6 MONITORING AND EVALUATION STRATEGY

Monitoring and evaluation is a key component of any CZMP for two purposes:

- To monitor, evaluate and report on the health of the Parramatta River estuary; and
- To determine if implementation of the Plan has been successful in meeting the management objectives.

Monitoring and evaluation permits adaptive management, whereby the adopted management approach can be modified in response to any changes in circumstances, or to provide improved management outcomes.

Section 6.1 provides an overview of how the implementation of the Plan will be measured against the management objectives, and Sections 6.2 and 6.3 provide further discussion on estuarine health monitoring requirements and coordination of the program. Section 6.4 contains the Parramatta River Estuary Health Monitoring Program.

6.1 Key Performance Indicators

To assist the Committee in measuring the success of implementation of the Plan, Key Performance Indicators (KPIs) have been developed for the Parramatta River estuary. The development of KPIs should ideally consider the SMART criteria, which means the measures should ideally be:

- Specific;
- Measurable (where possible);
- Achievable;
- Relevant; and
- Time phased, in this case the first period (5 to 10 years) of implementation of the Plan.

A series of KPIs have been developed to allow the Committee to measure whether the actions implemented under the Plan have been successful in working towards achievement of the management objectives (Table 6.1). Some more general KPIs have also been developed to assess the more procedural aspects of implementation of the Plan. Some KPIs would be informed by the estuarine health monitoring program, whereas others are either qualitative, or rely on other sources of information.

These KPIs should be assessed after a period of no more than five years, and a decision made by the Committee as to whether it is necessary to update the Plan. It may be beneficial to review the General KPIs listed at the bottom of Table 6.1 more regularly (e.g. annually). This process will assist the Committee in determining whether the actions list needs to be updated and additional actions incorporated for the forthcoming implementation period. This process should also be informed by the findings of the estuarine health monitoring program, particularly with respect to any emerging issues.

Table 6.1: Key Performance Indicators for Management Plan Objectives

Obj. ID	Management Objective(s)	Key Performance Indicator
Land Use Planning and 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.	▪ Relevant Plans of Management and statutory and non-statutory instruments that have been updated since adoption of the CZMP make reference to the Plan.
Water and Sediments		
2A	Minimise incidences of illegal dumping of waste into the estuary.	▪ The reported incidences of illegal dumping as recorded by the Committee members are reduced. ▪ The quality of stormwater runoff from the catchment is improved. ▪ The incidence of reported sewer overflows as recorded by Sydney Water is reduced. ▪ There is increased compliance with the ANZECC (2000) guidelines for primary and secondary contact recreation at sites within the study area monitored under the Harbourwatch program. ▪ Estuarine water quality shows improved compliance with the ANZECC (2000) and OEH (2013) guidelines for aquatic ecosystem health. It may be necessary to validate the guideline values against baseline conditions for the estuary. ▪ Reference conditions for chlorophyll-a concentrations are established for the estuary in accordance with the requirements of the NSW MER Strategy (DECCW, 2010c).
2B	Reduce the level of contaminated sediment and other pollutant loads entering the estuary from catchment runoff.	
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.	
2D	Limit the mobilisation of pollutants from contaminated foreshore areas and bed sediments into the water column through minimising their disturbance.	
2E	Ensure all new developments do not have a negative impact on estuarine water quality.	
3A	Reduce sedimentation in the estuary, particularly where it affects vulnerable ecological communities such as seagrass.	
Ecology		
4A	Protect and enhance estuarine habitats (both aquatic and foreshore habitats), with a focus on providing ecological connectivity between core habitats.	▪ The net extent and percentage cover of estuarine aquatic and intertidal vegetation is maintained or improved. ▪ Net extent and percentage cover of riparian vegetation is maintained or improved. ▪ The characteristic suite of vegetation types found in and around the estuary, and along the riparian zones of the major tributaries, is maintained into the future.
4B	Naturalise existing concrete lined and highly modified creeks as opportunities arise.	

