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HOMEBUSH BAY ECOLOGICAL STUDIES 1993-1995

VOLUME 2

OLYMPIC CO-ORDINATION AUTHORITY



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ECOLOGICAL STUDIES**

**1993-1995**



**VOLUME 2**

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# HOME BUSH BAY ECOLOGICAL STUDIES

1993-1995

Volume 2

Olympic Co-ordination Authority

Department of Defence



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# CONTENTS

<b>Introduction</b>	<b>ix</b>
<b><i>Fish, Prawns and Crabs Study</i></b>	
1. Introduction	3
1.1 Background and Aims	3
1.2 Existing Information	3
2. Study Methods	5
2.1 Sampling Locations and Times	5
2.2 Sampling Methods	6
2.3 Statistical Analysis	7
3. Results	10
3.1 General Observations	10
3.2 Fish and Crustaceans	10
4. Conclusions	19
5. Acknowledgments	20
6. References	21
<b><i>Waterbirds Study</i></b>	
1. Introduction	25
2. Methodology	26
3. Habitat Description	27
3.1 Saltmarsh and Mangroves	27
3.2 Freshwater/brackish Wetlands	37
3.3 Intertidal Mudflats	45
3.4 Open Marine Waters	47
3.5 Wet Grasslands	48
4. Discussion	49
5. Annotated Bird List	50
6. References	67

### *Woodland Birds Study*

Summary	71
1. Introduction	72
2. Habitat Description	73
2.1 Woodlands	73
2.2 Rough Grasslands	77
2.3 Parklands	77
2.4 Residential Areas	78
2.5 Industrial Areas	79
3. Methods	80
3.1 Limitations of techniques	80
4. Discussion	81
5. Annotated Bird List	82
6. References	95

### *Wetlands and Benthos Study*

1. Methods	97
2. Results	99
3. Discussion	105
4. Literature Review	108
5. Conclusion	109
6. Literature Cited	110

### *Saltmarsh Vegetation Study*

1. Introduction	113
1.1 Saltmarsh in Australia	113
1.2 Saltmarshes in the Sydney Region	115
1.3 The Current Survey	115
1.4 Plant Communities	116
1.5 Other Communities	118
1.6 Importance of Saltmarsh	118
2. Species of Special Interest	120
2.1 Apparent absences, and locally uncommon species.	121
2.2 Species List	122
3. Major weeds	124
4. Notes on other habitats	125
5. Acknowledgments	126
6. References	127

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## *Remediation Study*

1. Introduction	131
2. The Key Issues	133
3. How Risk Management Reduced Costs	134
3.1 The State Land	134
3.2 The Commonwealth Land	139
4. The Risk Management Process	141
4.1 Preliminary Hazard Assessment	141
4.2 Final Hazard Assessment	141
4.3 Development of Screening Criteria	141
4.4 Assessment of Risks	141
4.5 Identification of Remedial Objectives	148
4.6 Recommendations for Risk Management	149
5. Remediation Strategy Development	150
6. The Final Budgets For Remediation Costs	152
7. Conclusions	153
8. References	154
9. Acknowledgements	155

## *Fauna Impact Study*

Summary	159
1. Introduction	161
2. Description and location of the study area	164
3. Description of proposed development	166
4. Previous fauna studies	173
5. Project team	175
6. Director-General's Requirements for the conduct of this FIS and the Developer's responses to meeting those requirements.	176
6.1 Report Requirements	176
6.2 Description of the Fauna	176
6.3 Fauna Survey Requirements	178
6.4 Water Quality	182
6.5 Distribution and Habitat	184
6.6 Fauna Corridors	188
6.7 Description of Actions and Effect	189
6.8 Amelioration Measures	192
6.9 Habitat Restoration	195
6.10 Discussion of Options	195
6.11 On-Going Monitoring of Ameliorative Measures	196
7. Acknowledgments	200
8. References	201



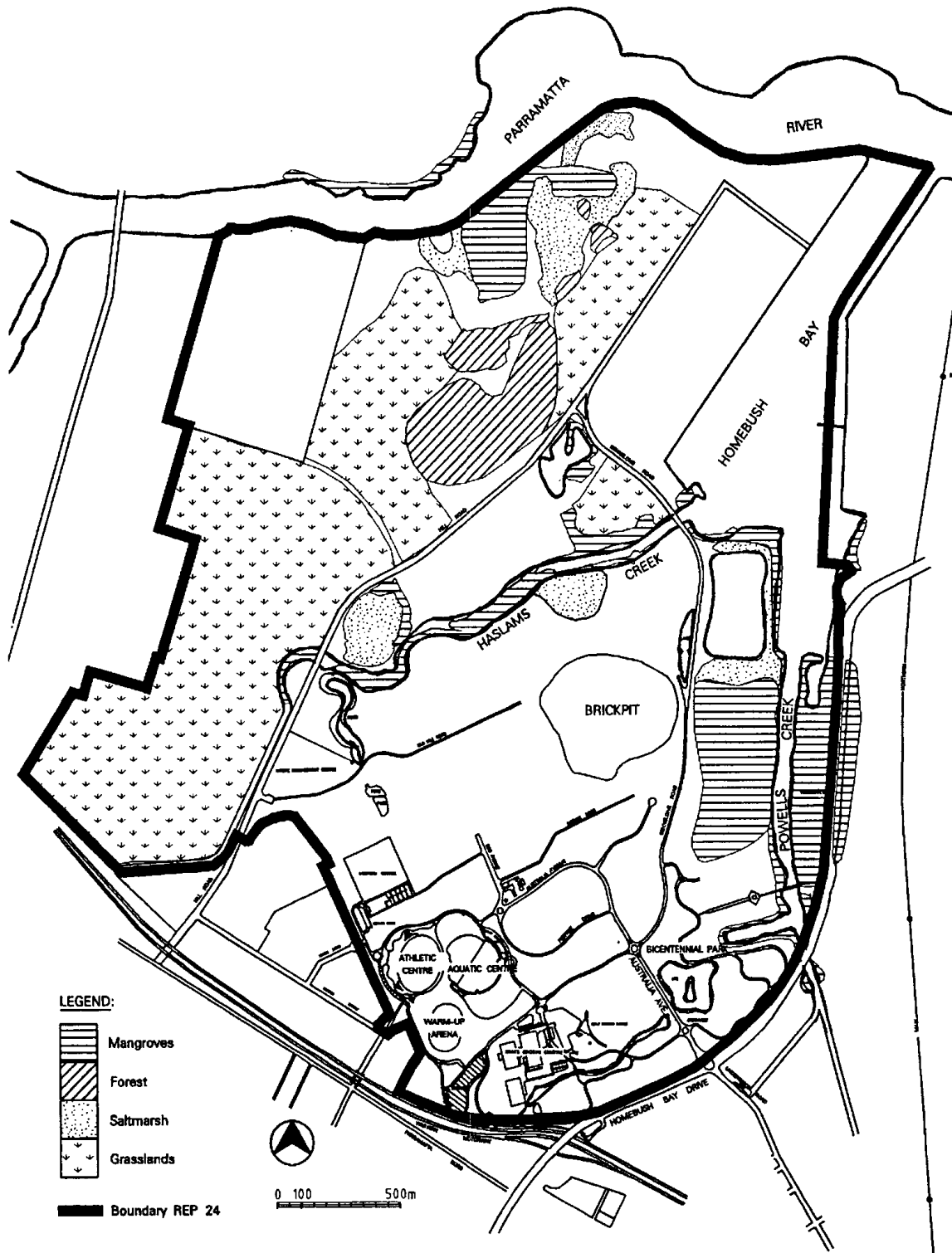


Figure 1. Homebush Bay showing the natural features

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## INTRODUCTION

### HOME BUSH BAY

Seven hundred and sixty hectares of land at the demographic and geographic heart of Sydney make-up the Homebush Bay Development Area (Figure 1, see also Figure 1 on page 7, *Homebush Bay Ecological Studies*, Vol.1). Most of this land has been under State or Federal Government control and has been since the early 1900s when ownership of two large estates, Newington and 'Home Bush' was returned to the government. Until recently, an abattoir, brickworks, and armaments depot occupied the site. For over 60 years low-lying mangrove 'swamps' were progressively reclaimed and filled with a variety of materials.

The area has been earmarked for renewal since the mid-1980s when the privately developed business park, the Australia Centre was established at the site. This was followed by the opening of the State Sports Centre in 1984 and followed by the Bicentennial Park in 1988.

Development of Homebush Bay was originally planned to occur over a 10–15 year period towards the year 2010. However, the decision to use Homebush Bay as primary zone for the Sydney Olympics means that by the year 2000, many international standard sporting facilities must share the site with commercial, recreational and residential developments. The first phase of construction — the Sydney International Athletics Centre and International Aquatic Centre — has already been completed. An extensive program of remediation of contaminated land is also well underway.

A full assessment of the values (and constraints) of the site has been undertaken to allow development to occur alongside, and benefit from, the natural environment.

#### *Values of Homebush Bay*

Homebush Bay retains remnants of its original vegetation and ecosystems in a unique setting at the heart of urban Sydney. From the start, its redevelopment posed the challenge of rehabilitation of large tracts of degraded land and integration of the natural and built environments.

The values of these ecosystems have been recognised and included on the register of the National Estate and the protection of migratory wading birds, which frequent the wetlands, by international agreements with Japan and China.

The remnant Eucalypt and Casuarina Woodlands and their associated mammal, reptile, amphibian and bird fauna are considered to be of national significance. The Homebush Bay wetlands form an essential link in the remaining coastal wetlands of Sydney, and as such form an important part of the coastal corridor of New South Wales.

### OLYMPIC CO-ORDINATION AUTHORITY

The Olympic Co-ordination Authority (OCA) was formed in 1995 to provide most venues and facilities for the year 2000 Olympics and to manage the redevelopment of Homebush Bay.

The Authority will develop Homebush Bay in a manner consistent with the *Environmental Guidelines for the Summer Olympic Games*, a document produced by the Environment Sub-Committee of Sydney Olympics 2000 Bid Ltd, and presented to the International Olympic Committee (IOC) in September 1993. The Guidelines have been incorporated into *State Environmental Planning Policy* (SEPP) No 38 which applies to all Olympic Developments.

The Authority must also plan beyond the Games, to provide a new suburb with a unique mix of residential, commercial and sporting developments in an extensive parkland environment suitable for both active and passive recreation.

The OCA has set out to support Ecologically Sustainable Development (ESD) in an urban setting and encourage best practice in all facets of development at Homebush Bay. Best practice is site specific, particularly with regard to the natural environment, and the pursuit of best practice by urban and landscape designers and architects for the renewal of Homebush Bay must reflect Sydney's lifestyle and climate and the unique setting of the site.

The principles for implementation of ESD at Homebush Bay come under three key performance areas: conservation of species, conservation of resources and pollution control.

### **HOMEBUSH BAY ECOLOGICAL STUDIES**

Jointly with the Commonwealth Department of Defence, the Olympic Co-ordination Authority has undertaken a comprehensive range of ecological studies of Homebush Bay. Separate studies have been commissioned by Bicentennial Park. From these studies, the most significant flora, fauna and ecosystems have been identified and are documented in Volumes I and II of the *Homebush Bay Ecological Studies, 1993-1995*.

Studies cover key species, particularly rare and/or endangered species, including their movement, distribution and interrelationship with other communities of Homebush Bay. Some studies are ongoing. The studies included in Volume I are as follows:

#### ***Fish Study***

The Ecology Lab:  
September 1994

The bay waters of Homebush Bay are home to a number of commercially important fish, prawns and crabs which include dusky flathead, yellowfin bream, silver biddy, king prawns, mud crab and blue swimmer crab. The mud flats appear to be the richest in species diversity, whereas the fish fauna of the wetlands were depauperate in comparison to the bay and the creeks. The assemblages of fish in Homebush Bay are similar to those in other parts of the upper estuary of the Parramatta River.

#### ***The Ecology and Management of Shorebirds (Aves:Charadrii)***

The Australian Museum:  
December 1994

The Australian Museum has completed a study on the ecology and management of shorebirds in the lagoons and intertidal mudflats of Homebush Bay. The study focused on the three most common species; Black-winged Stilt, Curlew Sandpiper and the Bar-tailed Godwit and also determined the relationships between bird densities, food abundance and the physical attributes of their habitats.

#### ***Wetlands Study***

University of Technology:  
May 1995

This study has addressed three aspects of the saltmarsh ecosystems of Homebush Bay; ecology, propagation trials and transplantation studies. The project has been successful in each of its three aspects and shows promise in the ability to recreate saltmarsh habitat at Homebush Bay. The study is ongoing and aims to also investigate the dynamic interaction of saltmarsh with mangroves.



Volume II contains the following studies:

***Fish, Prawns and Crabs in the 2SM Pond***

The Ecology Lab

August 1995

The plan to revitalise and recreate wetlands around Homebush Bay involves the monitoring of flora and fauna both before and after such remedial works. This study determined the fish, prawn and crab fauna in the 2SM pond and access channel before modification. The fish fauna in the pond was found to be significantly different from that in Haslams Creek. The presence of small juvenile fish in the 2SM pond indicates that the pond may be a suitable nursery habitat for fish of economic importance.

***Homebush Bay Avifauna Study: Part 1 — Waterbirds***

Royal Australasian Ornithologists Union

September 1993

Homebush Bay contains a unique mosaic of wetland habitats that support Sydney's most significant populations of waterbirds. The combination of saltmarsh, intertidal wetlands and freshwater wetlands provide habitat for many species of wading birds including Latham's Snipe, Pacific Golden Plover, Bar-tailed Godwits and Black-winged Stilts. The wetlands of Homebush Bay are an essential link to the remaining wetlands in the Sydney region and form part of the coastal corridor used by internationally protected migratory waders.

***Homebush Bay Avifauna Study: Part 2 — Woodland birds***

Royal Australasian Ornithologists Union

January 1994

The Homebush Bay site includes locally rare woodland communities that support a number of regionally rare species of birds such as the White-fronted Chat, Red-rumped Parrot, Osprey, White-bellied Sea-eagle, Marsh Harrier, Peregrine Falcon and Australian Hobby. The eucalypt woodland is a focus for many of the woodland birds providing roosting and breeding sites, while the surrounding grasslands and shrublands provide food resources for these species.

***Wetlands and Benthos***

The Australian Museum

February 1993

This survey is significant in being the most comprehensive survey of macrofauna of the estuarine environments of the Homebush Bay. The survey covered all of the wetland sites of Homebush Bay including the Newton wetlands, the 2SM and 2KY arials, Elcom ponds, the brickworks mangroves, Bicentennial Park and Mason Park. Although the mangroves and associated saltmarshes appear healthy the estuarine macrofauna biodiversity is depauperate. The absence of crabs and crab holes, oysters and barnacles at most sites was striking. The ponds and billabongs appeared to be eutrophic with very little fauna. Improved tidal flushing is recommended as the first step in the improvement of the biodiversity of the estuarine ecosystems.

***Saltmarsh Vegetation Study***

University of New South Wales

February 1993

This survey specifically identified saltmarsh flora of Homebush Bay and complements the information in the Vegetation Survey. Homebush Bay contains common saltmarsh species such

as *Sarcocornia quinqueflora*, *Sueada australis*, *Juncus kraussii*, *Juncus acutus*, *Cotula coronopifolia* as well as the rare plants, *Wilsona backhousei*, *Lampranthus tegens* and *Haloscargia pergranulata*.

**Remediation Report**

Nick Withers

AXIS Environmental:

December 1995

This paper details the evolution of the techniques used to manage contaminated land at the Homebush Bay Site. The risk assessment and management techniques used allowed integration of a range of issues including multiple landuses, a mosaic of habitats and a distribution of contaminants. The result was a major reduction in remediation costs with no loss in quality of environmental protection.

***Fauna Impact Statement — Masterplan***

The Australian Museum

November 1995

The endangered Green and Golden Bell Frog (*Litoria aurea*) has been observed throughout Homebush Bay. A Fauna Impact Study (FIS) was prepared to assess the impact of the development proposed in the 1995 Homebush Bay Masterplan on the continued survival of the frog. This report details the conditions required by two existing licences issued by the Director-General of National Parks and Wildlife which ensure the Green and Golden Bell Frog population at the site will be sustainable. Such ameliorative measures include the recreation of frog habitat, the provision of dispersal corridors and ongoing monitoring of frog populations.

# FISH, PRAWNS AND CRABS STUDY



# **Survey of Fish, Prawn and Crabs in the 2SM Pond, Homebush Bay**

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September 1994

# 1 INTRODUCTION

## 1.1 BACKGROUND AND AIMS

As part of an overall plan to improve the waters and lands around Homebush Bay, the Olympic Coordination Authority intends to revitalise and develop the Haslam's Creek Wetlands, focusing on improving the tidal flushing and water exchange of the wetlands. It is proposed that the 2SM pond shall be pumped dry and then the ashen sediments removed to 1.5 m depth. It is envisaged that the newly created wetland will duplicate the tidal range of Haslam's Creek and increase the diversity of habitats. As a requirement of the environmental assessment of the proposed scheme, The Ecology Lab Pty Ltd was commissioned by Waste Services to undertake a survey of fish, prawns and crabs in the 2SM Pond, located off Haslam's Creek, in Homebush Bay. The pond had earlier been sampled qualitatively by The Ecology Lab as part of a much larger survey of fish in Homebush Bay, Powell's Creek and Haslam's Creek. The present survey aimed to provide more detailed information by sampling more intensively and over two tidal cycles. More specifically, our aim was to determine which species of fish occur in the 2SM pond and access channel and how similar is the fish community there compared to Haslam's Creek. Sampling was to be done in the 2SM pond, in the access channel between the pond and Haslam's Creek, and within Haslam's Creek itself.

## 1.2 EXISTING INFORMATION

### 1.2.1 *Fish Habitats*

Previous studies (The Ecology Lab, 1994; West *et al.* 1985) have established that Homebush Bay has a variety of estuarine habitats that are utilised by various plants and animals. These habitats include mangroves, saltmarshes and muddy substrata. Importantly, the wetlands around Homebush Bay (of which the 2SM pond is a large part) support the largest stand of mangroves in the Sydney Harbour estuary and, of the 0.073 km<sup>2</sup> of saltmarsh estimated to exist in the estuary (West *et al.* 1985), nearly all of this is confined to the lands surrounding Homebush Bay (The Ecology Lab, 1994). Limited studies by the SPCC (1981 a; 1981 b) and by Bell *et al.* (1984) suggest that different estuarine habitats support different assemblages of fish. Although few fish could be regarded as unique to any given estuarine habitat, these and other studies suggest that mangroves may be important nursery areas for many species of fish from adjacent habitats (Hutchings and Saenger, 1987). Dominant fishes in mangroves include numerous species of Gobiidae (gobies), Pseudomugilidae (blue-eyes), Gerridae (silver biddies), Mugilidae (mullet), Sparidae (bream), Girellidae (blackfish) and Platycephalidae (flathead). In addition, crustaceans of economic value may occur in mangrove habitats, including species of Portunidae (blue swimmer and mud crabs) and Penaeidae (prawns) (The Ecology Lab, 1994).

The few studies (e.g. Gibbs, 1985 & Morton *et al.* 1987) that have been done on saltmarshes and muddy substrata suggest that these environments support far fewer species of fish than mangroves. The species likely to dominate in saltmarsh are mosquito fish (an introduced species), blue-eyes and gobies. Gobies also dominate the fish fauna in mud flats, and other fishes found in mud flats are common in mangroves.

### 1.2.2 *Fish Assemblages*

The only previous study focusing on the fish assemblages in and around Homebush Bay was by The Ecology Lab (1994). That study recorded thirty-three species of fish from Homebush Bay and the surrounding wetlands. The most speciose family was the Gobiidae, with at least 11 species. All other families contained only one or two species. Three species of fish, *Loopholes* sp., *Girella tricuspidata* and *Arenigobius* nov. sp., were not listed as having been recorded previously from the waters west of the Gladesville Bridge (The Ecology Lab, 1994). Six species from two families of crustaceans of economic value were also recorded. The value of the 2SM pond as a suitable fish habitat was estimated, and some sampling (between October and December, 1993) was done in an attempt to determine what species existed within the pond. The six species of fish recorded from the wetland were *Anguilla* sp. (eel), *Pseudomugil signifer* (blue-eye), *Gambusia affinis* (mosquito fish), *Mugil cephalus* (sea mullet), *Acanthogobius flavimanus* (oriental goby) and *Pseudogobius olorum* (Swan River goby). Although the fish fauna of the wetland was considered depauperate compared to the bay and creek habitats, the pond was considered to be a suitable habitat for fish due to the moderate tidal exchange and dense growth of surrounding mangroves.

## 2 STUDY METHODS

### 2.1 SAMPLING LOCATIONS AND TIMES

Sampling was done in the 2SM pond, the access channel draining to Haslam's Creek and in Haslam's Creek (Figure 1). The sampling took place in the middle and end of July to allow two tidal cycles to be sampled, thus obtaining a measure of short-term temporal variability in diversity and abundance of fish. All sampling had to be done during the upper half of the tidal cycle, as the water level was too low in the pond and access channel for sampling and navigation at low tide.

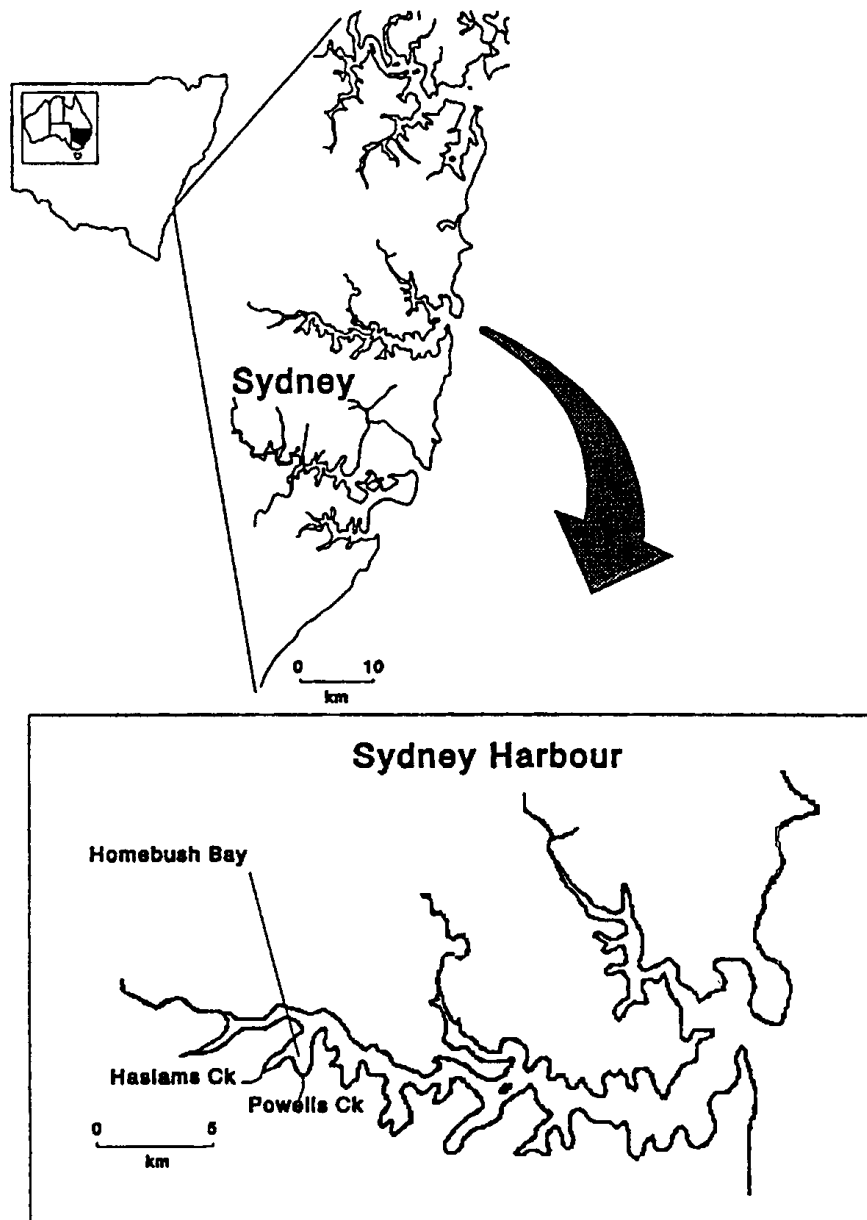


Figure 1. Regional setting of Homebush Bay

## 2.2 SAMPLING METHODS

### 2.2.1 Gill Nets

Three gill nets were laid at each of four locations (Figure 1) to catch relatively large, bottom-dwelling and pelagic fish. The gill nets were 60 m long, 2 m deep with 65 mm mesh (knot to knot), and were set in the water for about 4 hours. As the gill nets were retrieved, fish were identified and measured to fork length (LCF), and any fish that were deformed or had lesions were kept on ice and returned to the laboratory.

