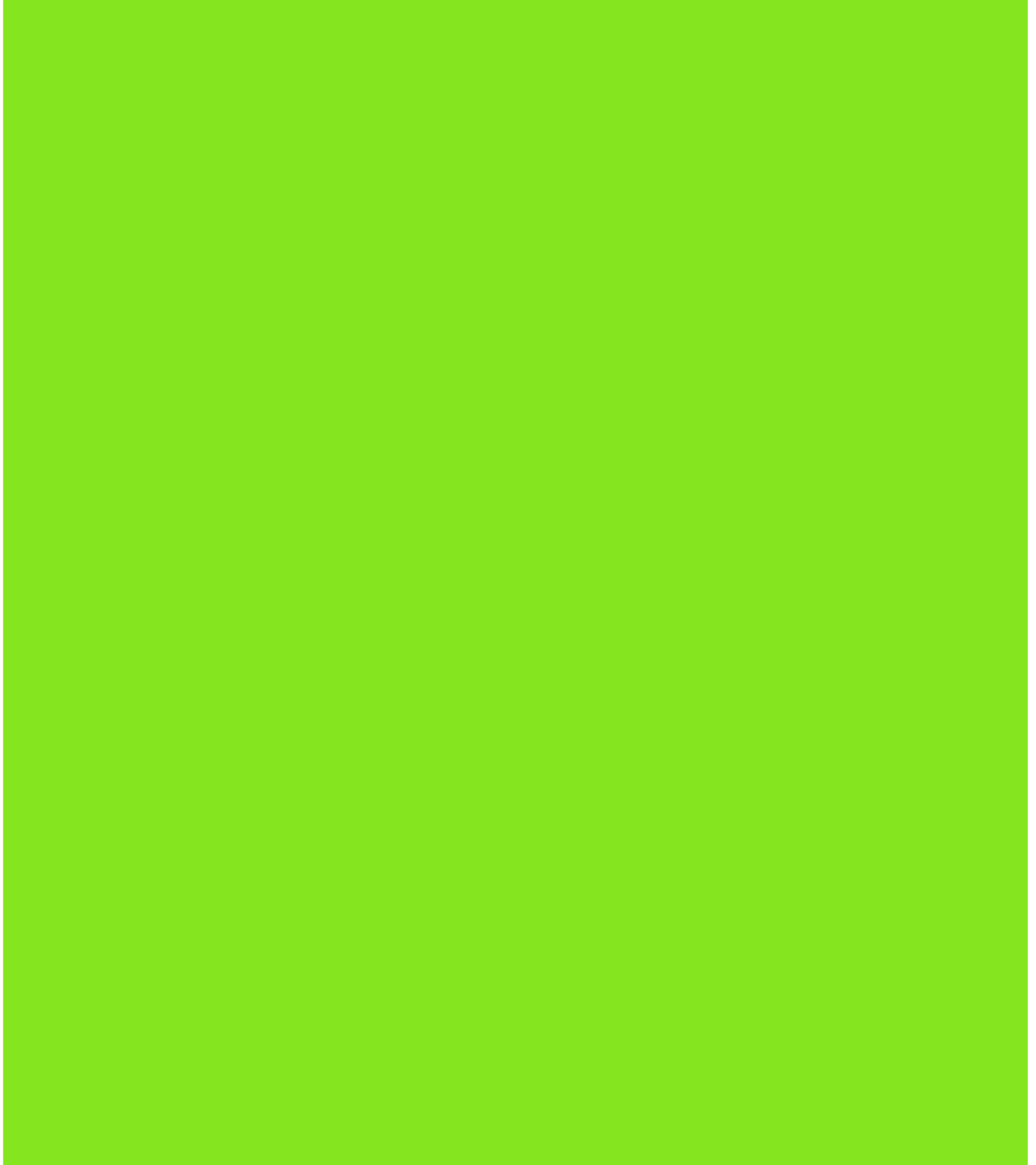


2.0 Historical Aerial Photo Comparison



2.1 Introduction

The estuary and its catchment have been exposed to ongoing stress due to a rapidly increasing population density and extensive residential, commercial and industrial expansion (Birch 2006).

Up until 1970 the Parramatta River was an open drain for industry in Sydney, and consequently the River's embankments and sediments are contaminated with a range of heavy metals and chemicals. Historically, industrial development has impacted upon the southern side of the harbour and river substantially more than the northern side due to well-established industrial development prior to the opening of the Sydney Harbour Bridge in 1932 (PCC 2008).