Obj. ID	Management Objective(s)	Key Performance Indicator
4C	Reduce the occurrence of weeds and pests in aquatic and terrestrial habitats in and around the estuary.	▪ Ecological connectivity is improved via the linking of discrete patches of core habitat. ▪ Reported incidences of vegetation vandalism are reduced. ▪ Environmental flows/tidal exchange is improved or restored (where possible) so as to permit fish passage. ▪ There is a decrease in the extent (linear length) of concrete lined channels/creeks. ▪ Occurrences of introduced animal species are reduced. ▪ Weed coverage in foreshore and riparian vegetation is reduced. ▪ Occurrences of aquatic pest species in the estuary and its tributaries are reduced.
4D	Incorporate additional aquatic habitat opportunities into existing areas of limited habitat.	
Bank Condition		
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).	▪ Increase in the extent (linear length) of environmentally friendly seawalls. ▪ Reduction in the extent (linear length) of artificial structures along the estuary foreshores. ▪ Reduction in the extent (linear length) of eroding natural shoreline. ▪ Increase in the extent of shoreline protected by natural vegetation (e.g. mangroves). ▪ The Committee enters into correspondence with Harbour City Ferries and initiates a dialogue on the RiverCat.
5B	Rehabilitate high priority sections of eroding shorelines.	
6A	Remove seawalls where feasible and restore a natural intertidal zone.	
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).	
Human Usage and Recreation		
7A	Maintain and improve public access along the estuary foreshores and waterway.	▪ Opportunities to improve public access to the foreshore are realised through the planning and development process. ▪ The extent (linear length) of pathways for pedestrians and cyclists is increased and existing pathway sections are connected along the estuary foreshores. ▪ There is an increase in the extent (linear length) of publicly accessible estuary foreshore. ▪ The Committee members work together to promote within their organisations a strategic approach to management and planning for recreation, public access and transport linkages.
7B	Ensure that recreational facilities continue to be provided for a range of different user groups at strategic locations.	
7C	Achieve recognition of the iconic status of the Parramatta River and capitalise on foreshore and waterway linkages.	

Obj. ID	Management Objective(s)	Key Performance Indicator
Monitoring, Evaluation and Reporting		
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.	▪ A centralised database is established and maintained to record all monitoring data. ▪ Estuarine health report cards are regularly produced. ▪ The Committee works with educational and research institutions to encourage scientific research and data sharing on the Parramatta River estuary. ▪ The community is involved in Plan implementation and monitoring activities. ▪ A web page is established to act as a centralised point for communication on the Plan and ongoing monitoring activities. ▪ The cultural heritage significance of the estuary is recognised, protected and (where appropriate) promoted.
9A	Promote public awareness of cultural heritage in and around the estuary.	
9B	Provide information to the community on the potential impacts of climate change on the Parramatta River estuary.	
Coastal Hazards		
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.	▪ The Committee members work together to promote within their organisations a strategic approach to biodiversity management and planning, taking into consideration the potential impacts of climate change. ▪ The Committee members work together to promote within their organisations a strategic approach to asset management that takes into account the potential impacts of climate change.
General KPIs		
▪ The Committee continues to meet several times during the year to progress the Plan. ▪ Committee members from local Government incorporate the initiatives and actions in the Plan into their strategic planning and reporting framework as required by the Department of Local Government. ▪ The Committee members are successful with grant applications to support implementation of actions identified in the Plan. ▪ A minimum of 75% of the management actions identified in the Plan have been initiated after a period of 5 years.		

6.2 Estuarine Health Monitoring Requirements

As previously identified, one of the requirements of a CZMP is to include a strategy for monitoring estuarine 'health'. The term estuarine health relates to the integrity and functioning of the estuarine ecosystem, and should consider whether it is in a 'natural' condition or a 'modified' condition (e.g. due to pollution or the impacts of other human activities).

It is difficult to define a baseline for a 'healthy' estuary, particularly in the context of the high rates of spatio-temporal variation in environmental parameters within an estuary (e.g. due to relative dominance of tidal and freshwater inflows), and differences between estuaries with different characteristics. It is therefore critical to collect data on indicators of estuarine health in each estuary as part of a comprehensive monitoring program to define a baseline condition, assess the range of natural variation in the system, and to track trends in the condition of the estuary. Estuarine health may be measured by a range of different variables. The Parramatta River estuary has historically been subject to significant impacts due to urbanisation of the catchment and use of the waterway, and is considered an extensively modified estuarine system.

The *New South Wales Natural Resources Monitoring, Evaluation and Reporting Strategy 2010-2015* (DECCW, 2010c) guides the Monitoring, Evaluation and Reporting (MER) of the status of natural resources in NSW. It presents a standard approach to coordinate the efforts of natural resource and land management agencies (including State Government agencies and the CMAs) to better understand whether the overall health of the natural resources of NSW are changing and to assess the effectiveness of remedial action in reversing observed negative trends. The state-wide natural resource condition targets in the Strategy (DECCW, 2010c) provide the structure for the MER program. The outcomes of the MER program also feed into the State of the Environment reporting prepared by OEH.