### 2.2.2 Beach Seines

Five beach seines were done at each location to catch small, bottom-dwelling and pelagic fish and invertebrates. The seine used was 10 m long, 1 m deep with 2 mm mesh throughout. After each haul of the net, fish and invertebrates collected were preserved in dilute (10%) formalin and returned to the laboratory for sorting, counting and identification. Species of fish of economic importance were also measured to fork length to enable an estimate of life history stage. Prawns were only identified to genus level and not measured.

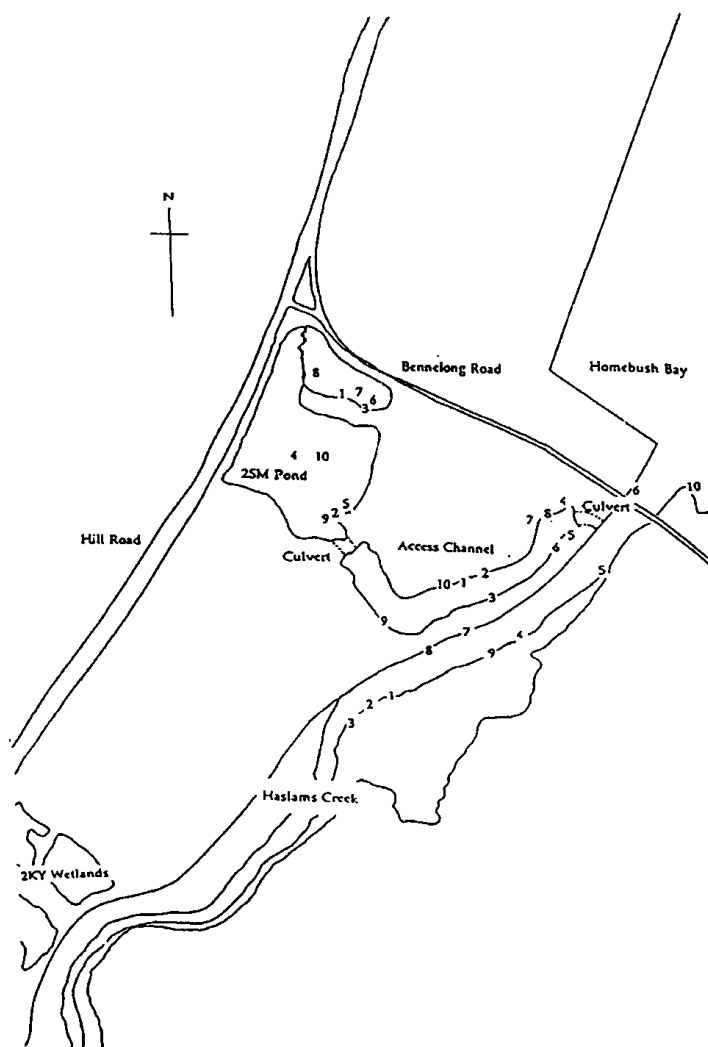


Figure 2. Map showing the beach seine locations.

### 2.3 STATISTICAL ANALYSIS

Data for the gill net samples were insufficient to allow extensive statistical analyses and results are described generally. However, the data collected from the beach seine samples were examined at two levels. First, we examined variation among various locations through time for the entire *assemblage*, that is all species of fish and crustaceans together. The statistical procedures, known as *multivariate analyses*, distill a measure of the assemblage from all the constituent species. The information obtained from the multivariate analyses included a) a measure of how similar (or dissimilar) one assemblage at one location is from another at a certain time or over several times; b) a statistical test which determines whether the (dis)similarity represents a real effect, or may simply have occurred by chance and; c) which species within the assemblage contributed most to the (dis)similarities observed from location to location or time to time.

The multivariate analyses used were the same as those described by Field *et al.* (1982) and Clarke (1993). These techniques use a measure of the rank similarity between samples to map their

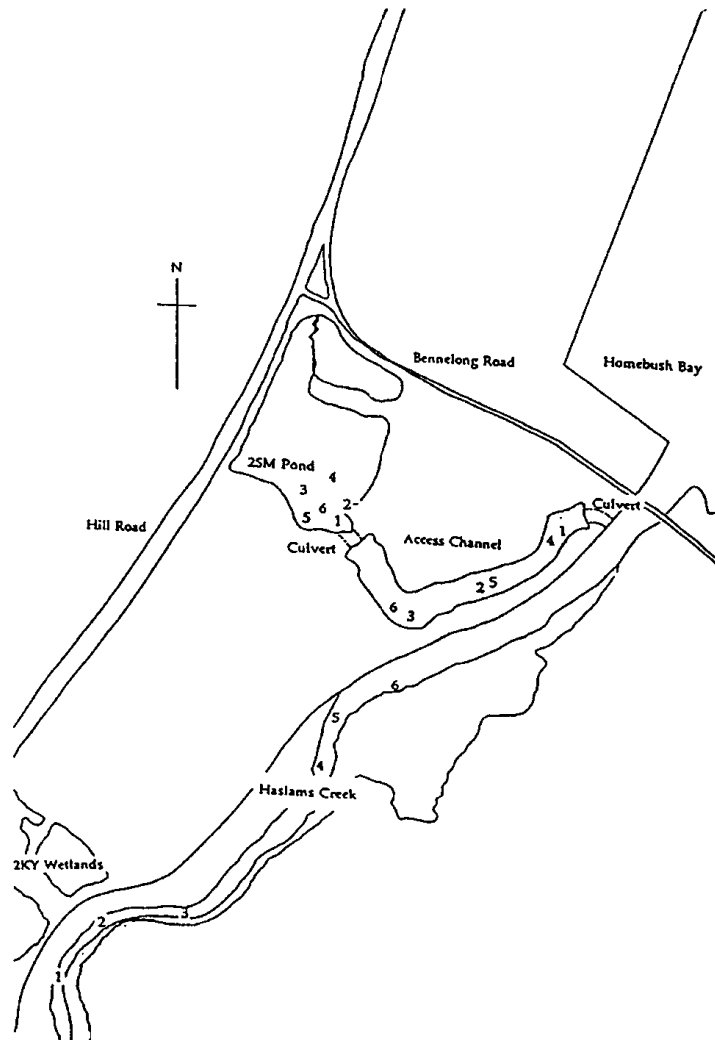


Figure 3. Map showing the gill net locations.

relationships in an ordination using non-metric Multi-Dimensional Scaling (MDS). They allow a graphical representation of the similarity (and dissimilarity) of the samples and an assessment of the relative contribution that a particular species make to variation among the whole assemblages of organisms (Clarke, 1993).

Ordination plots using all the taxa identified for each sampling technique examined the relationships of fish and crustacean assemblages. The replicates for each time/location combination were pooled to reduce the complexity of the ordination plots. Data were transformed by taking the double square root to reduce the numerical weighting given to abundant species and increase the weighting given to rarer species. Bray-Curtis (dis)similarities among samples were calculated and used to construct two-dimensional MDS plots. The adequacy of two dimensional plots was assessed by examining the stress values (Clarke, 1993). Plots with stress values less than 0.200 were considered to yield a suitable representation in two dimensions, values greater than 0.200 were considered unsuitable for interpretation (Clarke, 1993).

A 2-way crossed analysis of similarities (ANOSIM) randomisation test (Clarke 1993) was used to compare times and locations. The ANOSIM procedure is based on a rank order test. The entire data set is subjected to random permutations to construct a probability distribution against which the actual similarity may then be compared. This allows a determination of the probability that the actual similarity occurred by chance. Note that the number of treatments

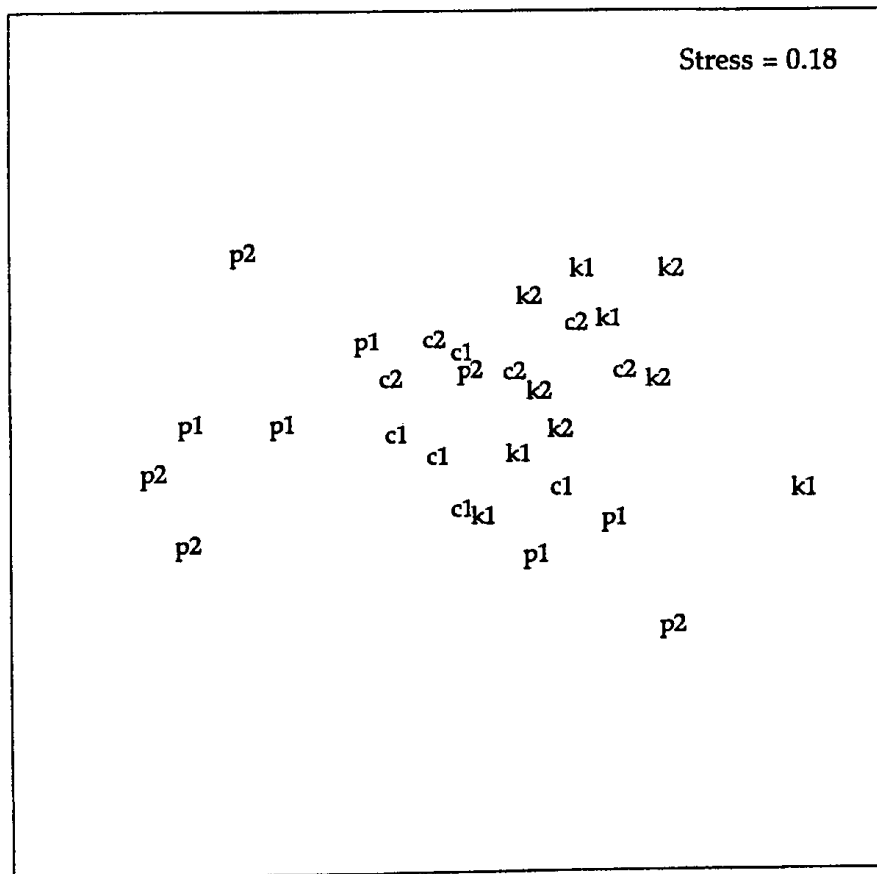


Figure 4. MDS plot comparing the three Locations.



must be large enough to provide an adequate number of permutations to determine significant pairwise comparisons.

Similarity analyses (SIMPER) were used to determine the relative contribution that a particular species or taxa made to the dissimilarity of groupings (Clarke 1993).

The second method of data analysis compared variation among locations through time for particular *species* of fish or crustaceans using *univariate analyses*. These analyses compared the average (or mean) abundance of a species among locations and/or times in association with the variance within and among the locations and/or times being compared. The information obtained from the univariate analyses included a) a measure of the mean abundance and variance of a species at the locations and times of interest; b) a statistical test which determines whether the difference in mean abundance of a species among locations and/or times represents a real effect, or may simply have occurred by chance and; c) which sites and/or times, if any, are significantly different from the other locations and times sampled.

The univariate procedure used was analysis of variance (ANOVA), which compared the numbers of species of fish and crustaceans, the total number of individuals (all species combined) and the abundance of several of the most common species. ANOVA allowed examination of the variability for three factors: sampling times; locations; and interactions between these factors.

There are several procedures associated with ANOVA that were followed (see Underwood, 1981; Winer *et al.*, 1991 for further details). Prior to ANOVA, Cochran's C statistic was used to determine homogeneity of variances. Where the Cochran's C statistic was significant, data were transformed to  $\ln(x+1)$  and re-analysed. If the C statistic was still significant, the ANOVA was done using raw data, but the significance criterion for the test, was reduced from the conventional level of 0.05 to 0.01. Where statistical interactions were non-significant ( $p \geq 0.25$ ), they were pooled to strengthen tests of other interactions and main effects (Winer *et al.*, 1991). Where ANOVA was significant, Student Newman Keuls (SNK) tests were used for pairwise comparisons of the significant terms in the analysis.

### 3 RESULTS

#### 3.1 GENERAL OBSERVATIONS

##### 3.1.1 *The 2SM Pond*

The pond is a large, tidal lagoon bordered by mature and immature grey mangroves, *Avicennia marina*. It is divided into two medium sized basins by maintenance tracks that lead to the radio mast. The depth of the pond was generally less than 1 m, and most of the pond was congested with green algae formed into very thin, broad sheets. The sediments were soft and anoxic. Juveniles of several species of fish were observed throughout the pond. A range of avifauna, including black ducks, herons and other wading birds, and a pair of white-breasted sea-eagles were also observed.

##### 3.1.2 *The Access Channel*

This channel linked the pond with Haslam's Creek and ranged from about 4–20 m wide. It was also fringed by grey mangroves and varied in depth from about 15 cm (the upper reach at low tide) to 2 m. The sediments in the channel were also anoxic, but not as soft as in the pond. In addition to algae, there was a large amount of gross pollution recovered in the gill nets and beach seines, composed mostly of plastic bags and pieces of styrofoam. A few ducks and one waterhen were observed.

##### 3.1.3 *Haslam's Creek*

Haslam's Creek enters the south-western corner of Homebush Bay. It ranges in width from about 3 to 25 m, and in depth from about 2 to 5 m. The creek is also lined with grey mangroves, broken intermittently by retaining walls or other anthropogenic structures. There were large amounts of debris in the creek, ranging from dead trees to plastic bags and wrecked cars. Cormorants, waterhens and black ducks were observed, particularly near the mouth of the creek.

#### 3.2 FISH AND CRUSTACEANS

Twenty-three species of fish from 14 families comprising of 30 395 individuals were recorded from the 2SM Pond, access channel and Haslam's Creek over the two sampling periods. The most speciose family was the Gobiidae (gobies), with 6 species, followed by Mugilidae (mullet) with 3 species. All the other families contained only one or two species and all the fish were typical of NSW estuaries. Four of the twenty-three species recorded occur in fresh and brackish water and, with the exception of Pacific blue-eye (*Pseudomugil signifer*), these species were restricted to the 2SM Pond.

Six species of crustaceans from five families with a total of 215 individuals were also recorded. Three species were of economic importance, *Penaeus plebejus*, the eastern king prawn (accounting for 2.3% of the invertebrate catch), *Metapenaeus* spp. probably juvenile school or bay prawns (38%), and *Scylla serrata*, the mud crab (0.5%).

##### 3.2.1 *Gill Nets*

The gill nets yielded a total of five species of fish totalling 34 individuals. All these species were of economic value. The most abundant species was the sea mullet (*Mugil cephalus*), accounting

Table 1 Number of fish and invertebrates caught beachseining (5 reps), Time 1.

Family Name	Species Name	Common Name		Location		
				Pond	Channel	Creek
Anguillidae	<i>Anguilla reinhardtii</i>	Long-finned eel	Mean	0.6	0	0
			SE	0.24	0	0
Clupeidae	<i>Hyperlophus spp.</i>	Sandy sprat	Mean	0	0	0.2
			SE	0	0	0.2
Poeciidae	<i>Gambusia affinis</i>	Mosquito fish	Mean	32.6	0	0
			SE	20.5	0	0
Pseudomugilidae	<i>Pseudomugil signifer</i>	Pacific blue-eye	Mean	242	44.2	6.4
			SE	167	31.2	5.91
Syngnathidae	<i>Urocampus carinorostrus</i>	Hairy pipefish	Mean	0.2	0.8	0.2
			SE	0.2	0.37	0.2
Platycephalidae	<i>Platycephalus spp.</i>	Flathead*	Mean	0.2	0	0
			SE	0.2	0	0
Ambassidae	<i>Velambassis jacksoniensis</i>	Port Jackson perchlet	Mean	0.4	0	4
			SE	0.24	0	3.51
Gerridae	<i>Gerres subfasciatus</i>	Silver biddy*	Mean	15.2	2	0.8
			SE	6.59	1.3	0.8
Sparidae	<i>Acanthopagrus australis</i>	Yellowfin bream*	Mean	0	0.4	0
			SE	0	0.24	0
	<i>Rhabdosargus sarba</i>	Tarwhine*	Mean	0	0.2	0
			SE	0	0.2	0
Mugilidae	<i>Liza argentea</i>	Flat-tail mullet*	Mean	0	0	41.8
			SE	0	0	41.8
	<i>Mugil cephalus</i>	Sea mullet*	Mean	0	0	0
			SE	0	0	0
Gobiidae	<i>Arenigobius bifrenatus</i>	Bridled goby	Mean	0	0.4	0
			SE	0	0.4	0
	<i>Favonigobius exquisitus</i>	Exquisite goby	Mean	0	0	0.2
			SE	0	0	0.2
	<i>Gobiopterus semivestita</i>	Glass goby	Mean	1350.8	64.6	198.2
			SE	916.28	52.19	181.76
	<i>Mugilogobius stigmaticus</i>	Goby	Mean	0.8	0.8	0
			SE	0.8	0.58	0
	<i>Pseudogobius olorum</i>	Swan River goby	Mean	9.6	157	66.8
			SE	2.79	42.3	19.8
	<i>Redigobius macrostoma</i>	Large-mouth goby	Mean	2	6.4	3.2
			SE	1.38	5.66	2.52
Elotridae	<i>Gobiomorphus australis</i>	Striped gudgeon	Mean	0.2	0	0
			SE	0.2	0	0
	<i>Hypseleotris compressa</i>	Empire gudgeon	Mean	0	0	0
			SE	0	0	0
Monacanthidae	<i>Monacanthus chinensis</i>	Fan-bellied leatherjacket*	Mean	0	0.2	0
			SE	0	0.2	0
Tetraodontidae	<i>Tetraodontid spp.</i>	Toadfish	Mean	0	1	0.2
			SE	0	0.63	0.2
Alpheid	<i>Alpheus euphrosyne</i>	Snapping-prawn	Mean	0	0.2	0.2
			SE	0	0.2	0.2
Caridae		Carid prawn	Mean	1.4	1.8	1.6
			SE	0.75	1.1	1.6
Penaeid	<i>Metapenaeus spp.</i>	Prawn*	Mean	0.4	0	8.8
			SE	0.4	0	3.16
Penaeid	<i>Penaeus plebejus</i>	Eastern king prawn*	Mean	0	0.2	0.8
			SE	0	0.2	0.8
?	<i>Halicarcinus spp.</i>	Beaked sea spider	Mean	0.2	0	0.2
			SE	0.2	0	0.2

\* denotes species of economic importance.

Table 2 Number of fish and invertebrates caught beachseining (5 reps), Time 2.

Family Name	Species Name	Common Name		Location		
				Pond	Channel	Creek
Anguillidae	<i>Anguilla reinhardtii</i>	Long-finned eel	Mean	0	0	0
			SE	0	0	0
Clupeidae	<i>Hyperlophus spp.</i>	Sandy sprat	Mean	0	0	0.4
			SE	0	0	0.4
Poeciidae	<i>Gambusia affinis</i>	Mosquito fish	Mean	15.6	0	0
			SE	8.3	0	0
Pseudomugilidae	<i>Pseudomugil signifer</i>	Pacific blue-eye	Mean	82.6	73.2	1.2
			SE	57.5	72	0.73
Syngnathidae	<i>Urocampus carinorostus</i>	Hairy pipefish	Mean	0	0	0
			SE	0	0	0
Platycephalidae	<i>Platycephalus spp.</i>	Flathead*	Mean	0.2	0	0
			SE	0.2	0	0
Ambassidae	<i>Velambassis jacksoniensis</i>	Port Jackson perchlet	Mean	0	0	17.2
			SE	0	0	16.7
Gerridae	<i>Gerres subfasciatus</i>	Silver biddy*	Mean	8.4	0.6	1.8
			SE	7.4	0.6	1.36
Sparidae	<i>Acanthopagrus australis</i>	Yellowfin bream*	Mean	0.2	0	0
			SE	0.2	0	0
	<i>Rhabdosargus sarba</i>	Tarwhine*	Mean	0	0	0
			SE	0	0	0
Mugilidae	<i>Liza argentea</i>	Flat-tail mullet*	Mean	0	0	41.8
			SE	0	0	41.8
	<i>Mugil cephalus</i>	Sea mullet*	Mean	1.2	0	0
			SE	0.97	0	0
Gobiidae	<i>Arenigobius bifrenatus</i>	Bridled goby	Mean	0	0	0.6
			SE	0	0	0.4
	<i>Favonigobius exquisitus</i>	Exquisite goby	Mean	0	0	0
			SE	0	0	0
	<i>Gobiopterus semivestita</i>	Glass goby	Mean	3380.2	31	43.4
			SE	3378.5	18.06	11.664
	<i>Mugilogobius stigmaticus</i>	Goby	Mean	0.2	0	0.4
			SE	0.2	0	0.4
	<i>Pseudogobius olurum</i>	Swan River goby	Mean	10.2	106	38.4
			SE	7.23	36	16
	<i>Redigobius macrostoma</i>	Large-mouth goby	Mean	0.8	0.4	2
			SE	0.8	0.4	1.05
Elotridae	<i>Gobiomorphus australis</i>	Striped gudgeon	Mean	0.2	0	0
			SE	0.2	0	0
	<i>Hypseleotris compressa</i>	Empire gudgeon	Mean	3.4	0	0
			SE	3.16	0	0
Monacanthidae	<i>Monacanthus chinensis</i>	Fan-bellied leatherjacket*	Mean	0	0	0
			SE	0	0	0
Tetraodontidae	<i>Tetraodontid spp.</i>	Toadfish	Mean	0	0	0.2
			SE	0	0	0.2
Alpheid	<i>Alpheus euphrosyne</i>	Snapping-prawn	Mean	0.4	0.2	0.2
			SE	0.4	0.2	0.2
Caridae		Carid prawn	Mean	0.6	10.6	7.4
			SE	0.4	3.7	1.99
Penaeid	<i>Metapenaeus spp.</i>	Prawn*	Mean	1	2.2	4.2
			SE	1	2.2	2.8
Penaeid	<i>Penaeus plebejus</i>	Eastern king prawn*	Mean	0	0	0
			SE	0	0	0
?	<i>Halicarcinus spp.</i>	Beaked sea spider	Mean	0	0.2	0
			SE	0	0.2	0

\* denotes species of economic importance.

for 60% of the catch, and this was the only species caught by gill net in the 2SM Pond (although several large flathead were observed prior to the sampling dates (J. Pym, Waste Services, *pers. comm.*)). The other species were flat-tail mullet (*Liza argentea*), sand mullet (*Myxus elongatus*), yellowfin bream (*Acanthopagrus australis*), and dusky flathead (*Platycephalus fuscus*), the latter three species taken only from Haslam's Creek. One juvenile mud crab (*Scylla serrata*), also a species of economic value, was caught in Haslam's Creek.

### 3.2.2 Beach Seines

The beach seines yielded a total of twenty-two species of fish totalling 30 361 individuals (Tables 1 and 2). By far the most abundant species was the glass goby (*Gobiopterus semivestita*): some 25 341 glass gobies were caught over the two sampling times and in all locations. It was most prolific in the Pond area; one seine shot catching nearly 17 000 fish. Pacific blue-eye (*Pseudomugil signifer*) and the Swan River goby (*Pseudogobius olorum*) were the next most

Table 3 Species of Fish and invertebrates contributing at least 80% of the dissimilarity between A & B.