Contaminated sediments in the river resulted in a complete fishing ban in Homebush Bay due to dioxin contamination, and a complete commercial fishing ban throughout the rest of Sydney Harbour and its tributaries, including the Parramatta River (2006).

The history of land use and likely future impacts from increasing population and urbanisation in the study area was identified by Cardno Lawson Treloar (2008). Recommendations for further studies included the compilation of the history of land use within the estuary and catchment area. A compilation of historical information was undertaken as part of this study. Current and historical aerial photography were used to assess both local areas which have undergone dramatic changes and the catchment area as a whole.

2.2 Method

GIS ortho-rectified imagery for 1943 and 2009 was provided by the Sydney Metropolitan Catchment Management Authority (SM-CMA) as ecw tiles which were analysed in Arcview v9.3 in order to assess the major changes over time in the estuary and its more immediate catchment.

Imagery and relevant GIS layers were interrogated to provide qualitative measurements of historical changes to the study area, and compiled within a project database.

Spatial data provided by SM-CMA, Parramatta City Council (PCC), and NSW Maritime, for use in this study are summarised in Table 2-1.

Table 2-1. Spatial data used in the historical aerial photograph assessment

Spatial Data	Resolution	Application	Limitations
1943 aerial photography (SMCMA)	10 cm pixels	Baseline assessment	Not all of foreshore and catchment available
2005 aerial photography (SMCMA)	20 cm pixels	Assessment of current conditions	
2009 aerial photography (SMCMA)	10 cm pixels		
Council land use data (PCC)	NA	Confirmation of current land use	Not all Council LGAs available
Contours (PCC)	10m	Define the extent of the catchment	
Mean High Water Mark (NSW Maritime)	NA	Reference for current foreshore	Approximated water line, which is inaccurate in a number of areas.

The following historical and current GIS layers were created:

- Land_use_changes.shp – polygons
- Foreshore_1943.shp and Foreshore_2009.shp – polylines
- Reclamation.shp – polygons

2.2.1 Major land use changes

The *Land_use_changes.shp* was created by merging land use data and cadastral layers. This allowed existing polygons (usually denoting one street block) to be used.

New fields were added to capture information from the visual assessment which are identified as:

- 1943 land use (LU_43); and
- 2009 land use (LU_09).

A hierarchy of landuse categories was developed (Table 2-2) and a category was assigned to each polygon. The hierarchy was created based on the perceived impact of the land use category on runoff water quality with numerical value increasing with the level of perceived impact. Thus, categories such as “Open space” and “Recreation” were assigned a low number and “Industrial” a high number.

Table 2-2. Land use categories

Hierarchy number	Landuse category	Description
1	Estuary	Estuarine areas that existed in 1943 but have since been reclaimed.
1	Open space	Undeveloped land. For 1943 this category was used for land with no buildings or infrastructure or any evidence of agriculture. However, 1943 land that appeared earmarked for residential development and that had at least one subdivided residential dwelling was categorised as Residential.
1	Recreation	Open space clearly exhibiting signs of recreation such as cricket pitches or landscaped areas.
2	Agriculture	Land exhibiting signs of agriculture such as crop fields, stock watering points etc.
3	Residential	Includes low, medium and high residential areas.
4	Mixed	Denoting land that has a mix of residential and commercial buildings.
4	Community	Includes hospital land, churches and schools.
5	Commercial	Includes shops/retail areas as well as offices and business.
6	Industrial	Includes general Industry; light industry; heavy industry and industrial estates (warehouses). It should be noted that distinguishing between business parks (which would fall under Commercial and industrial areas) and industrial estates is difficult. For the purposes of this study caution was applied and where it is difficult to distinguish the land was categorised as industrial
6	Infrastructure	Road and rail corridors; electrical substations etc

Changes in land use were then approximated by subtracting 1943 values from 2009 values. When an area changed in category, for example from open space to industrial it is referred to as ‘intensification of land use’.

2.2.2 Foreshore

Foreshore_1943.shp and *Foreshore_2009.shp* were created to denote the 1943 and 2009 foreshore extents. These were created by digitising the foreshore as visible in the aerial photography. The foreshore extents were then compared. The assessment of foreshores was also used to calculate the extent of reclaimed/lost land.