The MER Strategy aims to guide monitoring, evaluation and reporting efforts over the next five years to:

- Support continuous improvement of Natural Resources Management (NRM) and investment decisions;
- Inform evaluation and reporting on progress towards the NRM targets at the State and catchment level scales;
- Improve our knowledge of the condition of natural resources and the pressures on them, as well as on trends in the condition of our natural resources;
- Improve capacity to report on achievements of investments in NRM programs;
- Improve data management and sharing arrangements among MER partners; and
- Enhance collaborative partnerships with key NRM players to strengthen the MER effort.

The MER Strategy is supported by an Implementation Plan (DECCW, 2010a) that details the range of environmental indicators monitored under a series of 13 'themes'. The relevant theme for this Plan is the 'estuaries and coastal lakes' theme, under which a series of indicators are identified for monitoring (Table 6.2). OEH is the lead agency for this theme, with support provided by DPI (Fisheries). The 'current' program details activities that are currently undertaken using dedicated resources, however, the Implementation Plan (DECCW, 2010a) also details an 'essential' program which lists the activities that would need to be undertaken in order to meet the essential elements of the MER Strategy for 2010-2015 (DECCW, 2010c).

OEH provides guidance on implementation of the MER Strategy for estuaries in the document: *Assessing estuary ecosystem health: sampling, data analysis and reporting protocols* (2013). According to OEH (2013) monitoring as part of the estuaries theme of the MER Program focuses on estuarine biology to determine condition in preference to the stressors and pressures which are the external factors that cause changes in condition.

The estuarine ecosystem health indicators listed in OEH (2013) are summarised in Table 6.2. The MER water quality monitoring is scheduled to be undertaken approximately every 3 years, between mid-September and the end of March, in accordance with the sampling program outlined in Section 7.4 of OEH (2013). It is understood that the estuarine macrophytes and fish sampling would follow a similar cycle of sampling roughly every 3 years (DECCW, 2010a). The data collected is to be incorporated into the state-wide MER.

Table 6.2: Estuarine Ecosystem Health Indicators (after OEH, 2013)

Indicators	Method
Water quality indicators:	
Chlorophyll *a*	Filtration and extraction
Water clarity	Secchi disc; NTU
Other indicators:	
Estuarine macrophytes (saltmarsh, mangroves & seagrasses)	Areal extent
Fish assemblages	Estuarine Fish Community Index
Optional additional indicators:	
Macroalgae	Areal extent
Dissolved Oxygen	24hr in situ monitoring

OEH (2013) notes that these protocols do not address matters that reflect broader estuary uses, human health and community values such as the assessment of recreational water quality (see Beachwatch protocols), however, there may be opportunities to include additional indicators when reporting on estuary health or water quality more broadly.

In the event that the Committee obtains additional funding for implementation of the monitoring program under this CZMP, it is recommended they consider the recommendations provided in Appendix I. It is recommended that the Committee seek opportunities to introduce additional indicators (e.g. benthic assemblages) into their monitoring program for estuarine ecosystem health consistent with the advice of OEH (2013) as funding becomes available.

6.3 Program Coordination

The PRCG would be responsible for leading and coordinating the monitoring activities undertaken by each authority/organisation represented on the Committee. According to the *NSW MER Strategy* (DECCW, 2010c), data management, storage, sharing and dissemination standards and systems are the responsibility of the respective organisations carrying out the monitoring activity.

6.4 Parramatta River Estuary Health Monitoring Program

While a variety of stakeholders have in the past, and many continue to, monitor certain aspects of water quality and estuary health in discreet areas in the Parramatta River estuary, there has been no coordinated effort to monitor the health over the entire estuary.

Appendix H provides a brief overview of existing monitoring programs and activities conducted by a range of organisations within the Parramatta River, including details of indicative sampling locations and parameters monitored.

As part of developing this CZMP, the Committee agreed to adopt an Estuary Health Monitoring Program that will be used as a baseline to track how well the estuary is being managed over time, as well as whether implementation of the completed CZMP is contributing to improved estuary health.

The key objective of the monitoring is to look at how the overall health of the estuary changes over time. This monitoring program is consistent with the NSW MER Strategy (DECCW, 2010c) program principles. Other similar estuary health monitoring programs following the same principles also exist, including one for the Georges River, which will enable useful comparisons between estuaries.