Scientific Name	Common Name	Percent
<b>A.= The assemblages of the 2SM pond and access channel.</b>		
<i>Gobiopterus semivestita</i>	Glass goby	19.55
<i>Pseudomugil signifer</i>	Pacific blue-eye	12.83
<i>Pseudogobius olorum</i>	Swan River goby	12.7
<i>Gambusia affinis</i>	Mosquito fish	10.15
<i>Gerres subfasciatus</i>	Silver biddy*	7.61
Caridae	Carid prawn	6.7
<i>Redigobius macrostoma</i>	Large-mouth goby	4.62
<i>Metapenaeus spp.</i>	Prawn*	2.81
<i>Mugilogobius stigmaticus</i>	Goby	2.27
<i>Hypseleotris compressa</i>	Empire gudgeon	2.22
<b>B.= The assemblages of the 2SM pond and Haslam's Creek.</b>		
<i>Gobiopterus semivestita</i>	Glass goby	18.82
<i>Pseudomugil signifer</i>	Pacific blue-eye	14.35
<i>Gambusia affinis</i>	Mosquito fish	9.19
<i>Pseudogobius olorum</i>	Swan River goby	8.06
<i>Metapenaeus spp.</i>	Prawn*	7.07
<i>Gerres subfasciatus</i>	Silver biddy*	6.97
Caridae	Carid prawn	5.47
<i>Redigobius macrostoma</i>	Large-mouth goby	4.85
<i>Velambassis jacksoniensis</i>	Port Jackson perchlet	4.7
<i>Hypseleotris compressa</i>	Empire gudgeon	2.01

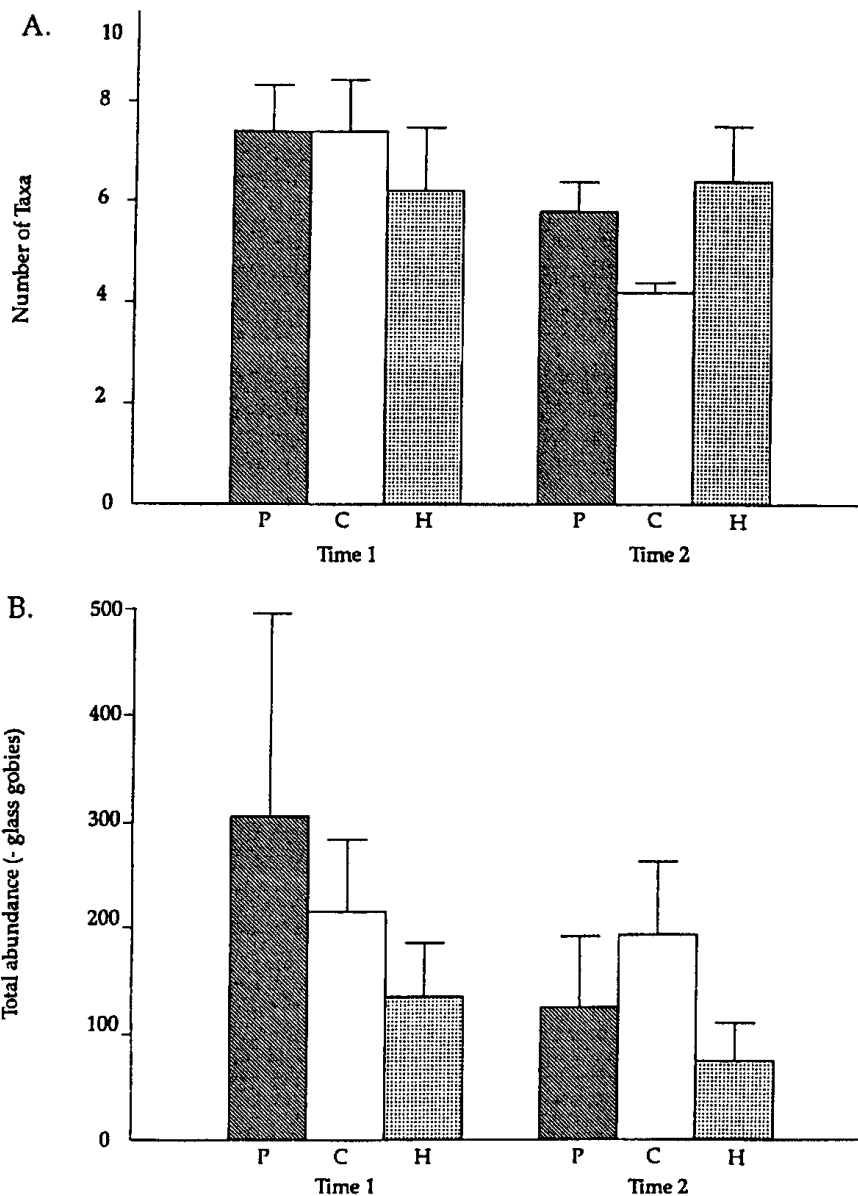


Figure 5. Mean number of taxa and total abundance ( $\pm$  S.E.) in beach seines.

abundant species (2246 and 1936 individuals respectively). Seven species of fish and at least two species of prawns of economic importance were also recorded. The most abundant of these fish was the silver biddy (*Gerres subfasciatus*), with a total of 134 individuals. One eastern king prawn (*Penaeus plebejus*) and eighty-three prawns of the genus *Metapenaeus* were recorded, and the majority of these were caught in Haslam's Creek.

The similarity between the beach seine samples is represented visually in the MDS plot (Figure 4), where most samples from the pond are clustered together and separate from the samples from the creek and channel. The analyses testing for difference in fish assemblages between the two Times (ANOSIM) indicated that there was no significant difference (Global  $R = 0.037$ ,  $p < 0.05$ ). There was a significant difference, however, between locations (Global  $R = 0.308$ ,  $p < 0.05$ ), and the multivariate analyses showed that the assemblage of fauna in the pond was significantly

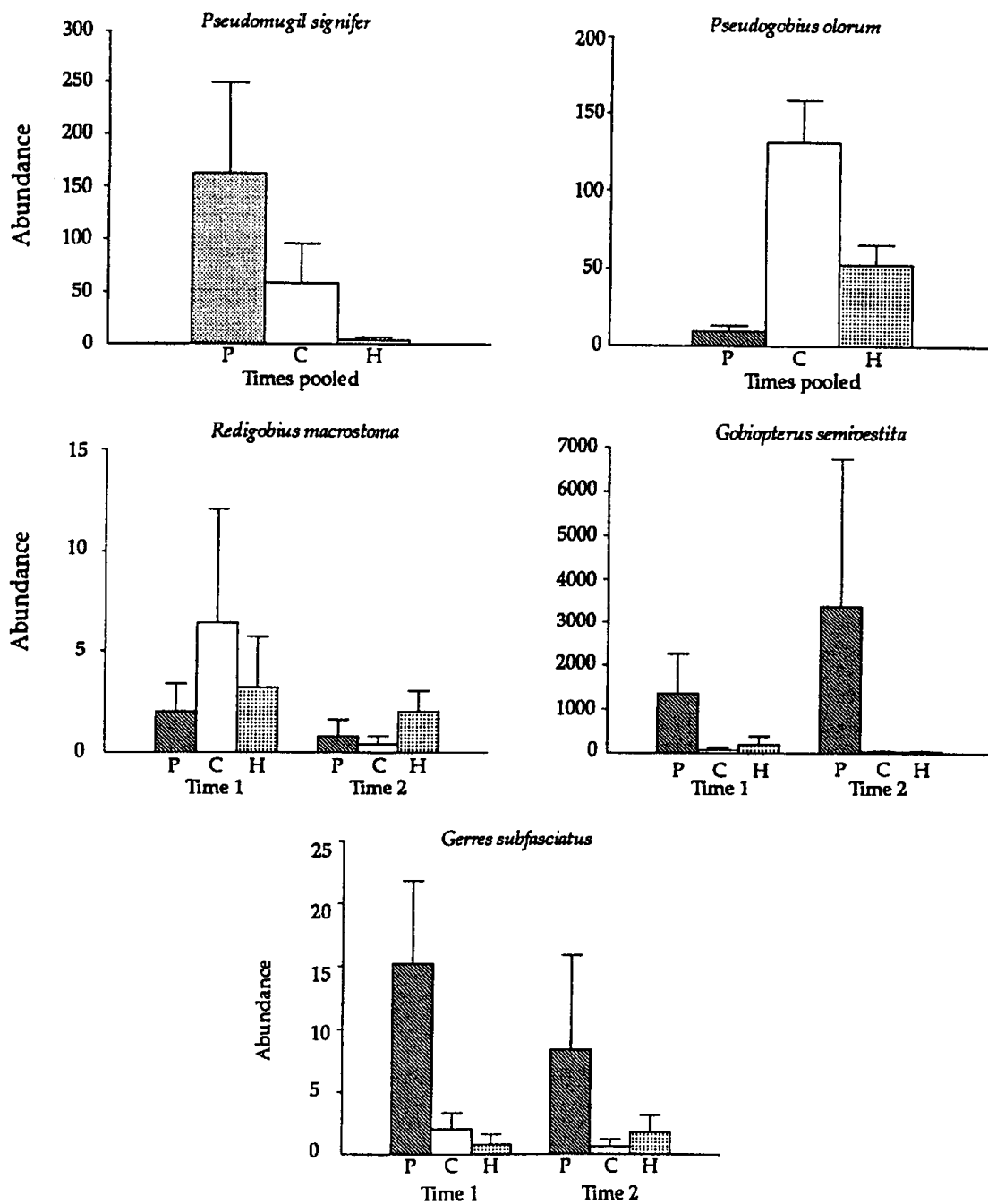


Figure 6. Mean abundances (+/- S.E.) of species examined by univariate analysis.

different to those of the access channel and the creek, which did not significantly differ ( $= 0.05$ ). The SIMPER analyses (Table 3) showed that the species which contributed most to these differences include glass goby, Pacific blue-eye, Swan River goby and mosquito fish.

ANOVAs were done for number of species, total abundance of animals (excluding glass gobies) (Table 4, Figure 5), Pacific blue-eye, silver biddy and Swan River, large-mouth and glass gobies (Table 4, Figure 6). Glass gobies were not included in the analysis of total abundance because



Table 4 Summary of ANOVAs and SNKs comparing the number of fish and invertebrates caught in beach seines among Times and Locations.

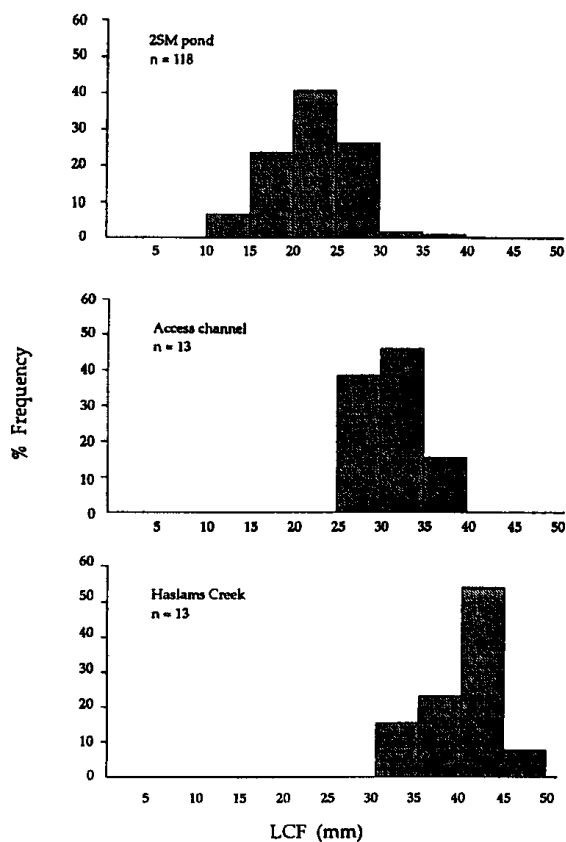
Variate	Source	df	MS	F	p	SNK
<b>Total number of taxa</b>						
	Time	1	17.63	4.07	>0.05	
	Location	2	1.63	0.23	>0.25	
	T x L	2	7.23	1.67	>0.10	
	Residual	24	4.33			
<b>Total Abundance (-glass gobies) log e(x+1) a=5</b>						
	Time	1	2.19*	1.55	>0.25	
	Location	2	2.33*	1.65	>0.10	
	T x L	2	0.28	0.18	>0.25	
	Residual	24	1.51			
<b>Pacific blue-eye (<i>Pseudomugil signifer</i>) log e(x+1) a=5</b>						
	Time	1	6.75*	2.06	>0.10	Location HCP
	Location	2	19.96*	6.1	<0.01	
	T x L	2	0.90	0.26	>0.25	
	Residual	24	3.47			
<b>Swan River goby (<i>Pseudogobius olorum</i>)</b>						
	Time	1	5174.53*	1.7	>0.10	Location PHC
	Location	2	37791.63*	12.41	<0.01	
	T x L	2	1672.63	0.53	>0.25	
	Residual	24	3160.60			
<b>Large-mouth goby (<i>Redigobius macrostama</i>) log e(x+1) a=5</b>						
	Time	1	1.03*	1.14	>0.25	
	Location	2	0.29*	0.33	>0.25	
	T x L	2	0.51	0.54	>0.25	
	Residual	24	0.93			
<b>Glass goby (<i>Gobiopterus semivestita</i>) log e(x+1) a=5</b>						
	Time	1	1.35*	0.2	>0.25	
	Location	2	1.07*	0.16	>0.25	
	T x L	2	0.74	0.1	>0.25	
	Residual	24	7.35			

**Table 4** Summary of ANOVAs and SNKs comparing the number of fish and invertebrates caught in beach seines among Times and Locations.

Variate	Source	df	MS	F	p	SNK
Silver biddy ( <i>Gerres subfasciatus</i> ) log e(x+1) a=5						
	Time	1	1.34*	1.08	>0.25	
	Location	2	4.00*	3.22	>0.05	
	T x L	2	1.23	0.99	>0.25	
	Residual	24	1.25			

\* Mean square has been tested over pooled mean square for Times x Location and Residual only if  $p > 0.25$  for the T x L interaction.

P = Pond, C = Channel. H = Haslam's Creek.

**Figure 7.** Length frequency distribution of *Gerres subfasciatus* collected by beach seines (Times are pooled).

where they did occur, it was in such numbers that the influence of other species would be overshadowed in the results. ANOVA requires that a large proportion of the values analysed are greater than zero. Thus, the species that were chosen for univariate analyses were relatively abundant throughout the sample locations, allowing meaningful conclusions to be made from the analytical results.

Significant differences occurred only in the abundances of Pacific blue-eye and Swan River goby between locations, with significantly more Pacific blue-eye in the pond compared with the creek and more Swan River goby in the access channel than in the pond (Table 4). No differences were detected between tidal cycles for any of the variables examined (Table 4).

Although the sample numbers were only small, the length-frequency data from all the locations (Figure 5) suggests that the silver biddies are utilising the three locations sampled at different sizes, although this finding must be regarded cautiously due to the small sample sizes obtained from the access channel and Haslam's Creek. Further studies would be required to confirm this hypothesis.

## 4 CONCLUSIONS

Given that sampling was done in mid-winter, it is considered that the sampling yielded a relatively large number of fish species and individuals compared to The Ecology Lab (1994) where only 4 species and 63 individuals were collected over one sample period from the pond. Sampling in the present study employed different methods and sampled the 2SM pond more intensively than the earlier study. Given the time of year that sampling was done, it may be prudent to sample again in summer, when we might expect to record different species of fish in the pond and access channel.

This study determined that the fish fauna in the 2SM pond is significantly different from both the Access Channel and Haslam's Creek (abundances of Swan River goby and Pacific blue-eye accounting for the respective differences), and that species were both more diverse and abundant in the pond. The presence of small juvenile fish of economic importance in the 2SM pond is encouraging, as it indicates that the pond may be a suitable nursery habitat.

Remediation of the area, including the removal of the gross pollution, should improve the habitat for fish; this could be of benefit to the fish populations and fisheries of the bay and possibly the whole estuary. Increasing the tidal flushing of the pond may further improve the areas value as fish habitat, by improving access for fish and improving water quality.

Conversely, it is unknown how long it will take for the pond area to be recolonised following modification, or which organisms will be involved in the recolonisation. Furthermore, we cannot confidently predict the composition of the fish assemblage after modifications, given that new conditions such as an increase in tidal exchange may also cause other changes, such as an increase in predators on fish.

This study provides a good description of fish occurring in the 2SM pond that can be used as part of a baseline to monitor the effects of future alteration of the area.

## 5 ACKNOWLEDGMENTS

This report was written by M. Green and A. Pope, with assistance from M. A. O'Donnell and M. Lincoln Smith. Statistical analyses and interpretation were done by L. Hewitt and A. Pope. A. Pope and M. Green produced the Tables and Figures. M. Lincoln Smith, A. Pope, M. Green and G. Hose conducted the field studies and M. Green and G. Hose sorted and identified the samples.

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**WATERBIRDS STUDY**



# **Waterbirds**

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## 1 INTRODUCTION

Homebush Bay is the site for some of the most important remnant coastal wetlands in NSW. The saltmarsh communities, for example, are the second largest in the Sydney area, after Towra Point Nature Reserve, but are more important as a waterbird habitat. The combination of saltmarsh, intertidal wetlands and freshwater swamps provide a unique combination of habitats which are of special significance to waders, of which about two thirds are migratory species. These birds breed in Asia from central Siberia to Alaska and southwards to northern China, passing through numerous countries on their way, travelling up to 27 000 km on a return trip. Australia has a consequent responsibility to protect them during their stay in this country. This responsibility has been accepted by the Australian Government through its signing of bilateral migratory bird protection agreements, with Japan and China and its assent to the Convention on Wetlands of International Importance, Especially as Waterfowl Habitat (known as the Ramsar Convention). Birds of particular concern are the Homebush Bay populations of Latham's Snipe and Pacific Golden Plover which form an important part of the NSW populations.

The wetlands at the Newington Naval establishment, Bicentennial Park and the tiny wetland at Mason Park are linked by a wetland corridor of tidal mudflats and mangrove forests to form an integral wetland system. The inclusion of intertidal areas further to the east, as far as Abbotsford are also an important aspect. Duck River and Parramatta River upstream of Silverwater Bridge were not included in this survey due to dredging operations and closure to all water craft during the duration of this study.

The wetlands of Homebush Bay are an essential link to remaining wetlands in the Sydney area and as part of the NSW coastal corridor used by migratory waders. This study addresses the state of waterbird habitat in the Homebush Bay area, the current bird populations and habitat usage. A baseline study was made of all waterbird populations after which a monitoring program was instigated to assess seasonal variations in populations and habitat usage. Throughout this report the term waterbirds encompasses waterfowl, waders, seabirds and any other group which depends for at least part of its life cycle on the aquatic environment.

Site descriptions in this report cover all significant habitats used by waterbirds and together with the annotated list of birds found in the area provide a comprehensive coverage of habitat usage and dependence of waterbirds.

## 2 METHODOLOGY

A review of literature was carried out to assess which species have been recorded within the study site in the past. A baseline study was conducted to establish which areas offered suitable habitat for water birds and to map distribution of waterbirds found. A monitoring program was then instigated to study seasonal variation of waterbird populations and monitor movements of waterbirds within the study area and between adjacent habitat.

Observations were made by walking along fixed transects once a week between August and April inclusive and once a month from May through to July. Transects used to assess relative abundance of woodland birds were measured from start to finish using a measuring wheel. All birds within 25 metres either side of the observer were then counted on each visit. The transects for waterbird observations were selected to obtain the best views of birds with the least disturbance. Most waterbirds including waders of the suborder Charadrii, seabirds and most duck were viewed clearly while some birds frequenting reeds and mangroves were not necessarily fully counted. Cryptic species such as crakes, rails and bitterns are particularly hard to observe and cannot be censused reliably by direct observations. Transect counts were conducted during early morning when most birds were active. The route was reversed on occasions to ensure that there was no bias at one end of the daily survey or the other. One nocturnal visit was carried out in conjunction with a woodland bird study to record nocturnal roosting species such as gulls.

Frequency of visits varied between sites with the most frequently visited sites being wetlands frequented by migratory waders. All sites were visited at least monthly with the exception of Brickworks Mangroves. All major sites within the study area were visited on at least a weekly basis from September 1992 to April 1993 inclusive then monthly from May to July 1993.

Observations were recorded verbally onto micro-tapes using a dictaphone to enable uninterrupted observations while counting with the aid of binoculars or telescope. Records were then entered onto data sheets and subsequently onto a database for later analysis. 10 x 50 binoculars and 25 x 77 telescope were used for observations.

### 3 HABITAT DESCRIPTION

#### 3.1 SALTMARSH AND MANGROVES

##### 3.1.0.1 Saltmarsh

Areas of saltmarsh utilised by waterbirds exist at Mason Park, Bicentennial Park and Newington. Small remnants of saltmarsh exist elsewhere but are not important bird habitats in their present condition. Observations of waterbirds have revealed that there are regular movements of part of the population of waterbirds between each of the main saltmarsh habitats. Most of these birds move via corridors formed by the Parramatta River and its intertidal shoreline.

The saltmarshes at Homebush Bay are the second most extensive in the Sydney area however as bird habitat the Homebush Bay saltmarshes are far more significant than any other in the Sydney area.

Saltmarshes which have associated ponds of water or which are flooded by occasional high tides usually attract waterbirds. Migratory waders such as Sharp-tailed Sandpipers, Curlew Sandpipers, Greenshank and Marsh Sandpipers utilise the saltmarshes in the Homebush Bay area for both feeding and roosting. Also non-migratory waders such as Black-winged Stilts, Red-kneed Dotterels and Black-fronted Plovers. The open nature of saltmarshes are an important factor in wader habitat as these birds prefer to feed and roost in the open where they have a clear view of potential predators. Wetlands closed in by tall trees or artificial structures will deter their use by these birds. Other species of birds found on Homebush Bay saltmarshes include herons, egrets, ibis, duck and White-fronted Chats.



Figure 1. Photo of northern ponded area at Mason Park showing small waders feeding and roosting islands



### 3.1.0.2 *Mangrove forests*

Mangroves form an important part of the wetland system of the Parramatta estuary providing nutrient input into intertidal mudflats and provide cover and nesting habitat for many birds. Birds utilising mangrove habitat include large wading birds, such as herons, egrets and ibis which feed along the fringes and shallow water margins and large numbers of passerines (woodland birds), such as Yellow Thornbills, Silvereyes, Superb Fairy-wrens and Brown Honeyeaters which feed and nest within the mangrove canopies. Mangroves and the adjacent mudflats provide the only habitat of the Striated, or Mangrove Heron which has suffered due to the loss of mangroves in many parts of NSW. The Mangroves also provide an important corridor between the various wetlands for many species of birds including the White-fronted Chat.

### 3.1.1 *Mason Park*

The wetland area at Mason Park is comprised largely of saltmarsh with a small mangrove area at the northern end and a small brackish reed swamp at the southern end. The Mason Park saltmarsh is partially intertidal with a large ponded area towards the northern end (Figure 1) which remains inundated at all times except during low tide periods, with no rain and high temperatures, when the area comes close to being dried out. A smaller ponded area (Figure 2) towards the southern area is more prone to drying out and fills only on very large tides or after heavy rain.

Tidal waters flood and drain the wetland via two 60 cm pipes placed behind a drop-log weir at the north-eastern corner of the wetland entering via the small mangrove swamp. These pipes were put in place by Sydney Water Board to enhance the wetland after it was extensively damaged by freshwater pumped into it from saleyard creek during maintenance operations. Since the construction of the weir a sill has formed around the mangrove area cutting the saltmarsh off



Figure 2. Photo of southern ponded area at Mason Park partially dried out.

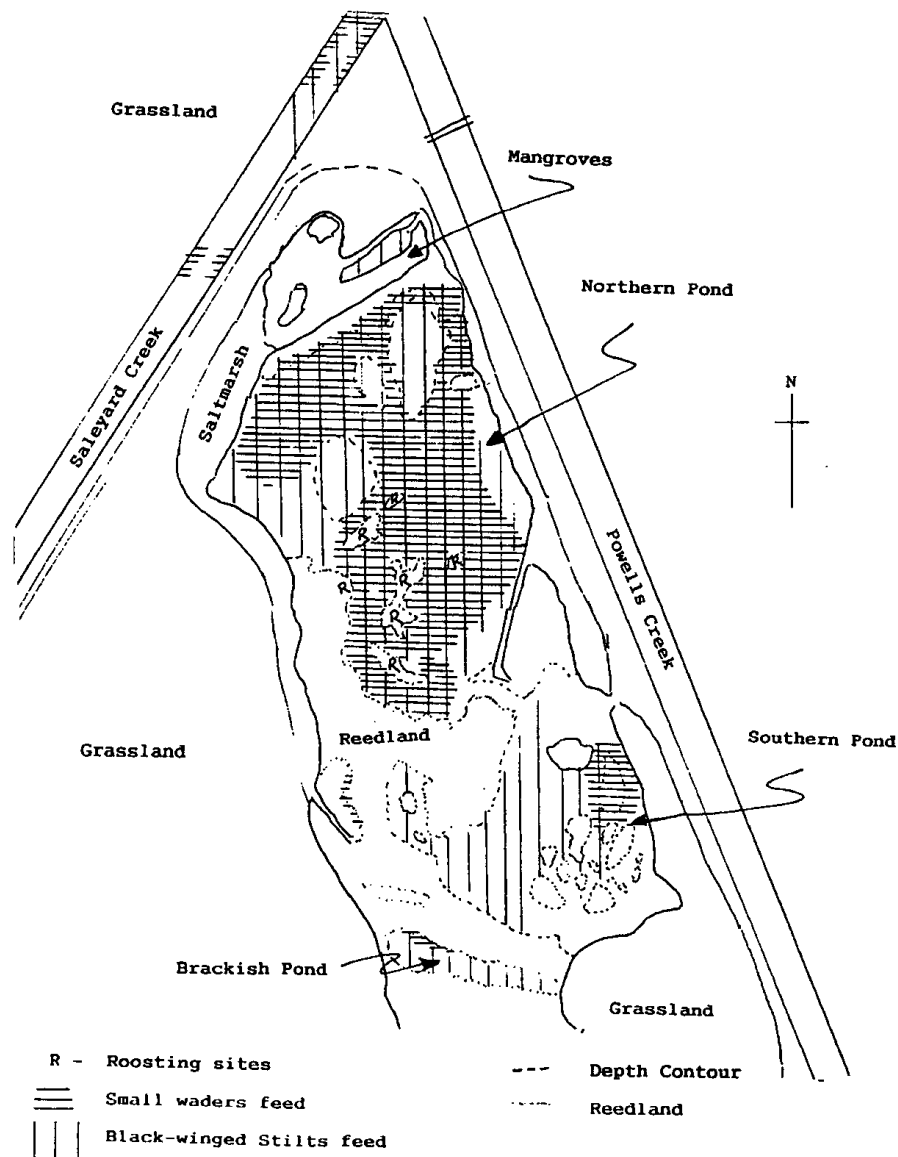


Figure 3. Mason Park Wetlands, wader feeding areas.

from tidal influence other than from tides greater than about 1.7 m in height. Heavy siltation of the channel immediately inside the weir has largely closed off a channel originally designed to flood and drain the wetland.

