		$35,000		$245,825	0.93	14

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
22_COM09	Liaise with Harbour City Ferries on opportunities to mitigate the impact of RiverCat wash on the foreshore and, where feasible, rehabilitate impacted areas.	Committee	Waterway-wide	Comms	Refer to linked action 22_COM08.	$ -		$38,000	Assume 0.1 FTE hours for a staff member & $30,000 for rehabilitation costs per year.	$266,896	0.92	15
32_COM15	Continue to coordinate the provision and maintenance of educational and prohibited activities signage at appropriate locations around the estuary by the local councils.	Committee	Catchment-wide	Comms		$75,000	Graphic design, tender & install 8 new signs in first year.	$40,000	Replacement or installation of up to 5 signs per year, plus maintenance.	$355,943	0.90	16
25_COM12	Coordinate the efforts of the relevant local Councils (Parramatta, City of Ryde and Hunters Hill) to extend the Parramatta Valley Cycleway Shared Path to the end of the Parramatta River estuary (near Cockatoo Island).	Committee Parramatta City Council, City of Ryde, Hunters Hill Council	Catchment-wide	Comms		$ -		$4,000	Assume 0.05 FTE hours per year.	$28,094	0.90	17
23_COM10	Collate and distribute guidelines to Councils and foreshore landowners on best practice bank and foreshore erosion control and rehabilitation techniques that promote the use of riparian and estuarine vegetation.	Committee	Catchment-wide	Comms		$5,000	Collate and update as required existing materials.	$6,000	Printing and distribution of brochures & liaison; assume 0.05 FTE hours per year.	$47,141	0.86	18
29_COM13	Address recreational needs across the catchment in a two-step process as follows: 1) Conduct a recreational needs analysis that incorporates the DP&I's Accessing Sydney Harbour Policy and RMS (Maritime)'s Better Boating Policy, and 2) Develop and implement a strategy for the integrated management of recreational amenity across administrative boundaries for the estuary as a whole, giving consideration to: - The need to maintain and improve access and address safety issues (e.g. installation of safety barriers where appropriate); - Liaison between local Councils; and - Identification of priorities for management.	Committee	Catchment-wide	Planning		$150,000	Undertake needs analysis and prepare strategy.	$ -		$150,000	0.77	19
39_COM21	When updating the CZMP, consider the implications of the coastal hazard assessment (Section 2.5 & Appendix C) for management.	Committee	Catchment-wide	Planning	Refer to Section 2.5 & Appendix C of the CZMP, which contains the CHA report.	$25,000	Review and refinements to the CHA incorporating new data obtained.	$ -		$25,000	0.68	20

Action ID	Action Description	Primary Responsibility Supporting Organisation	Location(s)	Management Category	Notes on Implementation and Decommissioning (as required)	Preliminary Indicative Capital Cost	Capital Cost Comments	Preliminary Indicative Annually Recurrent Cost	Annually Recurrent Cost Comments	Net Present Value	Cost:Benefit Ratio	Priority
10_COM05	Councils and the Committee should liaise with the HNCMA to prioritise and implement bank stabilisation works, focusing on upper catchment areas, based on the findings of the HNCMA's *Waterways Health Strategy* (EarthTech, 2007). The following recommendations from the Strategy are based on a desktop study only and must be ground-truthed prior to implementation: 1) Revegetate riparian zone, particularly focusing on riverbank stabilisation through revegetation for the Parramatta River main channel left hand bank between the confluence with Duck River downstream to the eastern extent of George Kendall Riverside Park, 2) Revegetate riverbanks and riparian zone on both banks of the Girraween Creek (between Great Western Highway and the western Railway line), 3) Revegetate riverbanks and riparian zone on both banks of the Lalor Creek (between M7 to confluence with Blacktown Creek), and 4) Revegetate riverbanks and riparian zone along the whole creek length of Archer Creek.	Committee	Catchment-wide	Works	Feasibility investigations, including ground-truthing required prior to implementation.	$2,000,000	Investigation into options (feasibility studies), design, EIA, tender, project management, site establishment, & revegetate sites.	$100,000	Maintenance requirements will reduce over time as plants become established.	$2,702,358	0.62	21