It should be noted that while this section describes the monitoring program adopted at the time of preparing this CZMP, there may be changes over time to aspects such as indicators sampled, sites, sampling periods and analysis of data. This will allow for improvements to be made once more information becomes available, as well as to adopt changes to State-wide programs such as MER that may be rolled out and need to be complied with.

Appendix I also contains some additional guidance on estuarine health monitoring and additional parameters that could be incorporated into the Estuary Health Monitoring Program should additional funding become available in the future.

6.4.1 Indicators

The adopted estuary health monitoring program is based around using key indicators that are monitored at the State level under the MER Program. This includes monitoring:

- Chlorophyll *a*;
- Turbidity;
- Other supporting physico-chemical indicators such as salinity, dissolved oxygen, pH, and temperature;
- Estuarine macrophytes (seagrasses, saltmarsh, mangroves) distribution change; and
- Riparian vegetation distribution and condition.

6.4.2 Sampling Period and Effort

- Sampling monthly for chlorophyll a and turbidity (with fortnightly sampling of chlorophyll-a over the warmer months to be considered – roughly mid-September to end of March). Fortnightly sampling

over the warmer months is recommended as algal productivity is greatest over these months and as per MER methodology, will ensure that the chlorophyll a maxima is more likely to be accurately captured;

- Assessments of estuarine macrophyte distribution and condition every 5 to 10 years to compare with existing data to identify change in extent and condition over time; and
- Assessments of riparian vegetation distribution and condition every 5 to 10 years to compare with existing data to identify change in extent and condition over time.

6.4.3 Sampling Sites

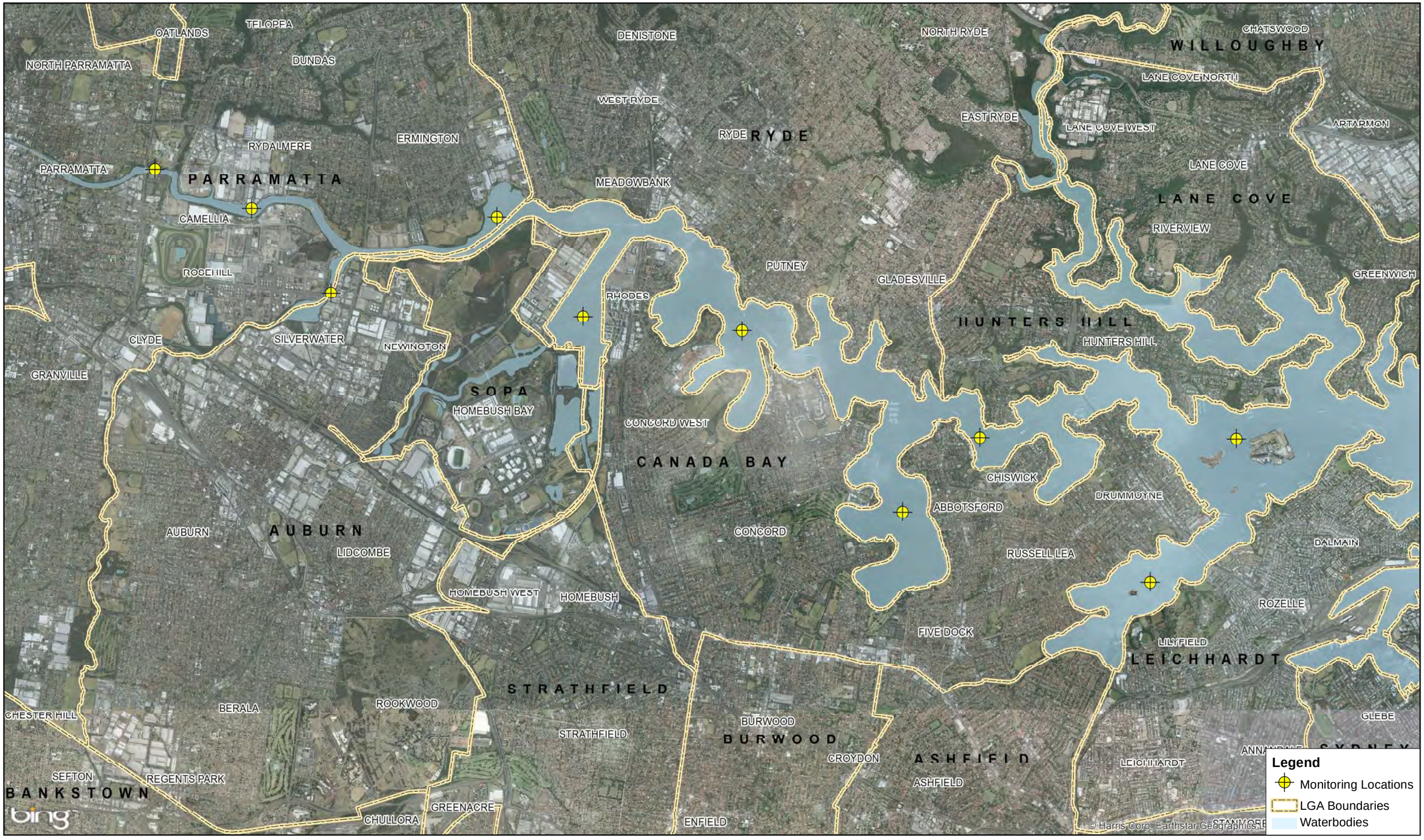
To gain a representative picture of the overall health of the Parramatta River estuary, it is recommended that ten sites are sampled (Figure 6.1). These include five sites along the main river channel that will capture the salinity gradient up the estuary from Cockatoo Island to the weir at Charles Street. The other four sites are located outside of the main river channel to ensure the major bays and tributaries of the Parramatta River are also included. These sites are located in Iron Cove, Hen and Chicken Bay, Homebush Bay and Duck River. For the site located upstream of Silverwater Bridge, boat access will need to be arranged with RMS (Maritime) and Harbour City Ferries.