The saltmarsh accommodates a very large number of waders in relationship to surface area providing both feeding and roosting habitat (Figure 3). Curlew Sandpiper which are becoming increasingly rare in the Sydney area utilise Mason Park and Hen and Chicken Bay, frequently moving between the two sites. These birds currently form the largest population in the Sydney district. Large numbers of Sharp-tailed Sandpiper and about twenty Pacific Golden Plover also utilise the saltmarsh during their stay in Australia, the Pacific Golden Plover population being especially significant to the NSW population.

Resident species of waders which nest at Mason Park include Black-winged Stilts, Black-fronted Plover and possibly Red-kneed Dotterel. Black-winged Stilts had a particularly successful season for such a small wetland with up to 10 nests at one time and a high proportion of eggs hatching successfully. One of the main reasons for this success was the continued inundation of the main ponded area which would have discouraged predators such as foxes, cats and dogs. For such a high success rate the food resource, largely invertebrates, must have been plentiful, contrary to early invertebrate sampling results which revealed a very low density in the area sampled.

One pair of White-fronted Chats appear to have bred at Mason Park, although a nest was not found, judging by the behaviour of one pair observed during the breeding season and at least one juvenile.

The brackish wetland to the south of the saltmarsh attracted small numbers of stilts and several pairs attempted to breed. Non bred successfully for some reason unknown, although a nearby fox den suggests that predation could be a contributing factor. Up to two Latham Snipe were flushed from the grassland or reedland area on a regular basis from mid-August to early February. A pair of Swampheens nested early in the season but later left the wetland.

### 3.1.2 *Newington*

A series of saltmarshes, separated by small bunds, form an extensive wetland at the northern end of Newington. These saltmarshes are quite different in character from each other, depending on the extent of tidal influence. Parts of this wetland provide excellent habitat while some parts are stagnant backwaters with little value to aquatic wildlife. The only opening to tidal influence for these wetlands is a single 90 cm floodgate which is partially blocked off. Drainage from local run-off enters the wetlands via several drains and channels.

### 3.1.3 *Main Lagoon*

Main Lagoon wetland is comprised of a large shallow lagoon, fringing mudflats (Figure 4), about 5 ha of saltmarsh vegetation and mangrove woodlands. The saltmarsh, which is largely covered with *Sarcocornia*, is flooded on very high tides or after heavy rain when small pools are formed (Figure 5). The marsh is bordered by dense mangroves on the northern and north-western sides, a thin row of mangroves on the eastern side and a dense stand of *Casuarina glauca* along most of the southern shore. The western shore has only sparsely spaced trees separating the marsh from grassland. A small pond in the south-eastern corner of the marsh appears brackish. This pond is regularly frequented by small numbers of teal (up to 35) and Black-winged Stilt.

The 'Main Lagoon' is partially influenced by high tides and has a slightly varying water level which occasionally floods the *Sarcocornia* vegetation surrounding the lagoon. The wetland accommodates large numbers of Black-winged Stilts, although they do not appear to breed at the site, with flocks of up to 300 birds being counted. Other waders which were found on the wetland included Marsh Sandpiper (up to 8), Greenshank (up to 4), and one Red-necked Avocet. These birds are rarely seen in the Sydney area and are therefore significant populations. Eastern Curlew (up to 7), although not scarce in the Sydney area, have rarely been observed in the Parramatta estuary prior to this study. Important feeding and roosting areas are shown in (Figure 6).

White-fronted Chats were observed on a regular basis feeding among the saltmarsh vegetation and occasionally in adjacent mangroves. Inspection of the site on several occasions revealed large numbers of insects including small butterflies among the saltmarsh plants. Small flocks of





Figure 4. Photo of Main Lagoon from SE showing shallows and mudflats used by feeding waders.



Figure 5. Flooded saltmarsh and pool, Main Lagoon.

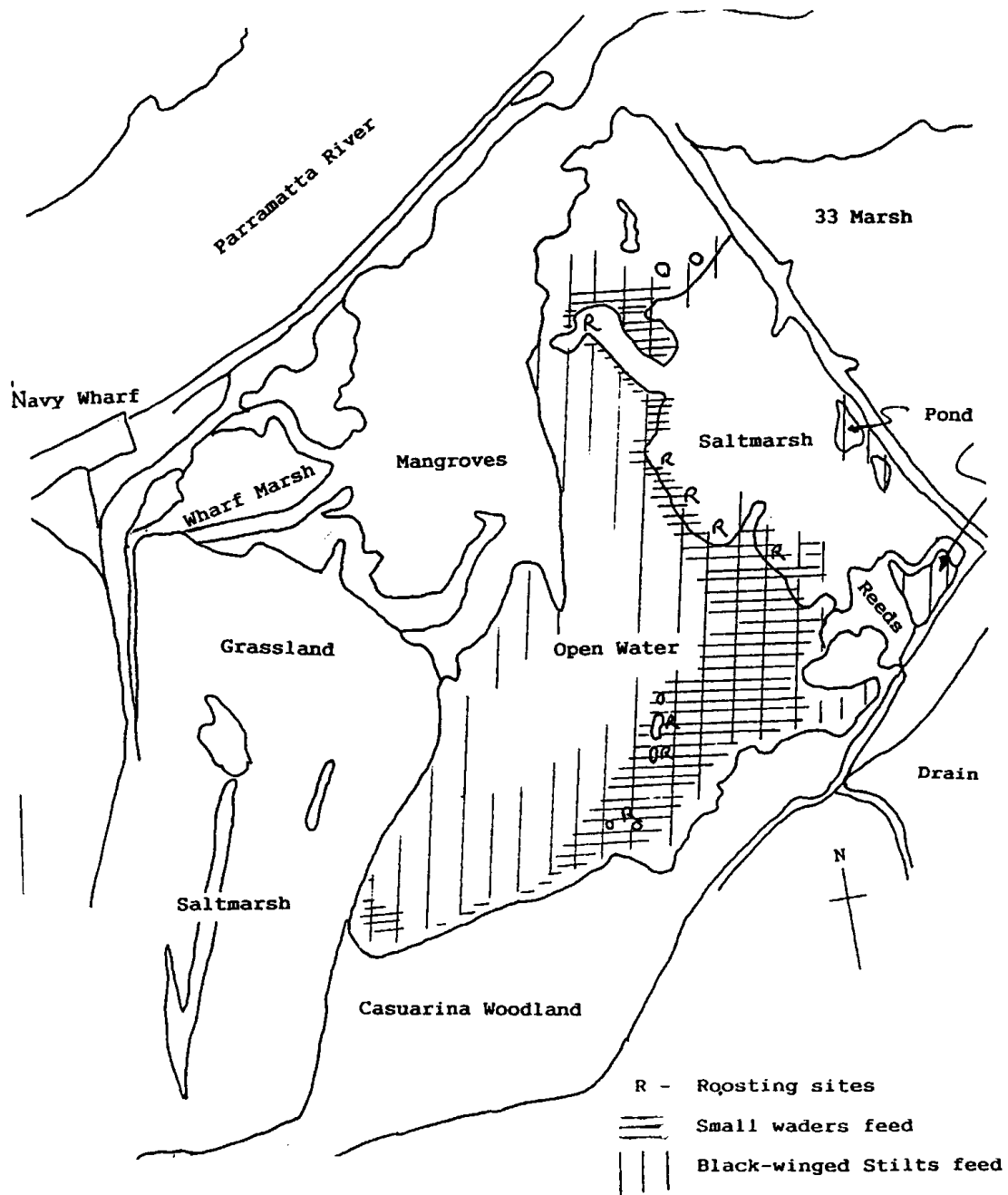


Figure 6. Main Lagoon and Wharf Marsh, wader feeding areas.

up to ten chats were observed regularly and up to 40 birds or more in a single flock during the breeding season. This was by far the largest number of chats recorded in the study area. One pair was confirmed nesting in clumps of *Suaeda* where a nest with three eggs was found.

A series of small islands in the lagoon and at in the saltmarsh provide important roost sites utilised by most species of waterbirds found using this wetland (Figure 6).

The large, open nature of saltmarsh is especially significant for waders which tend to avoid wetlands which are closed in by tall trees.





Figure 7. Photo of small pond and phragmites reed bed at Wedge Marsh.

#### 3.1.4 33 Marsh

This wetland is adjacent to Main Lagoon and is separated by a small mangrove fringed drainage channel. The marsh is made up largely of saltmarsh communities dominated by *Sarcocornia* and is basically a smaller version of the Main Lagoon wetland. A shallow pool with varying water levels which appear to be largely influenced by local run-off after heavy rains with little or no tidal flushing. A dense stand of mangroves and part of the *Sarcocornia* marsh on the northern side is flooded on large high tides. Small numbers of stilts, Sharp-tailed Sandpipers and Masked Lapwing are occasionally observed feeding along the margins of the pool. One or two Australian White Ibis were observed occasionally feeding along the margins of the fringing mangroves.

33 Marsh has very low concentration of waterbirds per hectare compared with Main Lagoon and Mason Park. Additional studies of the hydrology and invertebrate population may determine the reason for this discrepancy.

#### 3.1.5 Wedge Marsh

This wetland is largely dominated by *Sarcocornia* but has a small but significant stand of *Phragmites* growing on the western side of a small brackish pond (Figure 7). At least two pairs of Clamorous Reed Warblers nest in this reed bed. The water in the pond is very shallow with a very soft silty bottom. Small flocks of teal were often disturbed from the pond and an occasional Pacific Black Duck and small numbers of Black-winged Stilt were also noted.

White-fronted Chats feed in the saltmarsh vegetation and within the mangroves, either in the upper canopy or among the pneumatophores. At least one pair nested in clumps of saltmarsh vegetation. Other species observed feeding among the saltmarsh vegetation included Golden-

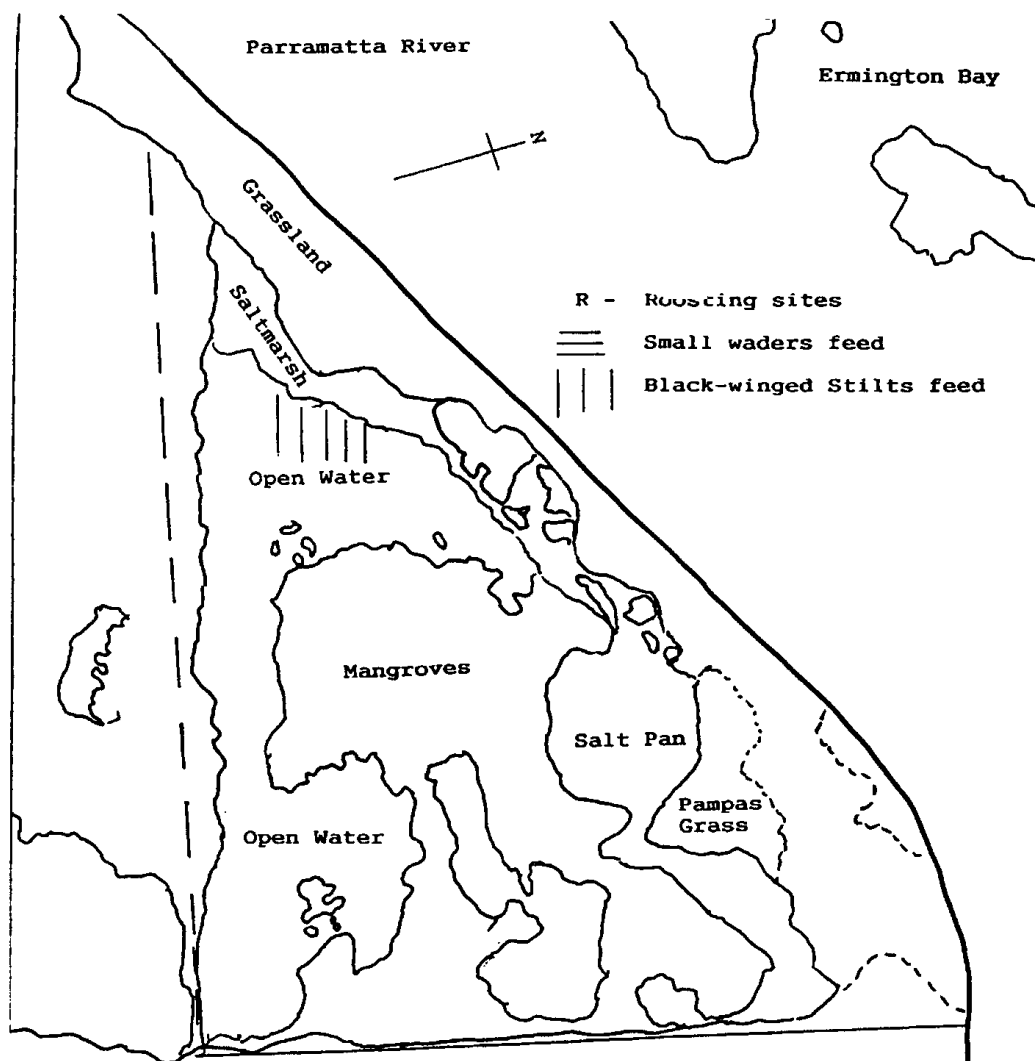


Figure 8. Corner Marsh, wader feeding areas.

headed *Cisticola*, Superb Fairy-wren and occasionally Red-rumped Parrots observed feeding on the seed heads of *Crepis* sp. Small numbers of White-faced Herons were also observed feeding at the edge of the mangroves or on the saltmarsh.

The nearby Casuarina woodland attracts small parties of woodland birds including Yellow Thornbills, Superb Fairy Wrens, Black-faced Cuckoo-Shrike and the occasional Grey Fantail. The wetland area appears in relatively good health.

### 3.1.6 Corner Marsh

This wetland is largely flooded with permanent water and has a large number of stunted or dead mangroves. The water is almost completely static with the only discernible tidal flushing close to the floodgate. Algae was at times prevalent throughout but died off during the study period. The wetland includes a small area of saltflat with sparse vegetation, an area of stunted mangroves as





Figure 9. Photo of Wharf Marsh showing pool and artificial roost sites.

well as a stand of reasonably healthy mangroves. Small clumps of *Casuarina* grow to the north-east of the marsh and along the river embankment. A section of the land between the wetland and the river is heavily weed infested with dense *Kikuyu* and *Pampas* grasses.

Small numbers of Chestnut Teal utilise the flooded wetland as a roost and feeding habitat. Small numbers of Black-winged Stilts and Royal Spoonbills were occasionally observed roosting or feeding in the shallow margins of the marsh. White-faced Herons feed within the mangroves and roost on dead mangrove stumps.

### 3.1.7 *Wharf Marsh*

A permanent lagoon surrounded by emergent vegetation. *Casuarinas* form a screen to the south and south-eastern side. A small area of saltmarsh is situated to the east of the lagoon. A shallow area (Figures 6 & 8), provides a small but valuable feeding and roosting area for small waders such as Black-fronted Plover and Red-kneed Dotterel. The wetland is separated from Main Lagoon by a broad stand of mangroves but appears to be part of the same water body. This area provides a diverse habitat which attracts a large number of birds for its size.

The number of waterbirds on this marsh varies to a large degree. Nineteen species of waterbirds have been recorded on the wetland during the study including Greenshank, Little and Great Egrets and up to 23 Dusky Moorhen, 20 Royal Spoonbills, and 30 Chestnut Teal. Clamorous Reed Warblers and Little Grassbirds inhabit the emergent vegetation bordering the edge of the lagoon. Waterbirds roost on raised platforms comprised of single planks of wood nailed on top of posts.





Figure 10. Wharf Marsh shallows (in flood).

### 3.1.8 Middle Marsh

Middle Marsh is an area of patchy saltmarsh and areas of low reedland. Small ponds within the reedlands appear attract small numbers of Pacific Black Duck, Purple Swamphen and herons, including the only observations of Pacific Heron in the study area. The area is also notable for relatively large numbers of White-fronted Chats and Golden-headed Cisticolas which nest here and are found feeding in the area for much of the year. Two nests of White-fronted Chats were found in clumps of *Juncus acutus*. Small numbers of Latham's Snipe were frequently observed during wet periods and a pair Black-fronted Plovers were often observed on the open mud flats. Nesting birds observed in open areas of the marsh included a pair of Skylarks which fledged three young and an occasional Richard's Pipit.

### 3.1.9 2KY Saltmarsh

The small saltmarsh near the 2KY antennae is occasionally partially inundated and at such times attracts small numbers of birds including Black-winged Stilt and Chestnut Teal which were observed during this study and a single White-faced Heron which was observed on a regular basis. This wetland is largely isolated from the tidal influence of Haslam's Creek and is of limited value as a waterbird habitat.

### 3.1.10 2KY Mangroves

An isolated arm of Haslam's Creek forms the northern boundary of the 2KY property. Although there is no obvious channel connecting this mangrove stand with Haslam's Creek it is subjected to tidal influence. The mangroves form a contiguous woodland habitat with Haslam's Creek

community and attracts birds such as Yellow Thornbill. A small area of saltmarsh at the western end of the mangroves and adjacent to Hill Road occasionally attracts small numbers of Chestnut Teal or solitary White-faced Heron when flooded.

#### 3.1.11 *Brickworks Mangroves*

This area of wetland is situated between the northern side of the brickworks site and the southern side of Haslam's Creek. It consists of an area of Mangroves which is largely isolated from Haslam's Creek but is connected by small channels allowing tidal flushing of the wetland. A area of about 1 ha of saltmarsh is situated to the western end of this wetland but appears to be rarely covered by tidal waters and consequently has not been observed to attract waterbirds.

The Mangrove habitat forms part of the Haslam's Creek community and provides feeding habitat for waterbirds. Small numbers of Australian White Ibis and occasional White-faced Heron and Large Egret were observed during this study.

#### 3.1.12 *Bicentennial Park Saltmarsh*

The 'Saltmarsh' at Bicentennial Park is only occasionally inundated to any great extent either by spring high tides or after heavy rainfall or a combination of these. Three ponds form part of this saltmarsh the smallest two of these are visible from the cycleway/walking track and these two are the most frequently inundated. The third pond is much larger than the other two and is situated on the southern side of the raised embankment on the south side of the Waterbird Refuge. When inundated these ponds attract small numbers of Black-winged Stilts, Chestnut Teal, Black-fronted Plovers and White-faced Herons. White-fronted Chats nest in the saltmarsh vegetation (1 nest found in *Juncus acutus*) and are frequently observed feeding along the margins of the pools.

#### 3.1.13 *Bicentennial Park Mangroves*

The most extensive area of mangroves in the Homebush Bay area. Because of the closed in nature of mangrove woodlands few waterbirds are found within the woodland itself but are found feeding along the fringes, either on the mudflats or waters edge of an estuary, waterhole or saltmarsh. A few exceptions include the mangrove heron, Australian White Ibis and occasional heron or egret. The most abundant birds found in mangrove woodlands at Bicentennial Park are woodland birds, such as Yellow Thornbill, Silvereve, Superb Fairy-wren and one or two pairs of Brown Honeyeaters.

### 3.2 FRESHWATER/BRACKISH WETLANDS

Freshwater wetlands in the Homebush area vary in size and structure between small reedbeds to large open lakes or freshwater swamps. Only those wetlands of significance to waterbirds are included in this report.

#### 3.2.1 *Bicentennial Park — Front Lake*

The 'Front Lake' at Bicentennial Park (Figure 11) is the largest body of fresh water in the Homebush study area. The lake is relatively deep (ca 7 metres) with a steep shoreline along the northern, eastern and southern shores with narrow submerged slopes capable of producing reed growth. The western shore in contrast is a shallow wetland with areas of *Typha* sp. and





**Figure 11** Photo of the shallows at Front Lake.

*Bolboschoenus* (Figure 11). The shallow muddy shores and open mudflat varies in extent between growing periods of *Bolboschoenus* and at times provides good feeding habitat for small waders. However due to frequent disturbance from the nearby walking/cycle track few migratory waders were recorded from this site. The drainage from Front Lake forms a small wetland (Figure 12) which attracts small numbers of Dusky Moorhens, Purple Swamphen, Little Grassbird and Clamorous Reed Warblers which appear to nest in the phragmites reed bed. During times of low disturbance one of two Black-fronted Plovers feed on a small area of exposed mud.

The Front Lake has three distinct islands which were built during the modification this largely artificial lake. Two of the islands, which are separated only by a narrow strip of water, are situated approximately in the middle of the lake and are covered with a dense stand of *Casuarina*. The trees on these islands provide roosting habitat for cormorants, egrets and Darter. The first recorded nesting of Darter in the Homebush area was in these trees, during this study. The third island is largely grass covered but with a few shrubs and is used as a roosting site for duck species.

Due largely to its depth the lake is devoid of floating weeds and has only a small area of submerged weed. The pond has a only a small duck population which depend to a large extent on hand feeding by the public. One pair of Black Swans bred on the lake during the 1993 breeding season and were reported nesting there prior to this study (Robert Crewes *pers. comm.*). A few feral ducks and hybrids also occur on the lake. The lake supports a large population of Dusky Moorhens which feed along the margins of the reed beds and graze on the grassy embankments, venturing as far as 50 metres from the waters edge but quickly run to the reed beds on the





Figure 12. Photo of small wetland formed by drainage from Front Lake.



Figure 13. Photo of small muddy beach and shallows and cumbungi swamp in the left background.