2.2.3 Reclaimed land

Reclaimed land was calculated by creating a polygon shapefile from the two foreshore polylines (polygons were created to fill the space between the two foreshore lines). The created shapefile was then interrogated to determine whether land had been reclaimed or lost to the estuary between 1943 and 2009.

During the assessment of reclaimed lands it became evident that extensive areas of estuary had already, or were in the process of being, reclaimed prior to 1943 aerial photography. To gain insight into the extent to which land had been reclaimed prior to 1943 a brief review of relevant literature was undertaken.

2.2.4 Limitations and clarifications

There are inherent limitations associated with remote sensing. In addition to generic issues with desktop assessments, specific limitations in this study related to using black and white 1943 aerial photography. These were:

- Accurate determination of foreshore often inhibited by vegetation canopies;
- Difficulties in distinguishing between terrestrial and estuarine vegetation in the 1943 aerial photography. Therefore, foreshore with canopy cover was assumed to be stands of mangroves. For the most part, the foreshore line was digitised on the landward side of the mangroves except where inundated mudflats/saltmarsh was evident;
- The exact date and time of when each aerial photography set was flown was not available. Therefore, the different tidal stages cannot be quantified and some of the variability exhibited between foreshore lines may be due to tidal difference; and
- Difficulty distinguishing between mudflats, saltmarsh and open grassed areas.

2.3 Catchment land use

A number of different land uses exist within the study area including residential, commercial, industrial, open space and recreation and infrastructure (transport and communications). Land zoning, management and planning within the estuary is governed by individual councils and moreover their Local Environmental Plans (LEP).

Birch and Taylor (2004) has found a strong correlation between land use and sediment and water quality. The impact on water quality runoff varies between land uses. For example, within the estuary itself high metal concentrations in bedload sediment and in adjacent estuarine sediments are associated with the highly industrialised and urbanised subcatchments of Iron Cove, Hen and Chicken Bay and Homebush Bay. In addition, sediments of Toongabbie Creek are elevated in heavy metals at sites located adjacent to the Seven Hills industrial estate (Birch and Taylor, 2004).

According to Birch and Taylor (2004) these areas are highly contaminated for several reasons: proximity to major contaminant sources; fine grained sediment able to readily absorb pollutants and reduced tidal influence to redistribute and dilute the sediments. Industrial land uses (both past and present) can be viewed as a threat to estuarine water quality.

Figure 2-1 illustrates the distribution of land use change across the catchment between 1943 and 2009.

2.4 Land use change

For the most part, land use change in the catchment is consistent with expectations of a growing metropolitan area. Residential areas expanded into what were once agricultural areas and commercial areas expanded and migrated into surrounding residential areas creating larger central business districts.

Land use change between 1943 and 2009 varies throughout the catchment (Figure 2-1). In parts of the catchment, mostly the western areas of the catchment, large areas of agricultural land were subdivided for residential use, while other areas, more towards the east of the catchment have not altered greatly. This is due to the eastern areas of the catchment being well established as residential suburbs (such as Drummoyne, Hunters Hill, Concord and Balmain) prior to 1943.

As expected there has been an increase in residential and commercial areas within the catchment. However, an additional trend was realised where land use has become less developed since 1943. In other words, areas once industrial, particularly along the foreshore, have since been redeveloped as residential and open space.

In addition, there are examples where land use has altered several times since 1943. This is the case with Homebush Bay. In 1943 the western bank of the bay was yet to be fully reclaimed. However, this area has since been used for industrial purposes until recently being redeveloped as residential and commercial areas.

Foreshore lands, such as these, that have been altered can be deceptive. Modern landscaping and rehabilitation techniques can disguise what were once industrial lands, highlighting the need to include details of past land uses in risk assessments (such as the environmental sensitivity analysis of this study) to assess threats to environmental values. This is because the impacts of historical land use, such as industrial, can remain in the local environment as is the case with pollutants carried in runoff from historically industrial areas which bind with sediments and deposit in the estuary.

2.5 Land reclamation

Land reclamation refers to the infilling of the areas between mean high water mark and mean low water mark. Reclamation in Sydney Harbour was deemed a suitable option to dispose of dredged sediments to create flat waterside lands for industry and recreation (McLoughlin, 2000b).

Approximately 292 ha of land were reclaimed from the estuary between 1943 and 2005 (Table 2-3 and Figure 2-2). It should be noted that land reclamation works began on the Parramatta Estuary prior to 1943. Therefore, the area calculated for this study does not represent the entire area of land reclaimed from the estuary.