Table 5.14: Generic Action Plan

Generic Action ID*	Action Description	Management Category
Land Use Planning and Development: When undertaking reviews of planning instruments or engaging in strategic land use planning, seek consistency with the Parramatta River Estuary CZMP and, where possible, update the relevant instrument as required. Primary Objective Addressed: 1A		
2_GEN01	Consult with the NSW Department of Planning and Infrastructure to develop a model LEP clause for inclusion into the statutory planning framework that provides for consideration of issues such as foreshore building lines, riparian setbacks and public access. Councils to incorporate into their standard instrument LEPs.	Planning
Land Use Planning and Development: Develop provisions under Development Control Plans that provide for the incorporation of best practice WSUD and ecological connectivity along the estuary foreshores for sites subject to re-development. Primary Objective Addressed: 2E		
4_GEN02	In consultation with the NSW Department of Planning and Infrastructure, develop model DCP clauses for more specific aspects of estuarine management, such as: - Environmentally friendly seawalls; - Site-based WSUD; - Stormwater retention, harvesting and re-use; - Foreshore inundation/flooding (including from sea level rise); - Biodiversity corridors and habitat conservation; - Public access; and - Riparian setbacks. Councils to incorporate into DCP.	Planning
Water and Sediments: Retrofit appropriate WSUD features in existing urban areas of the catchment targeting locations upstream from where stormwater runoff and associated pollutants are impacting sensitive estuary locations. Primary Objective Addressed: 3A		
7_GEN03	Improve the quality of stormwater flows by providing GPTs or other WSUD features as part of stormwater harvesting schemes.	Works
Water and Sediments: Modify, upgrade or repair existing SQIDs, stormwater infrastructure and management practices as required to maintain or improve their effectiveness. This should include development of maintenance schedules for existing infrastructure where they are not currently in place. Primary Objective Addressed: 2B		
8_GEN04	Investigate the efficacy of existing water quality controls and review maintenance regimes for stormwater infrastructure across the LGA.	Investigation
8_GEN05	Conduct a critical review of existing stormwater management practices to determine: - The efficacy of maintenance regimes of existing GPTs, and - Identify locations where additional gross pollutant trapping is required. Include a review of current street sweeping activities in catchment areas. Reference should be made to AECOM (2010) for further discussion of the issues relevant to this action.	Investigation
Water and Sediments: Work with Sydney Water to prioritise maintenance and upgrade of the sewerage network within the catchment on an ongoing basis to reduce sewage overflows. This activity should include investigations into the incidence of illegal private connections to the sewerage and / or stormwater network. Primary Objective Addressed: 2C		
9_GEN06	Provide support to Sydney Water in prioritising works to address sewer overflows affecting the estuary.	Communications

Generic Action ID*	Action Description	Management Category
Estuarine Ecology: Develop and implement a strategy for the coordinated management of estuarine and riparian biodiversity across administrative boundaries for the estuary as a whole. The strategy should incorporate biodiversity corridors and SLR consideration, to ensure the ongoing provision of habitat and connectivity between habitat areas. Primary Objective Addressed: 4A		
11_GEN07	Support the PRCG Biodiversity Sub-Committee to develop a biodiversity corridors strategy for the Parramatta River catchment area. Work with State agencies and other stakeholders for this Strategy to be recognised within planning and development frameworks including LEPs and DCPs, DA assessments and Plans of Management. Encourage on-ground rehabilitation works undertaken within these areas to support the biodiversity corridors concept.	Planning
Estuarine Ecology: Undertake improvements to foreshore infrastructure where possible to reduce their impacts on aquatic habitats. Consider the need, where feasible, to relocate or decommission infrastructure where it is impacting on environmentally sensitive locations. Primary Objective Addressed: 4A		
16_GEN08	Ensure that new stormwater infrastructure is designed to appropriately mitigate the impacts of scour on estuarine habitats.	Communications
Estuarine Ecology: Undertake works to provide for the ongoing preservation of estuarine and riparian habitats under climate change conditions. This should include the enhancement of existing habitats where there is possibility of retreat, or establishing additional habitat areas as required, to maximise habitat under SLR conditions. Primary Objective Addressed: 4A		
17_GEN09	Within Plans of Management, ensure provision for the landward retreat (where feasible) of all significant saltmarsh, swamp oak floodplain forest and mangrove communities. Issues to be addressed in Plans of Management include the protection and enhancement of the communities, and provision for areas for landward retreat.	Planning
17_GEN10	Undertake enhancement of estuarine vegetation as a stabilisation method in areas of erosion, and to protect existing seawalls from further erosion, for locations as identified in the *Estuary Processes Study* (AECOM, 2010).	Works
Estuarine Ecology: Undertake ongoing monitoring and management of aquatic and terrestrial weeds (incl. noxious weeds) and introduced species (both flora and fauna). Primary Objective Addressed: 4C		
20_GEN11	Continue bush regeneration in all reserves of the Parramatta River estuary catchment, including undertaking the recommendations made in the *Estuary Processes Study* (AECOM, 2010).	Works
Estuarine Ecology: Improve the environmental value of existing seawalls through the addition of habitat, where feasible. Primary Objective Addressed: 4D		
21_GEN12	Incorporate potential habitat opportunities into seawall designs and / or upgrades. This will include the advancement of knowledge through: - Contributing research into seawall habitat, and - Carrying out further research into retrofitting habitat to seawalls.	Works
21_GEN13	Periodically monitor the condition of seawalls along that portion of the Parramatta River within the LGA. If seawalls require attention incorporate the principles of the DECC and SMCMA (2009) Environmentally Friendly Seawalls guideline.	Monitoring
Bank Condition: All management authorities involved in the building, design and approval of new seawalls, or major upgrades of existing seawalls, should promote their compliance with the Environmentally Friendly Seawalls guideline (DECC and SMCMA, 2009) within legislative constraints. Primary Objective Addressed: 6B		
24_GEN14	Provide information to Council staff on the DECC and SMCMA (2009) Environmentally Friendly Seawalls guideline to promote their usage within the LGA.	Communications

Generic Action ID*	Action Description	Management Category
Human Usage and Recreation: Maintain and improve existing public access (i.e. bike and walking paths) for the Parramatta River estuary to provide transport linkages throughout the LGAs, giving consideration to sensitive environmental locations. Primary Objective Addressed: 7A		
25_GEN15	Facilitate the incorporation of public access into new and existing developments with due consideration of sensitive estuarine environments and ecological values.	Planning
25_GEN16	Incorporate environmentally friendly features into the designs for new (or upgraded) foreshore infrastructure. As part of the design and site selection process, due consideration should be given to the protection and enhancement of riparian zones, biodiversity corridors and estuarine vegetation.	Works

*The first number in the generic action ID is the relevant option number.