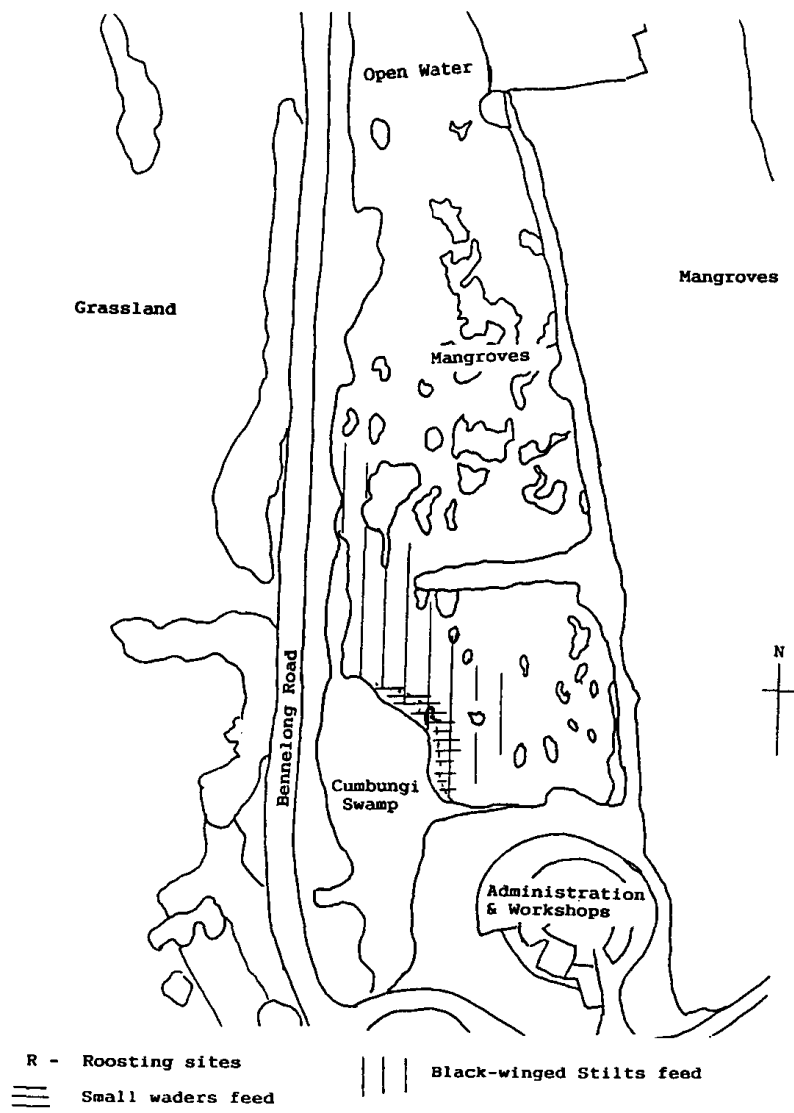


Figure 14. Back Pond, Bicentennial Park.

approach of people. A small population of Purple Swamphens were present on the lake feeding in the reed beds on especially on the shallow western shore to feed and also on the surrounding grasslands.

Other waterbirds utilise the lake for roosting purposes and feed on the adjacent Parramatta River. An exception to this was two pairs of Darter which nested in the Casuarinas on the smaller of the wooded island. One pair successfully reared two young. The fate of the other nest is unknown due to difficulty in observing the nest from the shore.

### 3.2.2 Back Pond

A fresh to brackish lagoon situated behind the administration building at Bicentennial Park was once part of the mangrove swamp. A low embankment retains freshwater run off which enters





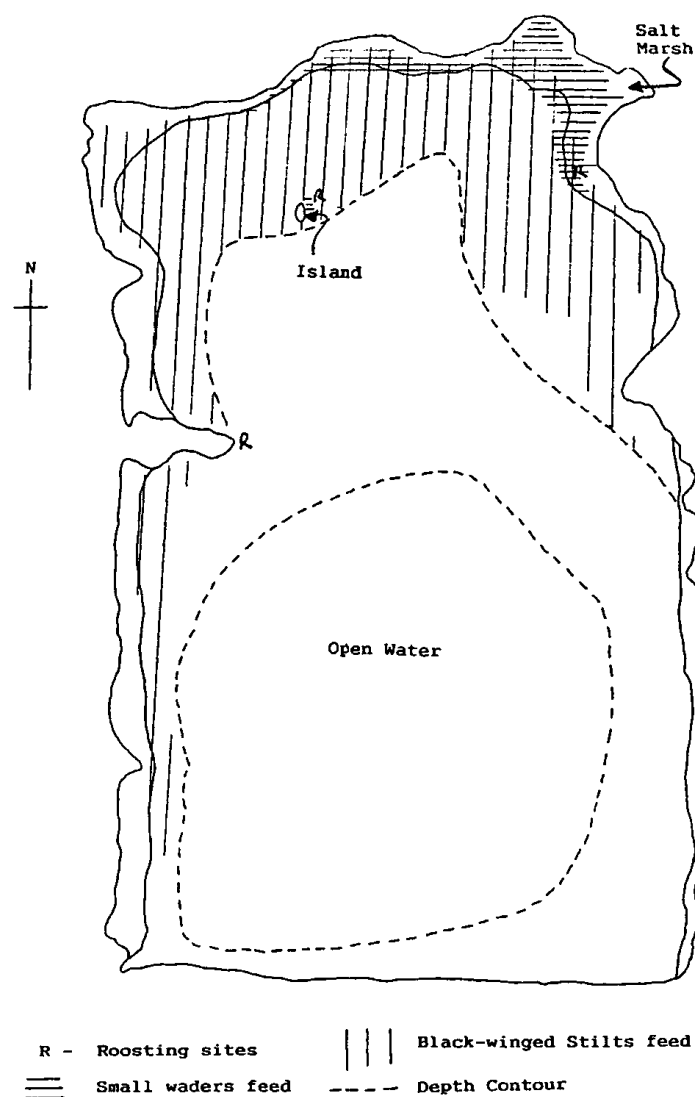
Figure 15. Extensive tidal wader feeding habitat in Saleyard Creek.

the park via a culvert under Bennelong Road and to a lesser extent from the grassland of the park. A small but dense reedland, comprised largely of *Typha* with margins of less dense aquatic vegetation forms a freshwater swamp at the southern end of the lagoon. This swamp attracts Clamorous Reed Warblers, small numbers of Latham Snipe, Dusky Moorhens and Purple Swamphens. A small muddy beach and adjacent shallows provides ideal habitat for waders (Figures 14 & 15). This area attracts small numbers of Black-fronted Plovers, Red-kneed Dotterels, Black-winged Stilts and an occasional Greenshank and Marsh Sandpiper. Black-winged Stilts attempted to nest amongst the sparse emergent vegetation of the shallows but two nests were flooded after heavy rain. An attempt was made to rescue one nest with eggs by elevating it with a flat rock. Although the birds continued to incubate the eggs were eventually predated.

The open water and inundated mangroves attract large numbers of Dusky Moorhen and Chestnut Teal. Smaller numbers of Eurasian Coot, Royal Spoonbill, Grey Teal, Pacific Black Duck, Australian Pelican, Australian Grebe. Birds nesting on this pond during this study included Dusky Moorhen, Eurasian Coot, Australian Grebe and Pacific Black Duck.

### 3.2.3 Waterbird Refuge

The Waterbird Refuge is a rectangular lagoon of about 10 ha. which was formed by bund walls in preparation for filling with dredge spoil in the late 1950s and early 60s. The lagoon was partially filled with fine silts from Homebush Bay before dredging operations ceased. The shoreline of the southern two thirds of the lagoon is relatively steep with little or no shallows or foreshore of use



**Figure 16.** Wader feeding areas, Waterbird Refuge, Bicentennial Park.

to small waders. The northern third of the lagoon provides a narrow shoreline of exposed mud and shallows suitable for waders and occasionally attracts up to about 100 stilts and 120 Curlew Sandpiper and 50 Sharp-tailed Sandpiper (Figures 16).

Water levels in the Waterbird Refuge did not fluctuate to any large degree during this study. Two small diameter pipes [20 cm?] have been installed through the eastern bund wall allowing water to pass between the lagoon and Powell's Creek. The pipes are fitted with floodgates to allow water to drain from the lagoon in order to lower the water level but shut out incoming tidal waters. The floodgates are currently left open to allow tidal flushing of the lagoon in an effort to lower nutrient levels which appear to be the cause of widespread algal growth.

### 3.2.4 *The Billabong*

An intertidal area of mudflat and mangroves which is subjected to restricted tidal influence due to a bund wall with concrete pipes built in to allow water flow. This wetland is utilised largely by

small numbers of duck of which Chestnut Teal were present on all visits (15) with numbers ranging from 1 to 56 birds. Grey Teal were observed on two thirds of visits in groups of up to 28. The next most frequent visitors were White-faced Herons up to 3 on 8 visits and up to six each of Royal Spoonbills, Pacific Black Duck and Australian White Ibis which were each present on 6 visits. Occasional sightings of nine other species of waterbirds were observed during the study. Single observations of waders included 1 Black-fronted Plover and 4 Black-winged Stilt. This was a reflection of the restricted area of intertidal mudflats outside of the mangroves. A large number of dead mangrove tree stumps provided roosting sites for many of the birds observed. Chestnut Teal and Pacific Black Duck appeared to have nested in tree hollows or on the banks of the lagoon as clutches of small dependant young were observed of each these duck.

### 3.2.5 *Brickworks Pond*

The Brickworks Pond is a permanent freshwater body of water on the eastern side of the old brickworks which was created during the construction of Bennelong Road between 1955 and 1961 (Webster and Kachka, 1992). It is situated adjacent to Bennelong Road and opposite Bicentennial Park.

Trees grow along much of the western bank interspersed with a fringing reedbed of *Typha*. The northern end of the pond is composed of reedland including *Typha* and Papyrus.

The bird numbers fluctuated with counts varying from 3 to 83. The most regularly encountered species included Dusky Moorhen, Eurasian Coot, Black Duck and one or two Purple Swamphen. Other species occasionally observed were Australasian Grebe, Pied Cormorant and up to 14 Hardhead. This site was the only place where Hardhead were observed during this study. This was one of the few wetlands on which no teal were observed.

### 3.2.6 *Cumbungi Swamp*

The cumbungi swamp at Newington is comprised of extensive reedbeds of *Typha* sp and a large floating mat of vegetation and little open water. The most significant birds associated with the cumbungi swamp is the Latham Snipe, an international migrant from Japan. Up to 30 Latham Snipe were disturbed during routine surveys of the wetland which would indicate a total population of 60 to 100 birds allowing for the area of suitable habitat not disturbed. This population may exceed this number as up to 100 birds were reported (Adam pers. comm.). Other species of birds recorded for this wetland included Clamorous Reed Warbler, Purple Swamphen, Chestnut Teal, Pacific Black Duck and White-faced Heron.

### 3.2.7 *South Marsh*

An extensive grassland south of the cumbungi swamp was subject to waterlogging for a large part along the western bank of Haslam's Creek for a distance of ca 100 metres inland during heavy rain. An ephemeral swamp and a small cumbungi swamp are included in this area. While the area is wet it is an important habitat for Latham Snipe and large numbers were disturbed during regular surveys. One or two pairs of Pacific Black Duck were observed in the ephemeral pond and the small cumbungi swamp.

The south marsh is an important habitat for Latham Snipe after heavy rains and has a large population of *Cisticolas*.

### 3.2.8 *Woodland Creek*

This is an open drain which runs along the edge of the road south of the eucalypt woodland, northward towards the woodland then eastwards across the Middle Fill area to Hill Road where it stops. It is presumed that the drain at one stage joined Bennelong Creek. The drain is fringed with emergent vegetation and at some places has areas of dense *Typha*. The habitat provided by this drain is utilised by White-faced Heron, Great Egret, Dusky Moorhen, Purple Swamphen and Pacific Black Duck. Three of four pairs of Clamorous Reed Warblers nest in the *Typha* reed beds.

### 3.2.9 *Bennelong Creek*

This channel runs along the final stage of Hill Road, then along Bennelong Road and drains into the Parramatta River. The channel appears to have at some stage been joined to Woodland Creek. Largely freshwater with sections of emergent vegetation and open water and a short section of intertidal mangroves. Small numbers of Chestnut Teal, Australian Grey Teal, Dusky Moorhen and Purple Swamphen. At least two pairs of Clamorous Reed Warblers nest in the dense areas of emergent vegetation.

### 3.2.10 *Sports Centre Pond*

A small pond immediately downstream of a stormwater channel exiting on the northern side of the M4 Motorway. A narrow reedbed of *Typha* fringes the southern and eastern banks and continues along the banks of Boundary Creek which runs down into the 'Front Lake' of Bicentennial Park. The pond is situated at the edge of a picnic/playground area adjacent to the car park of the existing sports complex. The pond currently attracts small numbers of Chestnut Teal, Australian Grey Teal, Black Duck and Dusky Moorhen plus an occasional Purple Swamphen and Australasian Grebe. One or two Clamorous Reed Warblers and Little Grassbirds were also observed in the reedbed. Boundary Creek is largely covered with *Typha* with several open pools. Small numbers of birds as found in the pond, apart from grebes, were found in the creek by Filewood (1992) and during this study.

### 3.2.11 *Boundary Creek*

Boundary Creek was being subjected to extensive earthworks as part of a habitat enhancement program involving extensive widening of the watercourse and re-routing around landfill. The 'old' creek was largely covered by cumbungi with small areas of open water. Birds associated with the creek were small numbers of Dusky Moorhen, Chestnut Teal, Pacific Black Duck, Purple Swamphen, Clamorous Reed Warbler and Little Grassbird. The 'new' creek will undoubtedly attract larger numbers of waterbirds once completed due to the much larger surface area and will serve as a more efficient nutrient trap helping to protect the wetlands of Bicentennial Park.

## 3.3 INTERTIDAL MUDFLATS

Intertidal mudflats extend along the shores of the Parramatta River and associated embayments however there is a wide diversification of usage by waterbirds. Intertidal flats are used by large numbers of waterbirds of many species however the variation in usage between apparently similar habitats warrants further investigation from other disciplines other than ornithological.

Open mud and sand flats form an essential habitat for most migratory waders but is one of the most poorly studied habitats. Intertidal flats provide a major food resource and because of their

open nature attract large numbers of waders which shun areas closed in by trees or artificial structures. The composition of substrate appears to play an important role in providing the right habitat required by various species of waterbirds and waders. The soft mud of the intertidal flats within the study area provide feeding habitat for large wading birds, Chestnut Teal and Silver Gulls. Black-winged Stilts were often recorded in large numbers on the expansive mudflats of Refuge Bay but rarely observed along the fringing mudflats of other parts of Homebush Bay or Ermington Bay. Migratory waders such as Bar-tailed Godwits, Curlew Sandpipers and Pacific Golden Plover were rarely observed on any of the mudflats in the study area but were observed in large numbers on the sandy mudflats east of the Concord railway bridge, especially Hen and Chicken Bay. Previous records have indicated that Bar-tailed Godwits utilised exposed mud and sandflats within the Waterbird Refuge at Bicentennial Park but for some reason are no longer attracted to this site.

### 3.3.1 *Homebush Bay*

Homebush Bay can be divided into a number of distinct habitats from a waterbird usage point of view, some of these differences are obvious others are more obscure. The head of the bay for instance is much shallower and has more extensive exposed mudflats at low tide than the mouth of the bay. The usage of the eastern embayment is more heavily used by birds which feed on intertidal flats than the western part of the bay including the mouth of Haslam's Creek. Notably absent from this type of habitat are species such as Eastern Curlew, Whimbrel, Grey-tailed Tattler and other species usually associated with intertidal mudflats and mangroves.

### 3.3.2 *Refuge Bay*

An area of Homebush Bay which is dealt with separately due to habitat differences from the larger bay and significant difference in bird population.

The mudflats of Refuge Bay are used extensively by Black-winged Stilts, White-faced Heron, Silver Gulls and Chestnut Teal. Occasionally flocks of Royal Spoonbills and a single Greenshank were observed feeding on these flats. Cormorants and Pelicans feed in the shallows during tidal inundation and roost on a derelict barge and wooden pylons. This small embayment is utilised to a greater extent than any other tidal area other than Hen and Chicken Bay in the Parramatta Estuary. The drainage of Haslam's and Powell's Creeks and an expanse of exposed mudflats at low tide are probably important factors in providing a variety of food resources.

### 3.3.3 *Ermington*

The mudflats on the northern side of Parramatta River adjacent to Ermington and Meadowbank attract large numbers of birds a low and receding tides. Large numbers of Chestnut Teal feed at the waters edge as the tide recedes and in small pools left by the tide. Other species such as White-faced Heron, Australian White Ibis and Silver Gull are regularly observed feeding at low tide. This part of the Parramatta River is not used by Black-winged Stilts, which is surprising since these mudflats are close to Newington saltmarshes which have the highest numbers of stilts in the Sydney area.

### 3.3.4 *Haslam's Creek*

Haslam's Creek is a tributary of the Parramatta River and is intertidal within the study area. The lower portion of the creek, from Homebush Bay to just below Hill Road is bordered with a



narrow belt of mangroves and small areas of saltmarsh. From just below Hill Road to the crossing of Parramatta Road the creek has been canalised with no natural embankment other than areas of silt built up near Hill Road bridge. The mangrove lined section of the creek provides intertidal feeding habitat for herons, egrets and ibis while the open water is frequented by small numbers of Chestnut Teal and Pacific Black Duck and occasional Darter, Little Pied Cormorant and Little Black Cormorant. The mouth of the creek, downstream of Bennelong Road is more productive and up to 40 Little Black Cormorants have been observed feeding on schooling fish. The shoreline at the mouth of the creek is the only known site where Common Sandpiper has been found (Hoskin *pers. comm.*, this study).

### 3.3.5 2SM Pond

A shallow lagoon of approximately 5.7 ha fringed with mangroves. Three bunds and the remains of an old sandstone wall that protrude into the lagoon also support mangrove trees. The lagoon is subject to restricted tidal movement. Large numbers of Chestnut Teal frequent the lagoon and roost under mangrove trees on the bunds and old wall. Other species which are occasionally present in ones or twos include Australian White Ibis, Little Pied Cormorant

### 3.3.6 Elcom Pond C (Elcom Pond East)

An L-shaped channel lined with mangroves which links 2SM Pond with Haslam's Creek. Small flocks of Chestnut Teal occasionally use this small body of water and solitary White-faced Herons and Royal Spoonbills were observed during this study. This channel forms a useful extension to the Haslam Creek mangrove wetland. Channel, together with 2SM Pond and Haslam's Creek provide an important corridor for water birds between the Newington Wetlands and Bicentennial Park, especially for small birds such as White-fronted Chats and Yellow Thornbills.

### 3.3.7 Powell's And Saleyard Creeks

The lower portion of Powell's Creek below Homebush Drive Bridge is a tidal mangrove fringed swamp. Upstream of the bridge Powell's Creek and Saleyard Creek are largely confined by concrete walls and floor. Silt accumulates in these creeks due flood events which is periodically cleared out of Powell's Creek and to a lesser extent Saleyard Creek. The sediment accumulated in Saleyard Creek and at the junction of the two creeks provides extensive valuable feeding habitat for waders and teal. The largest counts of Red-kneed Dotterel and Black-fronted Plover were from Saleyard Creek. Sharp-tailed Sandpiper, Curlew Sandpiper, Black-winged Stilt,

Chestnut Teal and Silver Gulls were frequently observed feeding in these creeks. The use of these creeks by large numbers of waders and duck are presumably due to lack of suitable habitat elsewhere.

## 3.4 OPEN MARINE WATERS

The open waters of the Parramatta River are frequented by four species of cormorants, Darters, Australian Pelicans, Silver Gulls and Common and Arctic Terns. Up to 150 Little Black Cormorants have been observed feeding in a single flock following schools of fish while smaller numbers of Little Pied, Pied and Great Cormorants feed singularly. Pelicans feed in small



numbers or as solitary individuals in many of the embayments. Pelicans roost on wooden pylons or in communal roosts on islands in the Waterbird Refuge at Bicentennial Park.

### **3.5 WET GRASSLANDS**

Certain grasslands in the Homebush Bay area are subjected periodical waterlogging providing significant habitat for herons, egrets, ibis, gulls and some waders. South Marsh, described elsewhere in this report, is particularly significant as a feeding and roosting habitat for Latham's Snipe. Other areas include a flat mown grassland adjacent to the western shore of Main Lagoon and an area of undulating grassland to the west of the eucalypt woodland at Newington. The grassland adjacent to Main Lagoon attracts small numbers of White-faced Herons, Australian White Ibis, Masked Lapwing and Black-fronted Plover. Water trapped in the depressions within the grassland west of the eucalypt forest attracts White-faced Heron (6) and Australian White Ibis (20+).

## 4 DISCUSSION

The wetlands of Homebush Bay and adjacent areas of the Parramatta estuary are remnants of a once extensive system of saltmarshes and mangrove swamps. Large expanses of these wetlands were lost during reclamation work which started over a hundred years ago reaching its height in the 1950s and 1960s.

The importance of Mason Park as a wader feeding and roosting area is out of proportion to its size. Food resources are obviously high judging by the number of waders using the site in recent years and the nesting success of Black-winged Stilts. The high usage of the adjacent canalised Powell's and Saleyard Creeks should not be overlooked. A build up of silt, especially in Saleyard Creek provides feeding habitat for waders, gulls and duck which move between the Mason Park saltmarsh and the creek beds as the tide fluctuates. Once these creeks are cleaned out by Sydney Water Board an important food resource will be lost.

Waders using Mason Park, such as Pacific Golden Plover and Curlew Sandpiper, move between the saltmarsh and intertidal flats of Hen and Chicken Bay and associated embayments. Hen and Chicken Bay plays an important role in providing habitat for waders found in the Homebush Bay area.

Much of the saltmarsh in existence today has in actual fact formed over landfill due to tidal flushing, pooling of salt water or salination. Freshwater wetlands have similarly been formed due to earthworks forming depressions or interrupting water flow. Brickworks Pond next to Bennelong Road and the cumbungi swamp at Newington are two examples of freshwater wetlands artificially created. Despite the degraded nature of these wetlands Homebush Bay provides useful habitat for a large number of waterbirds. The history of the area illustrates the feasibility of artificially creating valuable wetland habitat.

## 5 ANNOTATED BIRD LIST

A list of birds recorded during this study includes a brief description of each bird's status and distribution to give the reader an indication of the importance of Homebush Bay to the birds survival or otherwise. Recent records recorded in the literature are also included to illustrate population trends.

### PODICIPEDIFORMES (Grebes)

#### Hoary-headed Grebe

*Tachybaptus poliocephalus*

Endemic to Australia where it is widespread on lakes, reservoirs, floodwaters and large swamps. In winter often encountered in coastal bays and inlets. It is primarily a winter visitor to Homebush Bay. Occurred in small flocks of 8 to 38 downstream of Homebush in Iron Cove and Canada Bay with a maximum count of to 110 during 1981 and 1982 (Morris, 1990). During this study three birds were observed in Homebush Bay in June although a survey by boat revealed none present between Iron Cove and Silverwater Bridge on 21st July. Occasionally recorded in summer.

#### Australasian Grebe

*Tachybaptus novaehollandiae*

The Australasian Grebe is widespread throughout Australia, New Guinea, Solomons, Vanuatu and New Caledonia. Prefers freshwater habitats such as ponds or quiet backwaters especially if abundant aquatic floating vegetation. Feeds on small aquatic fish and invertebrates.

In Homebush Bay this species was recorded on Brickworks Pond, Back Pond and Front Lake at Bicentennial Park on a regular basis. Occasionally observed on Waterbird Refuge at times of heavy algae blooms and once on the Sports Centre Pond. Confirmed breeding on Back Pond where at least one young reached independent stage. Observations of up to 51 birds by Eskell (1978) are highly irregular (Morris 1992) for the area. Only 1 Hoary-headed Grebe was recorded for the same period, a species most likely to occur in large numbers.

### PELECANIFORMES (Pelicans, Darters and Cormorants)

#### Australian Pelican

*Pelecanus conspicillatus*

Widespread throughout Australia and recently southern New Guinea. It breeds largely on interior saltlakes and major river systems, less numerous on the eastern seaboard and arid areas. The nearest colony to Homebush Bay is at the Five Islands off Port Kembla where they started breeding in 1981 peaking at 174 pairs in 1986 Battam (Battam and Smith, 1988). The number of pelicans observed during this study (up to 111), were higher than previous records of 66 (Eskell, 1978) and 64 between 1983 and 1986 (Morris, 1990).

Pelicans are found throughout Port Jackson and tidal areas of the Parramatta River where they feed in shallow waters and close to boat ramps and fishing vessels. At Homebush Bay pelicans feeding in shallows of the bay, especially at low tide and to a minor extent in the Waterbird Refuge and Back Pond at Bicentennial Park. Pelicans often roost on posts, pylons and jetties in a dispersed fashion throughout the area but often in large numbers on the island in the Waterbird Refuge (up to 80 birds) where they share space with stilts, gulls and teal.

The largest counts of pelicans were made at the Waterbird Refuge where up to 80 birds were counted roosting between October and December. This confirms Morris' findings that numbers of pelicans increased during summer months.

Pelicans are a highly visible bird with a popular appeal to the public. There appears to be no reported nuisance factors associated with this species in the Parramatta estuary although they are a potential threat to aircraft movements when attracted by fishermen close to the airport.

#### Australian Darter

*Anhinga melanogaster*

The Australian Darter is found throughout Australia, except for arid regions, Indonesia and New Guinea. Prefers freshwater wetlands including rivers, lakes, swamps and lagoons in which to nest and feed.