Table 2-3. Areas of reclamation

Shapefile	Area (ha)
Land reclaimed since 1943	292.0
Land lost since 1943	32.7

Modification of foreshore areas in Sydney Harbour began soon after the arrival of European settlement in 1788 (McLoughlin, 2000). However, it is suggested that initial modification was localised to the Circular Quay area (outside the Estuary). Little reclamation was undertaken within the study area prior to 1889 and this was mainly restricted to the east side of Hen and Chicken Bay (Birch *et al*, 2009).

Between 1889 and 1922 reclamation in the Estuary increased and included: Canada Bay, Hen and Chicken Bay; Hawthorne Canal; White Bay and Iron Cove. For example, between 1890 and 1907 32.8 ha of land were reclaimed in Long Cove (head of Iron Cove Hawthorne Canal) (McLoughlin, 2000).

Birch *et al* (2000) reports that the most active era for land reclamation was during 1922 – 1955. This is supported by the 1943 aerial photography which shows several instances of land in the process of reclamation (Figure 2-3). During this period extensive reclamation was undertaken at Silverwater, the Homebush Peninsular; Exile Bay; Kings Bay and Iron Cove (Birch *et al*, 2009).

Reclamation in Homebush Bay makes up a large percentage of the reclaimed lands in the estuary (Figure 2-2). Sources of fill for the reclamation included dredged material from Homebush Bay, Parramatta River and other parts of the Harbour. In addition, waste and building materials were used (McLoughlin, 2000).

The purpose of reclamation in Homebush Bay was to provide areas of flat, stable and accessible waterfront land and was completed between 1949 and 1965 to (Birch *et al*, 2009). However, reclamation of Homebush Bay and Powells Creek began prior to 1943 as evidenced by the constructed bund visible in aerial photography (Figure 2-3). Dredging in Homebush Bay and reclamation began in the 1890s and consisted of enclosing the inter-tidal mud flats on the western

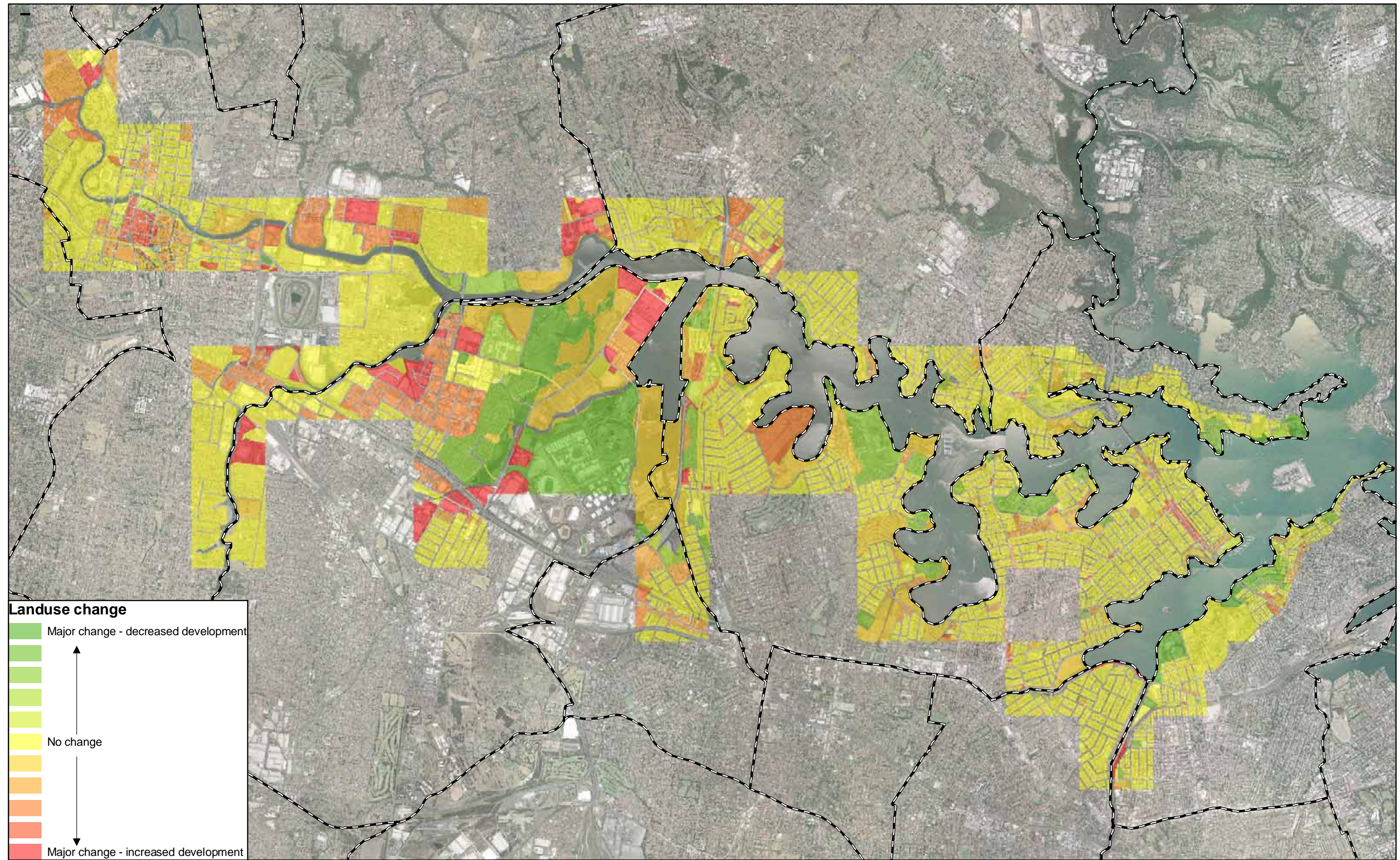
side of the Bay (McLoughin, 2000). Further work was undertaken during two major periods 1904–17 and 1948–62.