Parramatta City Council have also initiated the installation of two continuous water quality monitoring stations located within their LGA, which will monitor the same suite of indicators. These stations will align with the locations of the two most upstream sites in the main channel. A third continuous monitoring station is proposed at the downstream end of the estuary, in the vicinity of Cockatoo Island, once additional funding is secured. These stations are part of a broader *Sydney Harbour Catchment Water Quality Improvement Plan* project coordinated by the HNCMA, which will also see installation of the monitoring stations in Sydney Harbour, Middle Harbour and Lane Cove River. The stations will also provide useful supporting information for this monitoring program and will allow cross calibration between chlorophyll a monitored continuously on each station using a fluorometer, with the chlorophyll a samples sent off to the laboratory.

6.4.4 Sampling Protocols

Sampling protocols for the monitoring program are as follows:

- Water quality parameters of pH, salinity, turbidity, dissolved oxygen and temperature will be sampled in-situ using a water quality logger. The logger should be calibrated before each use with the appropriate standards and buffer solutions. Chlorophyll a will be sampled in containers supplied by a NATA accredited laboratory and will broadly follow the MER sampling protocols (Scanes *et al*., 2009). Chlorophyll a will be sampled on a five minute boat drift whereby a 1L sample is taken every 30 seconds and poured into a bucket, a total of 10L of sample water will be drawn and homogenised in a bucket from which a 1L sample will be collected in supplied sample container;
- Monitoring of all sites will be undertaken by boat;
- Chlorophyll *a* samples will be covered in foil to block out the light, chilled and kept in an esky until dispatched to the laboratory, usually on the same day of collection, but no later than 48 hours after collection; and
- A duplicate and field blank sample will comprise 1 out of every 10 samples.



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

Estuary Monitoring Locations

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 6.1

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: G6001_MonitoringLocations 03.mxd
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.

6.4.5 Analysis of Data

The assessment of chlorophyll *a* and turbidity data will be in accordance with the methodology used under the MER Program (OEH, 2013), including adoption of the trigger values derived from this program (Table 6.3). The methodology for assessing change in macrophyte distribution over time will also follow the MER methodology.

*Table 6.3: Trigger Values to be Used**

Indicator	Estuary Type	Estuary Zone (based on salinity)	Trigger Value
Chlorophyll *a*	River	Upper <10 ppt salinity	3.4 µg/L
		Middle 10-25 ppt salinity	2.9 µg/L
		Lower >25 ppt salinity	2.3 µg/L
Turbidity	River	Upper <10 ppt salinity	6.6 NTU
		Middle 10-25 ppt salinity	3.5 NTU
		Lower >25 ppt salinity	2.8 NTU

* Note: These trigger values were derived from data from reference estuaries sampled as part of the NSW MER.

6.4.6 Evaluation and Reporting

Evaluation and interpretation of the data is important for determining whether any priorities of the CZMP need to be amended or specific actions need to be taken. This should be an ongoing process.

Reporting of the data is important for highlighting to key stakeholders and the community in general how the health of the Parramatta River is changing over time, and how it compares to other estuaries. Reporting should be in the form of yearly report cards on estuary health/water quality.