This species was not recorded by Morris (1990) between 1983 and 1986 but was recorded by Harrington in 1989 and Bicentennial Park between 1988 and 1991. Up to 10 birds were observed during this survey roosting in trees on a small island on the Front Lake at Bicentennial Park. At least one pair successfully nested in casuarina trees on the island and reared two young. The success of a second nest in close to the first was not confirmed due to difficulties in observing the birds at a distance. Apart from nesting, Darters were only observed to roost on the Front Lake preferring to feed in the open waters of various bays along Parramatta River and in the lower reaches of Haslam's Creek.

It is unlikely that Morris *et al* overlooked this species indicating that it has only recently recolonised the area.

#### Great Cormorant

*Phalacrocorax carbo*

Widespread throughout Australasia, Eurasia, Africa and North America. In Australia it is common in all states but less numerous in the north. Favours coastal and permanent inland waters, may nest in small colonies up to several thousand pairs.

Occurs in small numbers in the study area, generally 1 to 3 birds. Observed throughout the Parramatta estuary feeding in open water or roosting on wooden pylons, boats or trees. Up to 20 observed roosting on wooden pylons in Homebush Bay during this study and a roost site on a wooded island on Front Lake at Bicentennial Park was observed to have up to 40 birds.

#### Pied Cormorant

*Phalacrocorax varius*

Widespread in New Zealand and throughout most of Australia except the arid interior and Tasmania. In Australia breeds mostly in coastal and sub coastal areas. Nearest breeding colony appears to be in Woolooware Bay where about 50 pairs nest in mangrove trees (*pers. obs.*).

In the Homebush Bay area occurs in small numbers, usually in groups of 2 - 4 individuals (Morris, 1990, this study). Similar numbers were observed throughout the estuary.

#### Little Black Cormorant

*Phalacrocorax sulcirostris*

Distribution includes Australia, New Zealand, Indonesia and New Guinea. It is widespread throughout much of Australia on coastal and inland waters including ephemeral wetlands in the arid zone. Nests largely inland, especially the Murray-Darling River, where colonies vary from a few individuals, often with other colonial waterbirds, to colonies of up to 1000 pairs or more.

In the study area flocks of up forty commonly observed, and occasionally over one hundred, feeding in Ermington Bay and Homebush Bay (at the mouth of Haslams Creek) and throughout the Parramatta River feeding on schooling fish. Roosts communally on boats, derelict barges wharf pilings etc. in Homebush Bay and in trees on an island on Front Lake at Bicentennial Park.

## Little Pied Cormorant

*Phalacrocorax melanoleucos*

Common throughout Australia, much of Indonesia, New Zealand and near Pacific Islands. Widespread, mainly freshwater, coastal and inland, including ephemeral waters in deserts in Australia. Breeds in small groups to large colonies of 500-1000+ nests.

In the Homebush Bay area present in small numbers (1 to 7), roosting on wooden pylons, boats or in mangroves. Also in casuarinas on small island in Front Lake, Bicentennial Park.

## CICONIIFORMES (Hérons, Bitterns, Ibises and Spoonbills)

## Pacific Heron

*Ardea pacifica*

Widespread throughout Australia but nowhere in large numbers.

Rarely seen in the Homebush area. 2 were observed during this study feeding in *Bolboschoenus* reedland north of the Cumbungi swamp. The only other records are of birds seen in November 1983 and March 1985.

## White-faced Heron

*Ardea novaehollandiae*

Common throughout Australia. Range includes Indonesia east to New Guinea and New Caledonia.

Common in the Homebush Bay area where lone birds or small groups are frequently observed feeding on intertidal mudflats and in shallow margins of freshwater and saltmarsh wetlands. The highest incidence of White-faced Herons was on saltmarshes (100%) and brackish/intertidal (75%) as apposed to freshwater wetlands (33%). This is probably due to the larger foraging areas of shallow waters and mudflats in the more saline habitats. Also occurs on grasslands, especially after rain. Counts of up to 48 have been reported for the Homebush Bay area (Eskell (1978)).

## Cattle Egret

*Ardeola ibis*

The Cattle Egret is widespread along the eastern coast and occurs in south-western WA and northern NT. It has spread from its original range covering Africa and south-western Europe, and southern Asia east to Korea, Japan, southern Malaysia and Philippines. It has now expanded to all continents except Antarctica and to many island regions.

Rarely observed at Homebush before this study. Groups of 1 to 13 birds were observed on a regular basis feeding at Mason Park, Newington Cumbungi Swamp, on the grassy banks of Haslam's Creek or roosting at Bicentennial Park Waterbird Refuge or wooded island on Front Lake. Were absent from the area between mid-November and late March which corresponds with its breeding season at coastal colonies such as Hexham Swamps.

## Great Egret

*Egretta alba*

Wide ranging species especially the Americas, Africa, Asia, Indonesia and Australasia also parts of southern Europe. In Australia widespread, but scarce or absent from drier parts of interior, not usually found in large numbers other than at some breeding colonies where several hundred may nest in association with other egrets.

Commonly observed singly or in small numbers (1 to 12) by Morris et al and during this study in saltmarshes at Newington and on intertidal mudflats, occasionally freshwater drains.

Little Egret

*Egretta garzetta*

Distribution includes Africa, Europe, to Japan and New Guinea, Australia and small numbers in New Zealand since 1951. In Australia mostly peripherally from north-western Australia through north, east and southern regions to Spencer Gulf. Some parts of coastal WA.

Rarely observed in the Homebush Bay area. Solitary birds reported in 1982 and 1984 (Morris, 1990) and during this study on two occasions at Wharf Marsh at Newington.

Intermediate Egret

*Egretta intermedia*

Range includes New Guinea, South-east Asia and Africa. In Australia this species is found in the north and east Australia and as far west as the Murray-Darling Rivers.

In Homebush Bay single birds observed on rare occasions (Morris 1990). One bird observed at Newington Cumbungi swamp during this study.

Striated Heron

*Butorides striatus*

Distribution is essentially pantropical in South America, Africa south of the Sahara, southern and eastern Asia to Japan, Philippines, Indonesia, New Guinea and Australia. In Australia distribution is strictly coastal; clockwise from Shark Bay WA to Mallacoota in Victoria. A solitary species. Little known about its breeding.

In Parramatta estuary occasional observations of solitary birds feeding among mangroves or on intertidal mudflats in Homebush Bay and other bays of the Parramatta estuary. A maximum count of two birds during this study and by Morris (1990). Recorded as breeding by Hoskin.

Rufous Night Heron

*Nycticorax caledonicus*

Distribution includes New Caledonia, Indonesia, Philippines, New Guinea and Australia. Widespread in northern, eastern and south-western Australia, rare or absent in western WA and central and eastern interior. Nest colonially in small colonies but in places as many as 3000 nests.

Single birds observed on rare occasions although up to 15 were recorded by Eskell (1978). Recorded as breeding at Homebush Bay in 1966 but none since.

Australasian Bittern

*Botaurus poiciloptilus*

Range includes Australia, New Zealand and New Caledonia. In Australia restricted to the south-east; where it is locally common in the Murray-Darling Basin, Tasmania and the extreme south west of Australia.

Not recorded in Homebush Bay in recent years, probably due to very little suitable habitat remaining in the area. A single bird was observed out of its typical habitat roosting at the Billabong, Bicentennial Park during the study period.

Australian White Ibis

*Threskiornis molucca*

Generally widespread in Qld, NSW, Vic, eastern SA and northern Aust. Also occurs south-western WA parts of Tasmania, New Guinea and Mollucas. Breeds in small to very large colonies (20 000 pairs) concentrating in southern NSW and Victoria.

In the past numbers varied greatly in the Sydney area from very few birds to several hundred (Hoskin, 1991). Now breed in Botanic Gardens, Centennial Park and Taronga Zoo grounds where the Sydney breeding population is attributed to started from escapees (Hoskin, 1991).

Commonly observed in small numbers on intertidal mudflats and among mangroves, occasionally on open grassland during and after wet weather. Elsewhere in Sydney this species is associated with rubbish tips and parks where it forages amongst human refuse often pulling rubbish from litter bins. Management of Bicentennial Park has been such as to avoid this problem through specially designed litter bins and the introduction of large hinge lidded garbage bins.

#### Royal Spoonbill

*Platalea regia*

Royal Spoonbills occur in Indonesia, New Guinea, New Zealand and throughout much of Australia other than the arid regions of central and south west of Australia. Usually nest in small colonies.

Commonly observed in small groups feeding in shallow water at the margins of mudflats, in Saltmarshes or fresh to brackish wetlands. Groups of up to 20 birds observed at Wharf and Main Lagoons at Newington and Back Pond at Bicentennial Park.

#### Yellow-billed Spoonbill

*Platalea flavipes*

Endemic to Australia. More common than the Royal Spoonbill but are more of an inland species. Nest in small colonies seldom numbering more than 50 nests (Kingsford, 1991).

A single observation of one bird roosting on an embankment between Haslam's Creek and the Cumbungi Swamp at Newington. Up to three birds observed by Eskill (1978), reported to have been seen at Bicentennial Park by Harrington (1989).

### ANSERIFORMES (Ducks, Geese and Swans)

#### Black Swan

*Cygnus atratus*

Endemic to Australia. Widespread in temperate and tropical terrestrial wetlands, sheltered estuarine maritime habitats.

Occasionally breeds at Bicentennial Park (Bird List 1988 -91). Present in small numbers (up to 4) usually at the Waterbird Refuge but occasionally in ones or twos at other wetlands including Front Lake on open water in Homebush Bay and on the Main Lagoon at Newington.

#### Freckled Duck

*Stictonetta naevosa*

Endemic to south-east and south-west Australia; vagrant to coastal districts in drought years. A rare bird in the Sydney area. The only record for Homebush Bay was in 1985. Not observed during this study.

#### Maned Duck

*Chenonetta jubata*

Endemic to Australia, vagrant to New Zealand. Widespread in eastern states and in southern and western parts of Western Australia. Inhabits grasslands, wooded lands and terrestrial wetlands. The Maned Duck, or Wood Duck, forages in short grass or herbage, mainly on land but also in shallow water at edges of wetlands. This duck nests in hollows often as high as 7 metres or more in height in (usually living) trees in or near water or up to 1.5 km away from water. Commonly found in near lakes in parks and numerous farm dams.

The maned Duck is uncommon in the Homebush Bay area occurring in small numbers of 2 to 6. Most observations by Morris and during this study were at the Front Lake at Bicentennial Park. Observations were also made of solitary birds on one occasion at 2SM Pond and twice at Main Lagoon at Newington.

Pink-eared Duck

*Malacorhynchus membranaceus*

Endemic to Australia. Widespread in terrestrial wetlands: stronghold in inland plains regularly reaching the coast only where mean annual rainfall <400 mm (Frith, 1982)

By no means numerous in the Sydney area occurring spasmodically depending largely on drought conditions inland. In Homebush Bay area occurs in small numbers (2 to 5) with an exceptional count of 41 on 21 July 1985. Usually roosting and feeding in the saltmarsh and brackish water of the embayments at Homebush Bay (Morris, 1990). No Pink-eared Duck were observed during this study.

Australian Grey Teal

*Anas gracilis*

Widespread throughout Australia and New Zealand. Now treated as a separate species to *A. gibberifrons* of Indonesia (Marchant and Higgins, 1990). Largely found on terrestrial wetlands, sheltered estuarine and marine waters.

In the Homebush Bay area occurs in groups of up to 300 birds (Morris, 1990) often with Chestnut Teal. Occasional influxes of large numbers, presumably in response to adverse inland conditions. More than 2000 were observed in October 1957 (Hoskin, 1991). During this study found on Back Pond and Waterbird Refuge at Bicentennial Park, Mason Park, 2SM Pond, saltmarsh lagoons at Newington and Brickworks pond.

Chestnut Teal

*Anas castanea*

Endemic to Australia. Inhabits terrestrial wetlands and estuarine habitats, mainly in coastal regions of south-east and south-west Australia.

Observed at 28 out of 34 wetland locations in the Homebush Bay area the exceptions being of Brickworks Pond and areas of little or no ponding of water. Small groups were observed at most sites (1-20) with concentrations of up to over 200 in Refuge and Ermington Bay mudflats, 300 Main Lagoon at Newington and 400 at the Waterbird Refuge at Bicentennial Park

In the Homebush Bay area frequently observed at all wetlands except Brickworks Pond Numbers varied but small groups were at most locations varying between on most wetlands in the Homebush Bay area. Overall counts for the area up to 1000 birds during this study, occasionally over 2000 birds (Hoskin, 1991). Nesting recorded at Bicentennial Park (Billabong).

Feeding was largely by up-ending and feeding from the substrate or sifting through muddy substrate at the waters edge and some feeding in areas of floating algae.

Mallard

*Anas platyrhynchos*

Introduced to Australia and New Zealand. Natural range Holarctic, Hawaii wintering in southern areas to Sub-tropics in America and south-eastern Asia. In Australia widely introduced to south-east and south-west at least as early as 1862, with main range expansion occurring since 1950's. Many variants in feral, domestic and hybrid forms. Hybridisation in New Zealand is probably so wide-ranging to expose most populations of Grey Duck (Pacific Black Duck) to some genetic dilution. The situation has been less studied in Australia. Any opportunity to rid natural habitats of Mallard and hybrid ducks would help to preserve genetic integrity.

Small numbers of Mallard and Mallard-hybrids were observed on Front Lake at Bicentennial Park and occasionally at the reeds swamp at Mason Park.



**Pacific Black Duck***Anas superciliosus*

Australia, New Zealand, New Guinea, Indonesia and nearby islands. In Australia this species is found throughout, except arid regions.

In the Homebush Bay area the Pacific Black Duck was encountered in small groups of 1 to 36. The majority of birds were on Front Lake at Bicentennial Park. Other significant areas Back Pond (up to 10), irregularly (up to 8) at Sports Centre Pond and Cumbungi Swamp. From 1 to 5 at most other significant wetlands other than intertidal mudflats.

**Australasian Shoveler***Anas rhynchotis*

Endemic to Australia and New Zealand. Disjunct population in eastern and south-western Australia (Aust. Atlas). Usually only seen in small numbers in the Sydney area.

Previously recorded in the Homebush Bay area only in 1985 when up to 6 birds were observed at Homebush Bay roosting on saltmarshes. 4 birds observed during this study at the Waterbird Refuge and on Back Pond (Hoskin *pers. comm.*).

**Hardhead***Aythya australis*

Endemic to Australia where it is widespread throughout but rare or absent in most arid areas of western SA and inland WA. The Hardhead is found on terrestrial wetlands and occasionally sheltered estuarine and inshore waters.

Reported by Morris (1990) to occur in small numbers (1 to 10) throughout the year and as nesting in 1985 and 1986. Up to 16 observed on Brickworks pond during this study and 1 on Front Pond at Bicentennial Park.

**Musk Duck***Biziura lobata*

Endemic to Australia where it occurs in the south-east and south-west of the continent and in Tasmania. Breeds in small numbers in the Sydney area in deep freshwater wetlands and reservoirs.

Only one recent record for Homebush Bay in 1984 (Morris, 1990) other records at Canada Bay in 1983 and Hen and Chicken Bay in 1985. Not observed during this study.

**FALCONIFORMES (Osprey, Kites, Hawks, Eagles and Falcons)****Osprey***Pandion haliaetus*

The subspecies occurring Australia, *Pandion haliaetus cristatus* ranges from south-east Asia and Indonesian Archipelago eastward to New Guinea and southward to Australia where it appears sedentary. The northern subspecies are migratory breeding in North America and Europe, migrating to South America, Africa and Philippines.

Strictly coastal in occurrence in Australia, more common in the north. A very rare species in the Sydney area (Hoskin, 1991). Not previously recorded in the Parramatta estuary. A single sighting was made on 22nd July 1993.

**Black-shouldered Kite***Elanus notatus*

Endemic to Australia where it is widespread. In NSW more common in the eastern part of the state.

A resident pair frequently observed hunting over rough grasslands at Newington and occasionally other locations at Homebush Bay. This pair nested in a eucalypt tree near the internal road west of the cumbungi swamp at Newington and successfully reared three young. Subsequently frequently observed hunting over adjacent grasslands throughout the study period.

Whistling Kite

*Haliastur sphenurus*

Occurs in New Guinea, western Pacific islands and Australia. Widespread especially in areas of eucalypt forest and woodland, generally near water. Widely distributed in the Sydney area though seldom seen in any numbers (Hoskin, 1991).

Rarely observed in the Homebush area. Single sightings (Haslams Creek) and calls heard during this study. According to Morris (1990) only three records of sightings have been made since 1964 one of which was in February 1986.

Brown Goshawk

*Accipiter fasciatus*

Distribution includes islands of the Indian and Pacific Oceans, New Guinea and Australia. Widely distributed throughout the Sydney area where most records are in the cooler months (Hoskin, 1991).

Up to two birds, an adult female and a juvenile male, were observed at Newington Woodland and hunting over rough grasslands from 19th March 1993, the male being still present on 12th August. A single bird observed at Mason Park was most likely the juvenile male observed at Newington. These observations were significant as only two sightings were recorded by Morris in February 1986 and only irregular sightings reported since 1965 (Morris).

White-bellied Sea-Eagle

*Haliaeetus leucogaster*

Ranges from India, south-eastern Asia and New Guinea to Australia. Mainly coastal in Australia and throughout the Murray-Darling Basin. Up to 12 nests were known in the County of Cumberland in late 1949 and early 1950's (Hoskin, 1991) but appear to have declined since.

Pairs of White-bellied Sea-Eagles have been attempting to breed at Newington at least in recent years. Two birds were observed in the area on 7th January 1993. One of these birds appeared to have a few brown feathers remaining and may have only just come into breeding condition. Previous observations of an immature bird in 1984 and one bird over Yaralla Bay was reported by Morris (1990).

Marsh Harrier

*Circus aeruginosus*

Cosmopolitan in distribution apart from the American continent. In Australia breeds mainly in south-eastern and south-western Australia, south of 33°S and appears to be a non-breeding visitor elsewhere. Widespread but uncommon in the Sydney area.

No recent records of this species in the Homebush Bay area before this study. A single adult bird was observed hunting over grasslands and wetlands of Newington on 18th November 1992.

Peregrine Falcon

*Falco peregrinus*

Almost cosmopolitan in distribution. Widespread throughout Australia except rolling downs and western deserts but is uncommon. The only records prior this study were 3 records between 1965 and 1972 and one bird in December 1984 (Morris, 1991).

Observations of a single bird was made on 21st January 1993 hunting over grassland at Newington and roosting in trees in the eucalypt woodland.

**Australian Hobby***Falco longipennis*

Endemic to Australia and parts of Indonesia. Widespread throughout Australia. Not common in the Sydney region though more prevalent than the Peregrine (Hoskin, 1991).

Only five records for the area between 1966 and 1984 were reported by Morris (1990). Observations of single birds were made during this study hunting over grasslands of the middle and north fill areas at Newington.

**Brown Falcon***Falco berigora*

Occurs in New Guinea and Australia where it was the most widely reported species during the compilation of the Field Atlas. Widely distributed throughout the Sydney area in open forest country and cleared lands although in smaller numbers than in previous year (Hoskin, 1991).

Solitary birds observed on a number of occasions at Newington, often perched on bunkers west of cumbungi swamp. Prior to this only three observations were recorded between 1966 and June 1985 (Morris, 1990).

**Australian Kestrel***Falco cenchroides*

Widespread throughout Australia, also found in New Guinea and Indonesia.

At least one pair appears to have successfully nested in or around Newington. Up to six birds observed on a regular basis hunting over grasslands at Newington. Morris (1990) recorded one bird feeding at Bicentennial Park in 1984 other records by Eskill (1978) and Bicentennial Park between 1988 and 1991.

**GALLIFORMES (Moundbuilders, Quails and Pheasants)****Brown Quail***Coturnix australis*

Range includes coastal eastern, northern and south-western Australia, Tasmania and New Guinea. Uncommon in the County of Cumberland (Hoskin, 1991).

Not recorded from the Homebush Bay area in recent years. One dark-phased bird observed during this study at Middle Marsh at Newington on 13th September, 1993. Probably occurs in small numbers within the middle and north fill areas and south marsh. Little suitable habitat occurs elsewhere in the area.

**GRUIFORMES (Rails, Coots, Cranes and Bustards)****Australian Spotted Crake***Porzana fluminea*

Endemic to Australia. Occurs mainly in south-eastern Australia and to a lesser extent south-western Australia.

A secretive bird which is hard to locate in dense reedbeds. Three birds were disturbed during a clean-up campaign at Mason Park saltmarsh in 1991 where no recent observations had been made. A call attributed to this species was heard during a nocturnal bird survey at Newington Cumbungi swamp during this study. It is quite likely that this species occurs in reedbeds within the Bicentennial Park, Newington and Mason Park.

Baillon's Crake

*Porzana pusilla*

Occurs in Europe, Africa, Asia, New Guinea and Australia. Found in freshwater wetlands around Sydney. Due to its cryptic behaviour not often observed. A bird answering this birds description was captured in the workshop of the Bicentennial Park and released in nearby reedbeds (Webster pers comm). Sightings reported by Harrington (1989), Eskell (1978) and Bicentennial Park (listed as breeding) bird list (1988-91).

Dusky Moorhen

*Gallinula tenebrosa*

Occurs in Indonesia, New Guinea and Australia. Appears to be largely restricted to eastern Australia and the extreme south-west. A common resident throughout the Sydney area frequenting freshwater swamps, creeks dams and tidal and freshwater streams.

A common species observed on most freshwater and brackish wetlands. Large numbers (over 20) accumulate on Wharf Lagoon at Newington, Front Lake and Back Pond at Bicentennial Park. Feeds on open water, in emergent aquatic vegetation and on open grassland near water.

Purple Swamphen

*Porphyrio porphyrio*

Distribution stretches from Africa, southern Europe, Asia, Pacific islands, New Zealand, New Guinea and Australia. Widespread in eastern Australia, south-western and parts of northern Australia. Frequents freshwater wetlands but often grazes 100 m or more from the waters edge.

In the Homebush Bay area is more restricted in distribution and numbers, being more selective in habitat to wetlands with substantial reedbeds. Recorded in small numbers of 1 to 11. Most numerous around Front Lake at Bicentennial Park.

Eurasian Coot

*Fulica atra*

Widespread in Europe, Africa, Asia, New Guinea and Australia. Also recently colonised New Zealand. Common throughout Australia in deep wetlands. Counts of up to 400 Eurasian Coot were reported in 1978 (Eskell, 1978) and 200 reported between 1983 and 1986 Morris (1990). Numbers have since appeared to have declined further with a maximum count of 60 for Homebush Bay, including 47 at Brickworks pond. During this study coot were observed on Front Lake, Waterbird Refuge and Back Pond at Bicentennial Park, Brickworks Pond and Bennelong Creek. Eurasian Coot prefer deeper wetlands with submerged or float weed on which to feed. This type of habitat is now restricted to the margins of some of the freshwater wetlands in the area.

**CHARADRIIFORMES (Waders, Gulls and Terns)**

Masked Lapwing

*Vanellus miles*

The Masked Lapwing is divided into two races with *miles* occurring across northern Australia south to around Townsville, also in New Guinea, and *novaehollandiae* in eastern Australia. Masked Lapwings occur on grasslands, around wetlands, saltmarshes and coastal mudflats.

In the Homebush Bay area frequently observed on intertidal mudflats, playing fields and saltmarshes where small numbers occur. Counts of up to 24 roosting or feeding on saltmarshes at Newington or on mudflats at or near Ermington.

Pacific (Lesser) Golden Plover

*Pluvialis fulva*

Breeds on arctic tundra in western Alaska and across the high arctic region of far north Russia. Migrates to Africa, the Middle East, India, South-east Asia, Australasia and the Pacific Islands.

About 9000 birds are estimated to visit Australia (Watkins, 1993) of these 1800 are estimated to visit NSW.

The summer population of Pacific Golden Plover in the Sydney region has been about 300 (200 Botany Bay and 100 Parramatta River). The population appears to have remained stable during the peak season in March each year in Botany Bay until 1985 (Straw 1992), but has declined since. The population in the Parramatta estuary has also declined but with fluctuations in recent years with a current population of only 24 birds.

Hen and Chicken Bay has been the most important feeding and roosting site, at least since the early 1980's. Other areas where significant counts have been made are the Waterbird Refuge, now part of Bicentennial Park and more recently Mason Park. Pacific Golden Plover were recorded as using Mason Park as a major roosting site since 1989/90 season. Although this species has been observed feeding at Mason Park (Straw pers obs) the main feeding area still appears to be Hen and Chicken Bay. The Waterbird Refuge is no longer used by this species.