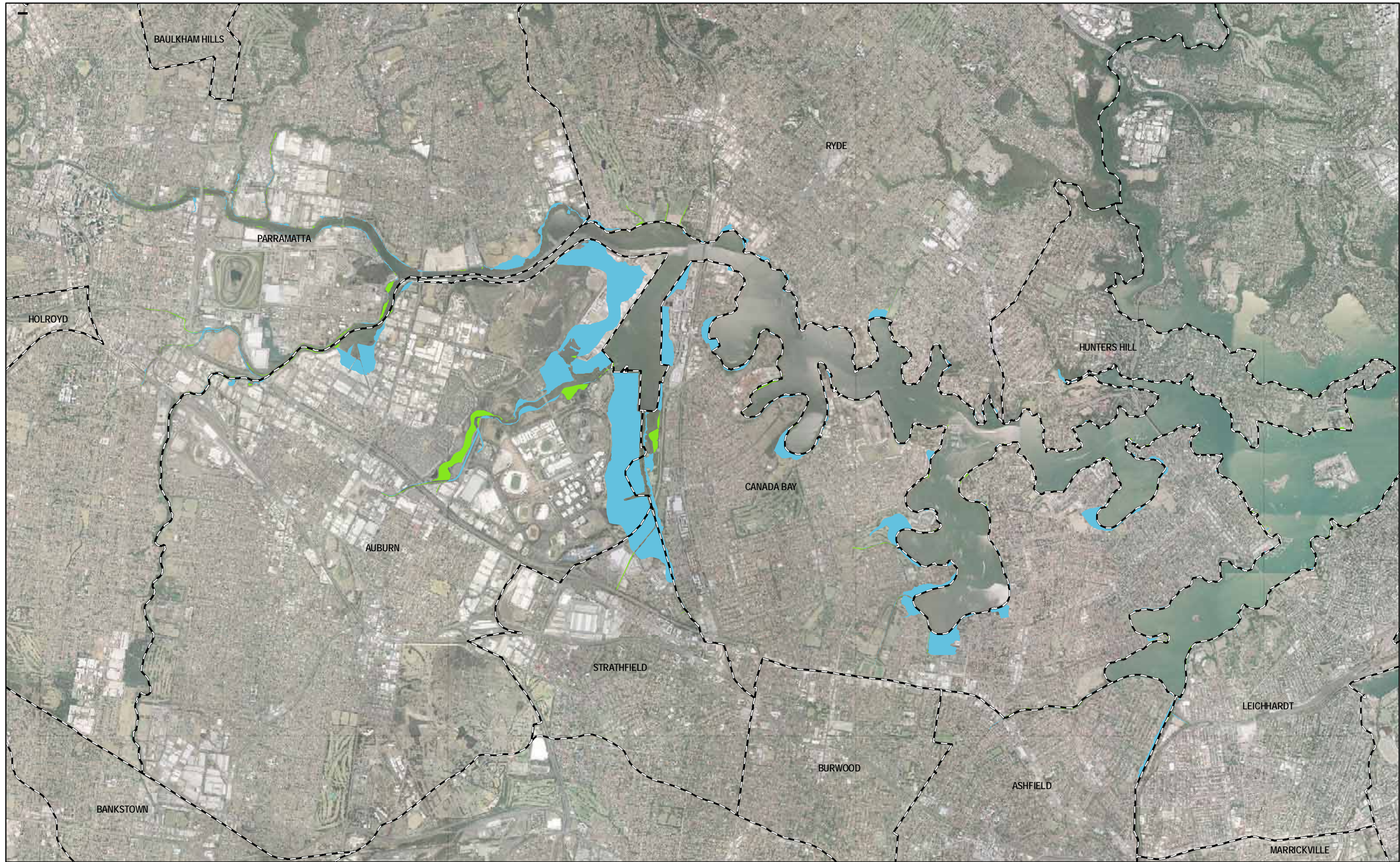
Reclamation in the Estuary continued post 1955. From 1955 to 1969 landfill (including industrial wastes) was increasingly used to reclaim land (Coward, 1988). In addition, reclamation was also seen as a means of garbage disposal due to a growing city and lack of existing land.