Forages on intertidal sand and mudflats and saltmarshes and occasionally on grassland including playing fields and airfields and rocky shores. Roosts on saltmarsh and coastal flats sandy beaches and rocks. (Lane, 1987).

#### Red-kneed Dotterel

#### *Erythrogonys cinctus*

Distribution restricted to Australia and southern New Guinea. In Australia it is widespread and is found mainly on ephemeral lakes and marshes where it feeds in shallow water and mud areas. Birds occur in pairs, small groups and at times flocks of several hundred. (Watkins, 1993). Widespread in NSW but less common east of the Great Dividing Range. Australian population estimated at 26000 of which about 5000 occur in NSW, although local populations can fluctuate greatly due to movements in response to flooding and droughts.

This species was unknown near Sydney before 1943 (Hindwood and Hoskin, 1954) but now frequently visits the area. The first record for Homebush Bay area was 15 June 1965. Morris reported it as uncommon during the 1983-86 study when it was recorded five times with counts between 2 and 8 (Morris 1990). During this study Red-kneed Dotterels were present during the whole year with maximum counts of up to 6 birds April and September.

#### Red-capped Plover

#### *Charadrius ruficapillus*

Endemic to Australia. Widespread throughout Australia where it is found on sand or shingle beaches along the coast or inland waters, on saltpans, saltmarsh and on muddy or sandy river edges.

This species appears to have bred regularly in the past in the Homebush Bay area. The last record appears to have been in 1986 (Morris, 1991). Not recorded during this study.

#### Black-fronted Plover

#### *Elseyornis (Charadrius) melanops*

Endemic to Australia, recently established in New Zealand. The most widely distributed species of wader breeding in Australia. Total population estimated at 17 000. Outside the breeding season the Black-fronted Plover gathers in small flocks.

Present throughout the year in the Homebush Bay area where it was recorded on all freshwater wetlands and saltmarshes at Newington, Mason Park and Bicentennial Park. Present as single birds or pairs most of the year but groups of up to 6 and max count for the area up to 18 during March to July.

Black-winged Stilt

*Himantopus himantopus*

The Black-winged Stilt is distributed over much of the temperate and tropical areas of the world. There are five races recognised of which one, *leucocephalus*, occurs in Australia and is also found in the Philippines, Indonesia, New Guinea and New Zealand. The Black-winged Stilt occurs on shallow wetlands throughout Australia.

Present in small numbers on most shallow wetlands in the study area but large flocks up to 300 hundred observed for most of the year at Newington saltmarshes. Black-winged Stilts nested at Mason Park; up to 10 nests, Back Pond; 2 nests, Waterbird Refuge; up to 4 nests.

Red-necked Avocet

*Recurvirostra novaehollandiae*

Endemic to Australia where is widely distributed east to the Dividing Range but as an infrequent non-breeding visitor to northern Australia and east of the Dividing Range.

Rarely recorded at in the Sydney region. A single bird present from early September throughout the study period.

Ruddy Turnstone

*Arenaria interpres*

Breeds on arctic coasts right around the pole, and occurs on the coasts of every continent during the non-breeding season. Australian population estimated to be 14 000 of which about 800 occur in NSW. Mainly coastal on rocky coasts, sometimes on ocean beaches, seldom on estuarine mudflats.

Recorded in small numbers (2 to 9) in Hen and Chicken Bay. Many records for Homebush and Wentworth Bays, max four birds prior to Morris' study of '83 to '85 (Morris, 1991). No birds recorded during this study.

Eastern Curlew

*Numenius madagascariensis*

The Eastern Curlew breeds in bogs and marshes in eastern Siberia and northern Mongolia. The bulk of the population migrates to Australia where it is distributed around the entire coastline. Most abundant on the eastern and south-eastern coasts, and during the southern migration, in the north-west. Australian population estimated to be 19 000 of which 2400 occur in NSW.

Rarely seen in the Homebush Bay area despite relatively large numbers visiting Botany Bay. Single birds recorded in Hen and Chicken Bay and Majors Bay on 26 February 1984 (Morris, 1990). During this study up to seven birds were observed on the saltmarsh at Newington, two on the mudflats at Ermington and a solitary bird on the Waterbird Refuge at Bicentennial Park.

Whimbrel

*Numenius phaeopus*

Breeds Arctic Russia, Siberia, Alaska, Canada and Iceland. During non-breeding season occurs on the coasts of every continent. A population of about 10 000 visit Australia of which about 700 are found in NSW. About 50 birds frequently observed in Botany Bay but rarely observed in the Parramatta estuary. A single bird recorded by Morris (1991) in 1984. Not observed in the Homebush Bay area during this study.

Wood Sandpiper

*Tringa glareola*

Breeds in coniferous forests of the Northern Hemisphere, from Britain and Scandinavia, across Russia, to Mongolia and north-eastern China. About 6000 are estimated to visit Australia of which 80 occur in NSW. Occasionally observed in the Sydney area usually singly with a maximum of three birds being observed (Hoskin, 1991).

Rarely observed in Homebush Bay. One bird observed in February 1966. (Morris, 1990, Hoskin, 1991). Not recorded during this study.

#### Grey-tailed Tattler

#### *Heteroscelus (Tringa) brevipes*

Breeds in the alpine tundra of Siberia migrating to South-east Asia and Australasia. Occurs around entire coastline of Australia during summer months but more abundantly in northern Australia. Of 36 000 estimated visiting Australia 900 occur in NSW. About 180 birds regularly visit Botany Bay but are rarely observed in the Parramatta estuary (1 to 2 in Hen and Chicken Bay (Morris, 1990)). No recent records for the Homebush Bay area.

#### Common Sandpiper

#### *Actitis hypoleucos*

Breeds throughout sub-arctic regions of northern Asia and Europe from where it migrates to southern Europe, Africa, the Middle East through to South-east Asia and Australasia. About 3000 are estimated to visit Australia with a NSW population estimated at about 80. Small numbers occur in the Sydney area where single birds have been recorded on rocky or muddy margins of estuaries and margins of freshwater swamps. Recorded on four occasions at Homebush Bay since 1964 (Morris, 1990). One bird observed on the intertidal shore between the ship breaking yard and the mouth of Haslams Creek during this study. This is also the site of previous sightings (Hoskin, *pers. comm.*).

#### Greenshank

#### *Tringa nebularia*

The Greenshank breeds largely in the coniferous forest zone of sub-Arctic Europe through to the Kamchatka Peninsula eastern Siberia. It migrates to Europe, Africa, the Middle East, India, South-east Asia and Australasia. Widespread throughout Australia on both inland and coastal wetlands. Australian population estimated at 20 000 of which 10% occur in NSW.

Uncommon in the Homebush Bay area where it is often present but usually only one or two birds. Morris (1990) found it mainly frequenting Majors Bay and one sighting of two at Newington (which is hardly surprising due to restricted access to ornithologists prior to this study). During this study single observations of solitary birds were observed at Back Pond, Refuge Bay at Bicentennial Park and Wharf Lagoon at Newington. Most observations were made at Main Lagoon at Newington where one or two birds were often present between early December and May.

#### Marsh Sandpiper

#### *Tringa stagnatilis*

The Marsh Sandpiper breeds in marshland in eastern Europe, south-western Siberia, Mongolia and northern China. After the breeding season this species migrates to Africa, the Middle East, India, South-east Asia and Australasia. The Australian population is estimated at 9000 of which 2000 occur in NSW.

Previously recorded in the Homebush Bay area in February 1985, November 1982 (2 birds) and on regular occasions between 1965 and 1966 with up to four birds (Morris, 1990). During this study this species was recorded on a regular basis at the Waterbird Refuge at Bicentennial Park (1 to 2 birds) and Main Lagoon at Newington (up to 8 birds). One observation of a solitary bird at Mason Park on 29th September 1992.

#### Latham's Snipe

#### *Gallinago hardwickii*

The Latham's Snipe breeds in Japan and migrates to south-eastern Australia. The species has an important place in shorebird conservation in the East Asia - Australasian Flyway as concern for its status and the need for international action led, in 1974, to the development of the Japan -

Australia Migratory Bird Agreement. (Watkins, 1993). Of an estimated world population of 36000 it appears that the entire population migrates to Australia.

The Latham's Snipe is a cryptic species which is rarely seen unless flushed from rank grassland or reedland. The highest counts made in NSW from 1978 to 1985 were between 100 and 180 birds (Smith, 1991). A large population visit freshwater wetlands at Newington each summer and an estimated population of over 60 birds (one count estimate of 100 Adam *pers. comm.*) utilise the Cumbungi swamp spreading out to nearby grasslands after heavy rains. Small numbers were observed at Mason Park (2) Main Lagoon (1) and Back Pond reedbed (2) during this study.

#### Black-tailed Godwit

*Limosa limosa*

Breeds in northern Europe, Siberia and northern Mongolia. Migrates to southern Europe and Africa through to South-east Asia and Australasia. An estimate of 82 000 visit Australia of which an estimated 650 occur in NSW, largely in the Hunter estuary. Rarely observed at Homebush Bay, recent records include 11 in March 1969, 2 in August 1982 and 5 in October 1984 (Morris, 1990). None were observed during this study.

#### Bar-tailed Godwit

*Limosalapponica*

Bar-tailed Godwit breed from Scandinavia, across northern Russia to Alaska. It appears that two races occur in Australia *baueri* in south-eastern Australia and *menzbieri* in the north-west. A total population estimate for the species in Australia has been placed at 165 000 by Watkins (1993) with a NSW population of 8000.

This species was previously recorded from the Waterbird Refuge at Bicentennial Park prior to 1988 with flocks of up to 50 birds and Mason Park 15 on 31st January 1991 (NSW Wader Study Group 1993). Morris (1990) reported a flock of 166 roosting on a saltmarsh on 11 June 1986 which is an exceptional winter concentration in the Parramatta estuary. No Bar-tailed Godwits were recorded in the Homebush area during this study but up to 353 were counted roosting in Hen and Chicken Bay. These birds feed largely on foreshores between Brays Bay and Abbotsford with a few birds in Iron Cove.

#### Red Knot

*Calidris canutus*

Breeds throughout the high-arctic wintering in Africa, Europe, North and South America and Australasia. The entire population of subspecies *rogersi* appears to winter in Australia and New Zealand. About 150 000 are estimated to be in Australia during the peak migration. Although larger numbers move through during migration the summer population of NSW is estimated to be about 300. Occasionally observed in the Parramatta estuary, mainly in Hen and Chicken Bay (1 to 39). No recent records in the Homebush Bay area.

#### Sharp-tailed Sandpiper

*Calidris acuminata*

The Sharp-tailed Sandpiper breeds in damp sedgeland in the high-arctic lowlands of north-eastern Siberia. It migrates to Indonesia and Australia, with most of the population coming to Australia. This species occurs on fresh water wetlands and in coastal areas around Australia. The number of birds at most sites in Australia is not stable with birds appearing to move in response to wetland conditions. The estimated population is 166 000 with 40 000 in NSW in mid-summer.



The largest concentrations in the Homebush Bay area occur spasmodically on saltmarshes Bicentennial Park and Mason Park.

Up to 150 Sharp-tailed Sandpiper were counted at the Waterbird Refuge during 1985/86, 250 during 1986/87 and 100 during 1987/88. Fewer birds were recorded between 1989 and 1991 with groups of up to 20 birds at Mason Park and the Waterbird Refuge. During this study Sharp-tailed Sandpipers were present from mid-September to late February at Mason Park with counts up to 160, 50 at the Waterbird Refuge and 15 at the Main Lagoon at Newington. Small numbers were counted on single occasions at Back Pond (2) and the Saltmarsh (5) at Bicentennial Park.

#### Red-necked Stint

*Calidris ruficollis*

Breeds on arctic tundra in central and eastern Russia. The bulk of the population probably migrate to Australia. Population estimated at 353 000 of which 4500 occur in NSW.

Only one Red-necked Stint was observed during this study. A species previously described as 'common' by Morris (1990) with counts of up to 147 during summer months. Counts kept by Kelsey indicate that this species may have been in decline in the area since 1988 while Hoskin (1991) comments that the species is less common than in earlier times, although the population in Botany Bay seems to have been stable (Straw, 1992).

#### Curlew Sandpiper

*Calidris ferruginea*

Breeds on high-arctic coastal tundra in central Siberia. Wintering grounds include Africa, the Middle East through to South-east Asia and Australasia. Australian population is estimated at 140 000 of which about 6000 occur in NSW.

The Curlew Sandpiper seems to have suffered a decline in numbers in the Sydney Region in recent years. Morris reported numbers ranging between 71 and 860 between September and March in Hen and Chicken Bay. An extended survey to monitor the numbers of waders during January revealed a maximum count of 240. These birds alternated between feeding at Hen and Chicken Bay and Mason Park. Numbers have declined in Botany Bay over recent years (Straw 1992) due to loss of habitat. It is not clear why such a large decline has occurred in the Parramatta estuary, although seasonal fluctuations in the breeding grounds can have a marked effect.

#### Silver Gull

*Larus novaehollandiae*

Large numbers of Silver Gulls are associated with picnic areas within Bicentennial Park, playing fields, riverside reserves and open mudflats. Flocks of up to 650 were recorded at Hen and Chicken Bay, 210 at the Waterbird Refuge, 300 in Refuge Bay, 240 in Ermington Bay and 130 at the picnic grounds at Bicentennial Park. A night time roost of 2400 were observed on Main Lagoon at Newington on 11th February 1993 and judging by the presence of feathers seen on morning visits roosting and preening occurs on the Main Lagoon and 33 Lagoon on a regular basis. Some of these birds breed in Homebush Bay on derelict barges, wooden pylons and on artificial nest sites within the Waterbird Refuge at Bicentennial Park. Other colonies are situated in Rozelle Bay but the vast majority of birds nest on the Five Islands of Port Kembla where an estimated 50 000 pairs nest each year, peaking between July and September (pers obs). The majority of birds nesting on the Five Islands move back to Sydney after the breeding season. The Silver Gull population increased dramatically after the 1940s due largely to the creation of large artificial food resources at rubbish tips close to ideal nesting habitat. The nesting colonies within Rozelle and Homebush bays have been created since 1984 (Hoskin). These colonies could expand if food resources are available close to suitable nesting habitat. Silver Gulls present a

number of problems including predation of other species such as Little Terns (Egan, 1991) and could pose threats to locally nesting species such as Black-winged Stilts.

Whiskered Tern

*Chlidonias hybrida*

Breeds in Eurasia, Africa and Australia. Widespread on the mainland where suitable habitat exists. A large proportion breed in the Murray-Darling Basin and south-eastern Australia south of 25°S.

In the Sydney region Hoskin (1991) notes that from 50–100 birds have been seen in the 'Hawkesbury Swamps' but did not indicate how recent these observations were. In the Homebush Bay area single sightings were made of birds feeding on the Waterbird Refuge and Back Pond during this study. Other recent sightings were of three birds in 1986 (Morris, 1990).

White-winged Tern

*Chlidonias leucoptera*

Breeds in the swamps of southern Europe and across Asia. Migrates to Africa and as far as Australia and New Zealand during the non-breeding season. Although large numbers are often seen in the north-west only small numbers normally reach south-eastern Australia.

Not recorded in the Homebush area in recent times and rarely seen in the Sydney region. A single sighting of one bird during this study hunting over the Waterbird Refuge and Back Pond.

Common Tern

*Sterna hirundo*

Breeds in North America, Europe, temperate Asia and Africa. A regular summer visitor to Australia (birds banded in Europe recovered in Aust.) occurring mainly along the northern, eastern and south-eastern coasts.

Small numbers (1–2) were commonly seen during summer months over open water of Homebush Bay, the Waterbird Refuge and Front Lake. An extended survey revealed that the larger proportion of Common Terns (20+) observed in January frequented open waters downstream from Homebush Bay.

Crested Tern

*Sterna bergii*

Occurs around the entire coast of Australia, also in south-east Asia, some Pacific islands, New Guinea and countries bordering the Indian Ocean including Australia.

Colonies of 200–1000 pairs nest on islands off the NSW coast, the closest being the Five Islands off Port Kembla.

Occasionally observed in small numbers (1 to 4) Morris (1990) and this study feeding in the bays of the Parramatta estuary including Homebush Bay.

Little Tern

*Sterna albifrons*

Occurs in Europe, Africa, Asia and Australia. Has declined in numbers in many countries including Australia. Occurs in much of coastal Australia as a summer migrant, including NSW where it is listed as 'threatened fauna'. Nearest colony is in Botany Bay where numbers had been greatly reduced since the late 1940's. Population increased over past two years due to secure nesting site and close monitoring.

Previously nested at Homebush Bay. This species was not observed during this study and was recorded as uncommon by Morris (1990) who reported small numbers of 1 to 3 between 1983

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and 1985. Last recorded as nesting on a sandspit at Homebush Bay 1964/65 when a pair reared two young (Morris 1979).

#### **SPECIES NOT INCLUDED IN THE ANNOTATED LIST**

Records not substantiated

Western Sandpiper (*Calidris mauri*).  
A reported sighting at Homebush Bay in 1978 was rejected by the RAOU Appraisals Committee. There are no substantiated record of this species occurring in Australia.

#### **No recent records**

Double-banded Plover (*Charadrius bincinctus*).  
There are no recent records of this species being observed in the Parramatta estuary except for an observation reported in the EIS for the 2SM radio mast. This record and that of several other species of birds listed in that report are of doubtful accuracy and have not been included in this report.

Little Curlew (*Numenius minutus*).  
The only record of this species in the Parramatta estuary was in January 1958 (Hindwood and McGill, 1958). A rare vagrant to the Sydney area.

#### **No recent published records:**

Great Knot, Glossy Ibis, Straw-necked Ibis, Little Bittern, Australasian Bittern, Collared Sparrowhawk, Broad-billed Sandpiper, Ruff

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# WOODLAND BIRDS STUDY

# **Woodland Birds**

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## SUMMARY

Although Homebush Bay is a highly modified site the area supports locally rare wetland and woodland communities. The wetlands accommodate a diverse suite of waterbird species including migratory wading birds protected under international treaties (see part 1 of this report). The woodland habitats include wetland associated communities such as mangroves and casuarina woodlands and shale associated woodlands such as the Newington remnant eucalypt woodland. A number of regionally rare species of birds, such as the White-fronted Chat, Red-rumped Parrots, Osprey, White-bellied Sea-Eagle, Marsh Harrier, Peregrine Falcon and Australian Hobby were observed during this study.

Few places provide a habitat for such a wide variety of parrots per hectare as the Newington eucalypt woodland. No scientific study was carried out prior this study, partially due to the isolation of Newington as an armaments depot. This isolation may also have been instrumental in protecting these valuable wildlife habitats.

## 1 INTRODUCTION

Since 1940 a total of 92 land bird species had been recorded for the Homebush Bay (Webster and Katchka, 1992) prior to this study. Some of these records were of birds which are now rare to the area or locally extinct. Sixty-two of the species previously recorded were observed during this study and 20 species observed during this study had not been previously recorded in the area. Many of the birds recorded prior to, but not during, this study no longer exist in the area due to loss of suitable habitat. Others may have been vagrants or rare in the area and may still occur on an irregular basis. These birds would be detected during a prolonged study. Of the 20 species observed during this study but not previously recorded for the area, all but one, were observed in the Newington woodlands. One reason why these birds were not previously recorded is due to the exclusion of observers from the high security armaments depot prior to this study, rather than an influx of bird species in recent years.

The most significant woodland at Homebush Bay is an island community of eucalypt and an adjoining casuarina woodland at Newington. The importance of the Newington eucalypt woodland is illustrated by the large number of parrot species nesting or attempting to nest in hollows in the mature trees in this woodland. The results of this study has shown that 23% of woodland bird species of Homebush Bay were found only in this eucalypt woodland while 70% of the woodland species rely on the woodland to some degree.

Many woodland species are threatened by a number of introduced and one native bird species which take advantage of woodland fringes and open parklands. Potential pests include Common Myna, Common Starling and Noisy Miner. Threats from these birds include competition for nesting hollows of parrots, and food resources and aggressive territorial behaviour towards small woodland birds, which normally take refuge in woodland understorey. These more aggressive birds tend to become more prolific with the introduction of parklands. Another potential pest species, which tends to increase in numbers due to the increased artificial food availability associated with people and parklands, is the Silver Gull, which then competes with many of the more timid species of birds for natural food resources.



## 2 HABITAT DESCRIPTION

### 2.1 WOODLANDS

#### 2.1.1 *Newington Eucalypt Woodland*

The remnant eucalypt woodland at Newington is the only substantial woodland in the Homebush Bay area and consequently attracts a diverse population of birds. Of the 81 species of land birds recorded in the Homebush Bay study area from November 1992 to October 1993 70% were recorded from Newington eucalypt woodland and 23% were found exclusively in this woodland. A large proportion of the birds found only in this remnant woodland were breeding at the site, including a high proportion of parrot species.

The varied habitat in the Newington eucalypt woodland attracts a high diversity of birds. The mature stand of scribbly gums (*Eucalyptus haemastoma*) provide nesting hollows for a number of parrot species including Red-rumped Parrot, Eastern Rosella, Rainbow and Scaly-breasted Lorikeets and Sulphur-crested Cockatoo. The combination of tree hollows and native grasses make this ideal habitat for Red-rumped Parrots (see Figure 1). The flowering trees provide food resources for a large population of White-plumed Honeyeaters and nectar eating parrots. The understorey within the woodland provides important feeding and nesting habitat and protection for small woodland birds from predators (see Figure 2) for such birds as Superb Fairy-wrens, Willie Wagtails and a number of finch species.



**Figure 1.** The combination of tree hollows and native grasses make this ideal habitat for Red-rumped Parrots.





**Figure 2.** The understorey within the woodland provides important feeding and nesting habitat and protection for small woodland birds from predators.

### 2.1.2 *Newington Casuarina Woodlands*

A dense stand of *Casuarina glauca* is situated on the northern side of the Eucalypt woodland and small patches occur between 33 Marsh and Wedge Marsh and on the boundary between Corner Marsh and the Parramatta River. Most woodland birds were found inhabiting the fringes of the main woodland or in the small patches of casuarina. The dense canopy and leaf litter of the Casuarina Woodland excludes most understorey plant species and provides little suitable habitat for birds (Figure 3). A number of shrubs, including introduced weeds, grow along the periphery of the woodland which attract a number of small bird species.

Twenty-five species of woodland birds have been associated with this woodland of which three species; Southern Boobook, White-browed Scrubwren and Golden Whistler were located only at this site. The outer margins of the Casuarina Woodland also provided habitat for a large proportion of other species such as Eastern Yellow Robin, Grey Fantail and Red-browed Firetail.

### 2.1.3 *Abattoir and Brickpit Woodlands*

The Abattoir Woodland is a small remnant of mixed woodland comprised largely of species introduced to the area but relatively low numbers of exotic species. This woodland acts as a useful link between other remnants and parklands (Figure 4).

The Brickpit woodlands are comprised of a series of remnants of mixed woodland with a high incidence of weeds and introduced species in a highly disturbed area. Under storey, whether exotics or native plant species provide important habitat for small woodland birds such as Superb Fairy-wrens and Double-barred Finches acting as a refuge from predators and feeding areas and nesting sites.



#### 2.1.4 Mangrove Woodlands

Mangrove woodlands provide feeding and nesting habitat for a large number of woodland birds and shelter from predators. Twenty-nine species were associated with mangrove woodlands of which most use these dense woodlands as corridors. The continuous band of trees allow small woodland birds to move between sites without extensive flights in open country and exposure to predatory birds. Species which use this type of habitat to a major degree include Yellow Thornbills, White-fronted Chats, Silvereyes, Superb Fairy-wrens and Goldfinches. Rufous Fantails and Brown Honeyeaters were found exclusively in mangrove woodland in Homebush Bay.

#### 2.1.5 Bicentennial Park

A large part of Bicentennial Park is covered with mangrove woodlands which attract large numbers of woodland birds and act as an important corridor for these birds as well as providing a habitat for some waterbird species. Most birds use the outer canopy and outer margins of the more extensive mangrove woodlands and few birds are found on or near the ground below this dense canopy (Figure 5).

#### 2.1.6 Mason Park

In addition to its importance for wetland birds Mason Park attracts small numbers of woodland birds due to a small stand of mangroves and a screen of trees and shrubs between the wetland and adjacent sports fields. This area supports migratory waders which require an open habitat in order to see and avoid potential predators. They will not feed or roost close to tall vegetation.



Figure 3. Woodland should be allowed to regenerate over an expanded area which is currently grassland.