Land reclamation has an immediate, localised impact on estuarine ecological function through habitat and species loss as well as broader implications for receiving or downstream ecosystems. In the Estuary, reclamation of estuarine areas for development has resulted in the loss of many mudflats, wetland, mangrove and saltmarsh communities.

In addition to the obvious physical alterations and loss/displacement of ecological communities there are implications of land reclamation for estuarine sediment and water quality.

Reclamation in the Estuary has been undertaken using waste materials and dredged estuarine sediments. Depending on the permeability and physiochemical characteristics of the fill material, leachate from reclaimed lands may be a major source of contaminants to the Estuary (Suh et al., 2003; Suh et al., 2004; Birch and Taylor, 1999; Birch and Taylor, 2004). Therefore, reclaimed areas of land can be viewed as threats to environmental values.





- Extent of reclaimed estuary
- Extent of reclaimed land
- Local Government Area Boundary

PARRAMATTA RIVER ESTUARY PROCESS STUDY
LAND RECLAMATION BETWEEN 1943 AND 2009

AUG 2010
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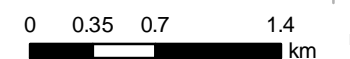
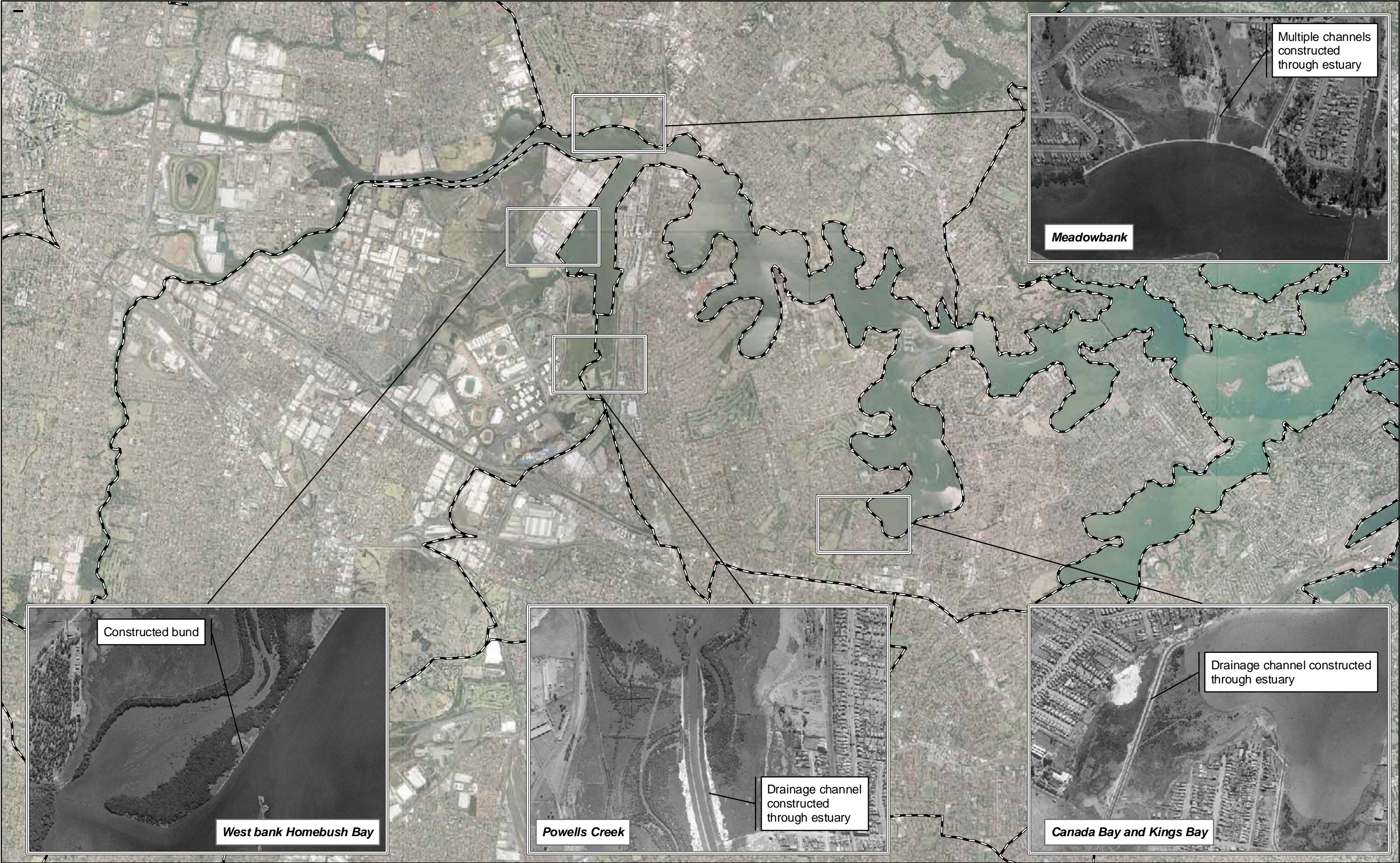


Fig. **2.2**



2.6 Foreshore Alteration

The current study indicates that the loss of foreshore in the Estuary between 1943 and 2009 is around 1km (Table 2-4 and Figure 2-4).

Table 2-4. Loss of foreshore

Shapefile	Length (m)
1943 Foreshore	136,477.8
2005 Foreshore	135,454.7
Difference	1,023.2

However, substantial reclamation occurred prior to 1943 and the total length of foreshore lost since European settlement is known to be far greater. For example:

- NSW Maritime estimated that the length of the entire Sydney Harbour foreshore line has been reduced from 322km to 245 km (24%) (Birch and Taylor, 2004); and
- Birch (2006) indicates that the Parramatta River Estuary has been reduced by 22 per cent over 220 years of almost constant reclamation.

2.7 Summary

The estuary and its catchment have been exposed to persistent stress over the last two centuries due to historical and current anthropogenic impacts. This desktop historical assessment has provided insight into temporal changes in the catchment including: the extent of reclamation; major land use changes; and loss of foreshore. The historical nature of these three processes is important to consider when assessing past, and therefore potentially continuing, and present threats to estuarine environments. This understanding assists in the effective management of these threats.

The historical analysis highlighted the following threats to the estuary:

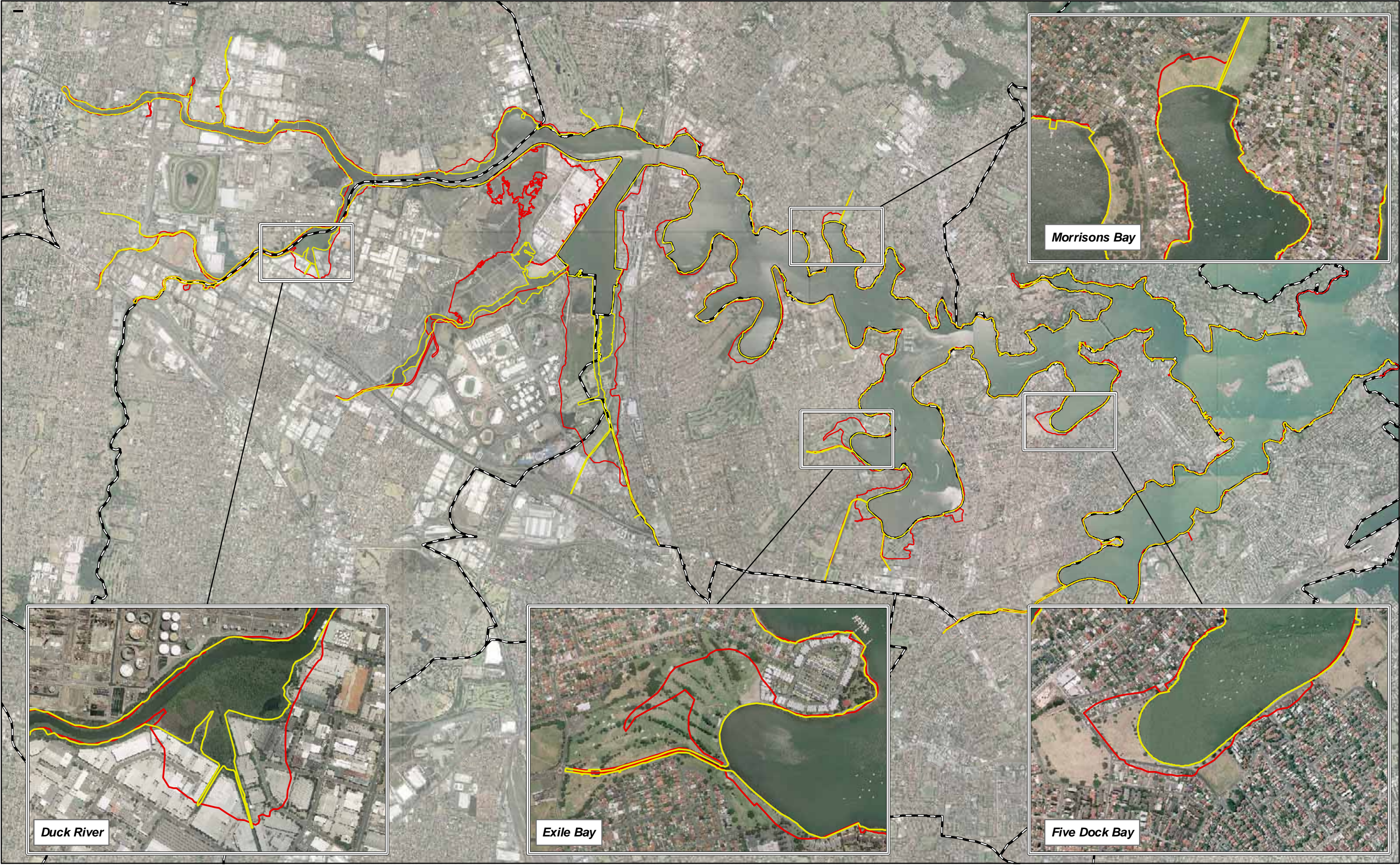
- Loss of natural estuarine environments through reclamation and foreshore development;
- Industrial development within the catchment;
- Reclamation of estuarine areas with potentially contaminated sediments and general waste.

Past (1943) and present (2009) industrial areas as well as land reclaimed since 1943 are displayed in Figure 2-5.

The figure shows that currently Parramatta and Auburn LGAs contain the greatest areas of industrial lands with Auburn LGA also exhibiting large areas of historical industrial land use. In addition, Auburn LGA has large areas of reclaimed lands. Therefore, estuarine areas more likely to be adversely affected by industrial areas and leachate from land reclamation are located in Parramatta and Auburn LGAs. Other areas of potential concern are several bays in Canada Bay City which have been truncated by land reclamation.

Understanding the extent to which natural estuarine areas have been modified/lost highlights the importance of remaining natural resources of the estuary and serves to promote the preservation and rehabilitation of remaining natural areas. In addition, identifying the threats posed by reclaimed and industrial lands and their proximity to estuarine values allows managers to target areas for monitoring and remediation.

In this study, recognition of threats to estuarine environments provides input into the environmental sensitivity analysis to determine their potential impact on environmental values. The environmental sensitivity analysis will allow managers to better target estuarine management activities.



— Foreshore 2005
— Foreshore 1943
 Local Government Area Boundary

PARRAMATTA RIVER ESTUARY PROCESS STUDY
EXAMPLES OF FORESHORE ALTERATION BETWEEN 1943 AND 2009
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