**Figure 4.** The dense canopy and leaf litter of the Casuarina Woodland excludes most understorey plant species and provides little suitable habitat for birds.

## 2.2 ROUGH GRASSLANDS

The grasslands of Homebush Bay provide important feeding habitat for the Red-rumped Parrot which feeds on seed heads of native grasses and several weed species (pers. obs., Keith Egan pers. comm.). Although this grass parrot nests in the eucalypt woodland at Newington the species could not survive on the food resources found in the woodland and depends on large areas of grassland and parkland for food (Figure 6). The Red-rumped Parrot has been observed feeding on grasslands of Ermington and Wilson Parks and within the Newington naval establishment.

### 2.2.1 *Newington fill sites*

The rough grasslands on the north fill site at Newington (Figure 7) provide nesting and feeding habitat for large numbers Golden-headed Cisticola, Superb Fairy-wren and important foraging habitat for several species of birds of prey, finches and occasional Latham's Snipe. Grasslands on the southern fill site at Newington (Figure 8) abuts saltmarsh and cumbungi swamps. These sloping grasslands provide foraging and nesting habitat for White-fronted Chats, Golden-headed





Figure 5. This woodland acts as a link between other remnants and parklands.



Figure 6. Mangrove woodland at Bicentennial Park. Most woodland birds use the outer canopy and outer margins and few birds are found below this dense canopy.





**Figure 7.** Newington north fill site - nesting and feeding habitat for large numbers of Cisticolas, Fairy-wrens and foraging for several species of birds of prey.

Cisticolas and Richard's Pipits. Locally rare species of birds of prey such as the Black-shouldered Kite, Brown Falcon and regionally rare species such as Brown Goshawk, Australian Hobby and Peregrine Falcon and ground birds such as Brown Quail and Latham's Snipe also utilise this area for foraging.

### 2.3 PARKLANDS

Parklands, for the purpose of this report are open areas of modified habitat comprising largely of grasslands with well spaced trees or where trees are largely absent. Grasslands are regularly mown. Access roads or pathways are well formed or sealed.

#### 2.3.1 *Newington*

A major proportion of the RANAD site is parkland. Management of the site has resulted in large areas of mown grasslands with widely spaced trees. These parklands attract large numbers of Australian Ravens (flocks of up to 50) and small numbers of other birds which feed on invertebrates including Richard's Pipits and occasional Australian Kestrels if the grass is allowed time to grow a few centimetres. After heavy rains some areas become waterlogged and attract White-faced Herons and Australian White Ibis.





**Figure 8.** Newington south fill site. Important foraging habitat for locally rare birds of prey and nesting sites for White-fronted Chat.

### 2.3.2 *Bicentennial Park*

The parkland of Bicentennial Park is largely mown grassland with rows of introduced tree species and some small clumps of native bushes and shrubs. The grasslands attract large flocks of starlings, and smaller numbers of other introduced species of birds such as Nutmeg Mannikins and Common Mynas. As the trees in the parkland additional cover and nesting habitat will be provided for species such as Black-faced Cuckoo-Shrike, Magpie-Larks and Magpies.

## 2.4 RESIDENTIAL AREAS

Residential areas were not visited as part of this study. Casual observations of residential areas revealed a number of birds not associated with other habitats. These included the introduced Blackbird which was heard singing on regular occasions at Mason Park and at Ermington. Domestic doves and pigeons were observed in and around gardens at Mason Park.

## 2.5 INDUSTRIAL AREAS

The industrial areas were largely devoid of birds other than House Sparrows and Common Mynas except where trees and shrubs have been planted for aesthetics, screening buildings etc. In which case visiting honeyeaters and other woodland birds were occasionally found.

### **3 METHODS**

A review of literature was carried out to assess which species have been recorded within the study area in the past. An initial visit was made to all parts of the study area and sites selected for ongoing monitoring.

Observations were made by walking along fixed transects every fortnight over a twelve month period between November 1992 and October 1993. Transects used to assess relative abundance of birds were measured from the start to the finish using a measuring wheel. All birds within a twenty-five metre strip of habitat with either side of the observer were then counted on each visit. The length of each transect varied, starting and ending at convenient, well defined land marks such as a road or perimeter fence. Transect counts were conducted during early morning when most birds were actively feeding and more easily detected and counted. One nocturnal visit was carried out at the Newington woodlands using spotlights during a random walk. Tape recordings of species which were known to occur in the Sydney area were played for periods of three minutes followed by a ten minute listening period. Any incidental observations of birds made during the survey or moving from one site to another were noted and included in the bird list in the appendix of this report.

All sites which appeared significant to woodland birds were visited on at least fortnightly intervals. Other sites were visited on at least one occasion included the vegetation along the periphery of the main brickpit and the extensive land fill area between Hill Road and the abattoir site.

#### **3.1 LIMITATIONS OF TECHNIQUES**

Transect counts are the most effective method to estimate the abundance of birds within a given area. The technique is especially useful for large areas which cannot be completely covered for practical or economic reasons. Some bird species may be missed in areas not covered, especially cryptic species which do not move until flushed by approaching in close proximity and other birds, such as birds of prey, which fly away from the area on the approach of an observer.

## 4 DISCUSSION

Homebush Bay has been largely cleared of natural vegetation and consequently provides very restricted areas of habitat suitable for woodland birds. This study has examined the remaining natural habitat and areas of established parkland to determine the importance of all sites to birdlife. Part 1 of the study covered the wetland habitat and birds relying on wetlands for at least part of their life cycle (Straw 1993). Part 2 covers habitats of special significance including remnant woodlands, mangrove forests, rough grassland and shrubland and parkland.

The woodlands at Newington are especially important to woodland birds of the Homebush Bay area and hold a diversity of species which is rare in the Sydney area for such a small area. The diversity of parrot species is of particular significance.

Introduced species of birds were found to have an impact on the parrots nesting at Newington eucalypt woodland by competing for nesting hollows. Common Mynas and Common Starlings were observed to display aggressive behaviour towards Red-rumped Parrots and Rainbow Lorikeets excluding them from nesting hollows.

With the loss of a large proportion of woodlands in the Sydney area the remnant woodlands of Homebush Bay provide important habitat for many bird species. Some of these birds are residents while others are migrants or vagrants moving through or visiting the area and use the area as a corridor between other areas of woodland in or near Sydney.

## 5 ANNOTATED BIRD LIST

A list of birds recorded during this study includes a brief description of each bird's distribution and local, regional and national status to give the reader an indication of the importance of Homebush Bay to the birds survival. This list is set out in a standard systematic classification based on *Peter's Checklist of Birds of the World*, Volume 1 (1979) and the Wetmore order of 1960.

### FALCONIFORMES (Osprey, Kites, Hawks, Eagles and Falcons)

Osprey,

*Pandion haliaetus*

The subspecies occurring Australia, *Pandion haliaetus cristatus* ranges from south-east Asia and the Indonesian Archipelago eastward to New Guinea and southward to Australia where it appears sedentary. The northern subspecies are migratory, breeding in North America and Europe, then migrating to South America, Africa and the Philippines.

It is strictly coastal in occurrence in Australia, more common in the north. This species is very rarely seen in the Sydney area (Hoskin, 1991) and has not previously been recorded in Homebush Bay or the Parramatta estuary. A single sighting was made on 22nd July 1993.

Black-shouldered Kite,

*Elanus notatus*

Endemic to Australia where it is widespread. In NSW it is more common in the eastern part of the state.

A resident pair was frequently observed hunting over rough grasslands at Newington and occasionally other locations at Homebush Bay. This pair nested in a eucalypt tree near the internal road, west of the cumbungi swamp at Newington, and successfully reared three young. Subsequently frequently observed hunting over adjacent grasslands throughout the study period.

Whistling Kite,

*Haliastur sphenurus*

Occurs in New Guinea, western Pacific islands and Australia. Widespread especially in areas of eucalypt forest and woodland, generally near water. Widely distributed in the Sydney area though seldom seen in groups of more than 2 or 3 individuals.

It has been rarely observed in the Homebush Bay area in the past. Sightings of single birds and calls heard near Haslams Creek during this study. According to Morris (1990) only three records of sightings have been made since 1964 one of which was in February 1986.

Brown Goshawk,

*Accipiter fasciatus*

Distribution includes islands of the Indian and Pacific Oceans, New Guinea and Australia. Widely distributed throughout the Sydney area where most records are made in the cooler months (Hoskin, 1991).

Up to two birds, an adult female and a juvenile male, were observed at Newington Woodland and hunting over rough grasslands from 19th March 1993, the male being still present on 12th August. A single bird observed at Mason Park was most likely the juvenile male observed at Newington. These observations were significant as only two sightings were recorded by Morris in February 1986 and only irregular sightings reported since 1965 (Morris, 1990).

White-bellied Sea-Eagle, *Haliaeetus leucogaster*  
 Ranges from India, south-eastern Asia and New Guinea to Australia. Mainly coastal in Australia and throughout the Murray-Darling Basin. Up to 12 nests were known in the County of Cumberland in late 1949 and early 1950's (Hoskin, 1991) but appear to have declined since.

Pairs of White-bellied Sea-Eagles have been attempting to breed at Newington at least in recent years. Two birds were observed in the area on 7th January 1993 and appeared to have taken over the territory. One of these birds appeared to have a few brown feathers remaining and may have only just come into breeding condition. Previous observations of an immature bird in 1984 and one bird over Yaralla Bay was reported by Morris (1990).

Marsh Harrier, *Circus aeruginosus*  
 Cosmopolitan in distribution with the exception of the American continent. In Australia breeds mainly in south-eastern and south-western Australia, south of 33°S and appears to be a non-breeding visitor elsewhere. Widespread but uncommon in the Sydney area.

There are no recent records of this species in the Homebush Bay area before this study. A single adult bird was observed hunting over grasslands and wetlands of Newington on 18th November 1992.

Peregrine Falcon, *Falco peregrinus*  
 Almost cosmopolitan in distribution. Widespread throughout Australia except rolling downs and western deserts but is uncommon. The only records prior this study were 3 records between 1965 and 1972 and one bird in December 1984 (Morris, 1990).

Observations of a single bird was made on 21st January 1993 hunting over grassland at Newington and roosting in trees in the eucalypt woodland.

Australian Hobby, *Falco longipennis*  
 Endemic to Australia and parts of Indonesia. Widespread throughout Australia. Not common in the Sydney region although more prevalent than the Peregrine (Hoskin, 1991).

Only five records for the area between 1966 and 1984 were reported by Morris (1990). Observations of single birds were made during this study hunting over grasslands of the middle and north fill areas at Newington.

Brown Falcon, *Falco berigora*  
 Occurs in New Guinea and Australia where it was the most widely reported species during the compilation of the The Atlas of Australian Birds (Blakers, 1984). Widely distributed throughout the Sydney area in open forest country and cleared lands although in smaller numbers than in previous year (Hoskin, 1991).

Solitary birds observed on a number of occasions at Newington, often perched on bunkers west of cumbungi swamp. Prior to this only three observations were recorded between 1966 and June 1985 (Morris, 1990).

Australian Kestrel, *Falco cenchroides*  
 Widespread throughout Australia and also found in New Guinea and Indonesia. Morris (1990) recorded one bird feeding at Bicentennial Park in 1984 other records by Eskill (1986) and Bicentennial Park between 1988 and 1991. One or two birds were frequently observed,

occasionally up to six foraging over rough grasslands at Newington. Observations appear to relate to one pair of birds which nested at Newington (nest was not located). Two birds observed on one occasion catching grasshoppers on mown grassland and one bird carrying a lizard (ca 15 cm). Not observed at other sites during this study.

Feral Pigeon, *Columba livia*  
This species is a feral version of the European Rock Dove and most likely originated from escapees from racing lofts. It is now a common breeding bird of towns where it nests in buildings and other built structures including derelict ferries and barges (pers obs). Common in the Homebush Bay area around residential areas and on adjacent sports fields. Flocks of 100 or more were observed on a regular basis on open grasslands, notably on Mason Park sports fields and smaller flocks elsewhere including the south landfill area at Newington.

Spotted Turtle-Dove, *Streptopelia chinensis*  
Introduced species, native of southern Asia. Occurs throughout coastal NSW. Common breeding resident in Homebush Bay, observed in small numbers in most localities where trees occur, including mangroves, parklands and Newington woodlands.

Common Bronzewing, *Phaps chalcoptera*  
Widespread throughout most of Australia but described as uncommon in the Sydney area (Hoskin, 1991). Rarely observed in the Homebush Bay area. Single sightings were made on two occasions, during this study, feeding on the ground at Newington Woodland.

Crested Pigeon, *Ocyphaps lophotes*  
Common throughout most of Australia but was not recorded in the Sydney area prior to the 1940s. The extension of its range is attributed to releases of birds from aviaries in parts of Sydney (Hoskin, 1991). The species is however still extending its range, in recent years reaching Canberra (McComas 1992), which casts some doubt on this theory. Small numbers observed on a regular basis during the study period at Mason Park, Bicentennial Park, Newington mangroves and woodland.

Galah, *Cacatua roseicapilla*  
Common throughout most of Australia however this species was not recorded in the Sydney areas, other than aviary escapees, prior to the drought of 1941 when large numbers were seen in some areas. The first authenticated breeding record for the county of Cumberland was at Richmond in 1955 (Hoskin, 1991). This species has since increased and breeds in many areas in the Sydney region. Flocks of up to 30 birds observed on open grasslands at Bicentennial Park during this study and small numbers were observed prospecting for nesting sites at Newington Woodland, however nesting did not take place.

Sulphur-crested Cockatoo, *Cacatua galerita*  
Widely distributed throughout most types of timbered country in coastal Australia from the Kimberley around to the east and south to south-eastern Australia. This species has increased in numbers in the Sydney area since the 1960s prior to which it was much less common than now. The lack of mature wooded terrain is probably the main reason few birds occur in the Homebush Bay area. One pair was observed nesting at Newington eucalypt woodland during October 1993. Small numbers, up to 8, observed on a regular basis in and around Newington woodland and a single observation of two birds at Mason Park.



**Rainbow Lorikeet***Trichoglossus haematodus*

Occurs throughout coastal regions of Australia from Cape York south to Victoria and west as far as the Eyre Peninsula. Up to ten birds observed at Newington eucalypt woodland from November 1992 to the end of this study. Breeding was deduced from the fact that nesting holes were occupied. Breeding success was not confirmed and may be influenced by availability of food resources.

**Scaly-breasted Lorikeet***Trichoglossus chlorolepidotus*

Mainly coastal distribution from near Cooktown south to the Illawarra district in NSW. Less common than the Rainbow Lorikeet in the Sydney area. Was not recorded as breeding until 1967 at Glenfield (Hoskin 1991). Rarely observed in the Homebush Bay area. A single bird observed prospecting a nesting hollow at Newington eucalypt woodland on 6th October 1993.

**Crimson Rosella***Platycercus elegans*

Occurs in eastern and south-eastern Australia. Widespread throughout the Sydney area. Rarely found in the Homebush Bay area due presumably to lack of habitat. Single observations at Newington Woodland on 7th September 1992 and 6th October 1993.

**Eastern Rosella***Platycercus eximus*

Occurs in south-eastern Australia, including Tasmania. Widely distributed throughout the Sydney area. A small population appears to be resident at Newington Woodland as observations were made during all months of the study period. Up to 12 birds were counted within the woodland during transect counts.

**Port Lincoln Ringneck***Barnardius zonarius*

Widely distributed in southern, central and western Australia, west of the Flinders Ranges, South Australia. Feral populations, originating from escapees, reported from Sydney and confirmed breeding in Canberra and Melbourne (Forshaw and Cooper, 1981). A single observation, presumably an aviary escapee, at Newington eucalypt woodland on 5th October 1992.

**Red-rumped Parrot***Psephotus haematonotus*

Occurs in south-eastern Australia, chiefly the interior. Now localised in the Sydney area where it was previously reported as being widespread throughout the shale country (Hoskin, 1991). Up to 40 birds previously recorded at Meadowbank Park (Hoskin, 1991) were presumably from the Newington colony. They are resident and breeding at the eucalypt woodland at Newington where up to 55 birds were counted during transect counts. These parrots were observed feeding on grass seeds and green seed-heads of various weeds such as Chickweed, Milk Thistle, Flatweed, Cobbler's Peg and Fire Weed. Feeding sites included open grasslands and Middle Marsh area at Newington and occasionally at Wilson Park, Bicentennial Park and near the Abattoir Woodland. Feeding was observed largely in open situations and occasionally in saltmarshes where appropriate grasses or weeds were growing. The infrequently mown grasslands in and around Newington are of particular importance as a food source where grasses are allowed to seed.

**Fan-tailed Cuckoo***Cuculus pyrrhophanus*

Occurs throughout eastern, south-eastern and south-western Australia, also in New Guinea. Widespread throughout the Sydney area. Single birds seen or heard in and around the woodlands at Newington during summer months. This species bird most commonly parasitises small woodland birds which construct covered nests such as Brown Thornbill, scrubwrens and



occasionally the open nests of some honeyeaters. The latter would be the most likely at Homebush Bay as both Brown thornbills and scrubwrens are rare in the area.

Horsfield's Bronze-Cuckoo

*Chrysococcyx lucidus*

Widespread throughout Australia in timbered areas from inland to the coast. Observed or heard occasionally in open woodland at Bicentennial Park and Newington mangroves. The Horsfield Bronze-Cuckoo parasitises host species such as Superb Fairy-Wrens and Cisticolas (both of which are widespread and common in the Homebush Bay area), which construct small domed nests.

Common Koel

*Eudynamys scolopacea*

Occurs throughout coastal regions of northern and eastern Australia as far south as southern NSW. Also in New Guinea, China and India. Single sightings of females on two occasions in the sparse woodland on the west side of Newington Woodland.

Known to lay eggs in the nests of friarbirds, wattlebirds and orioles. The wattlebird is the most likely host at Homebush Bay.

Channel-billed Cuckoo

*Scythrops novaehollandiae*

Summer migrant to northern and eastern Australia as far south as Sydney. Rarely observed in the Homebush Bay area. Generally depends on Pied Currawongs as foster parents frequenting woodland and forest areas. A single bird observed flying over Newington on 7th January, 1993 which appeared not to stop in the area.

Southern Boobook

*Ninox novaehollandiae*

The Southern Boobook is widely distributed throughout the Australia where there are suitable trees for nesting and roosting. In Homebush Bay observations were made of solitary birds roosting during daylight hours in the eucalypt woodland on one occasion and on two occasions in the casuarina woodland.

Barn Owl

*Tyto alba*

Found in all parts of Australia, other subspecies throughout much of the world. Observed once during this study when a single bird was seen roosting in a tree in the remnant eucalypt forest at Newington. Reports of previous sightings of 'white owls' were reported by Naval Security Guards (pers comm) indicate that this species may be regular visitor or resident. The open woodland and rough grasslands provide an ideal habitat for this species.

Azure Kingfisher

*Alcedo azurea*

Occurs throughout coastal regions of northern, eastern and south-eastern Australia, also in New Guinea and the Moluccas. Although once widely distributed throughout the Sydney area this species is considered as extremely rare largely due to development (Hoskin, 1991). A single observation at Back Pond at Bicentennial Park 30th May 1993 during this study is the only recent record of this species for the Homebush Bay area.

Laughing Kookaburra

*Dacela novaeguineae*

Occurs throughout eastern, south-eastern and extreme south-western Australia. Widespread and common throughout the Sydney area. A resident pair at were observed on a regular basis, with a maximum count of three, at Newington in and around Newington eucalypt woodland and up to two birds observed at Abattoir Woodland. Usually common in parks and gardens in the Sydney area but the lack of mature trees, which provide convenient perches from which to locate prey, may be the reason for lack of observations at Bicentennial Park.

## Sacred Kingfisher

*Halcyon sancta*

Widespread throughout much of Australia, (except the arid interior), where it is found in tall, open woodlands and forest, paperbark forest and mangroves forests. This species is a partial migrant and a few birds remain in the Sydney area over winter. Little suitable habitat exists in the Homebush Bay area. Observed on three occasions in the eucalypt woodland and on one occasion in the Abattoir Woodland.

## Dollarbird

*Eurystomus orientalis*

Summer migrant to northern and eastern Australia where it occurs on the edges of tall tropical forests or in open woodland. Widespread throughout the Sydney area from September to March. This species was observed visiting the Newington eucalypt woodland on three occasions. A hollow nesting species it is thought to be under threat from competition by nesting Common Mynas (Hoskin, 1991).

## Skylark

*Alauda arvensis*

Introduced species to south-eastern Australia. Exists in small numbers in the Sydney area where it is thought to have declined in numbers in recent years (Hoskin, 1991). One pair observed on a regular basis throughout the study period at Middle Marsh at Newington where they appeared to have nested, rearing three young.

## Welcome Swallow

*Hirundo neoxena*

Resident in eastern, southern and western Australia, summer migrant to Tasmania and partial migrant in Victoria and southern NSW where numbers are noticeably fewer in winter.

Present throughout the year, more numerous in summer months, frequently observed feeding over wetlands and grasslands.

## Fairy Martin

*Cecropis nigricans*

Widespread throughout Australia except Cape York. Summer migrant of southern Australia, a few birds may remain in the Sydney area. Present at Homebush Bay from September to March.

Fairy Martins nest on a regular basis under concrete culverts at Bicentennial Park and are particularly common at Newington where they nest under the eaves of many of the storage bunkers and other buildings. Nest sites are close to low lying areas of grasslands or open water where insects are taken on the wing. The muddy shores of freshwater wetlands or pools are relied upon for a supply of mud for nest construction. Regular observations of birds foraging over grasslands and wetlands throughout the study area.

## Richard's Pipit

*Anthus novaeseelandiae*

Widespread throughout Australia, New Zealand, much of Africa and Asia to New Guinea. Observed in small numbers on regular occasions throughout the year on open grasslands at Newington, where it was observed nesting, and at Bicentennial Park. Nests were largely on rough or infrequently mown grasslands.

## Black-faced Cuckoo-Shrike

*Coracina novaehollandiae*

Widespread throughout Australia where it is common in most types of woodland, also occurs in New Guinea and southern Asia. Observed on a regular basis in small numbers at Newington, Bicentennial Park, the Abattoir Woodland and occasionally at Mason Park. Rarely observed on the ground preferring to feed in canopies of medium to tall trees. This species was observed feeding a dependant young at the Newington eucalypt woodland.

Red-whiskered Bulbul

*Pycnonotus jocosus*

A resident of India and Asia which was introduced to New South Wales in about 1880 becoming a common species by about 1920. Observed in small numbers (pairs or family parties of up to five birds) in most wooded areas throughout Homebush Bay where it appears to breed quite successfully. No obvious threat to native species observed during this study.

Blackbird

*Turdus merula*

Introduced species. No significant impact observed on native wildlife. Frequents residential gardens where it was occasionally heard singing or uttering its familiar alarm call. Also observed near the mangroves bordering Haslam's Creek and Ermington.

Eastern Yellow Robin

*Eopsaltria australis*

Occurs along the coastal region of Australia from Cooktown to south-eastern Australia. Widely distributed throughout the Sydney area in all types of forest country and parkland with adequate tree and shrub cover. Up to two birds observed or heard in the Casuarina woodland most months (Jan-Oct '93) of the year and single birds in the eucalypt woodland.

Golden Whistler

*Pachycephala pectoralis*

Resident throughout the coastal region of eastern, south-eastern and south-western Australia. Widespread throughout well timbered parts of the Sydney area especially damp gullies in Sandstone and rainforests. Restricted to Newington Casuarina woodland and eucalypt woodland. Limited habitat available in the Homebush Bay area for this species.

Leaden Flycatcher

*Myiagra rubecula*

Occurs throughout coastal regions of northern and eastern Australia into south-eastern Victoria becoming rare in the south. Birds breeding in the south-eastern Australia migrate to north-eastern Australia and New Guinea in winter. Visits the Sydney area between September and March where it nests in forest country including estuarine mangroves. A single observation on the edge of the Bicentennial Park mangroves on 2nd December 1992 was the only record for Homebush Bay during this study.

Restless Flycatcher

*Myiagra inquieta*

Found throughout northern and eastern Australia, including much of the inland, also in south-western Australia. A breeding resident in the western part of the County of Cumberland. A single observation was made of a bird at the edge of the eucalypt woodland at Newington during this study.

Rufous Fantail

*Rhipidura rufifrons*

Migratory to coastal south-eastern Australia as far as southern Victoria, resident further north as far west as the Kimberley. A regular migrant to Sydney where it breeds in rainforest gullies and mangrove forests but is often seen in open forest while on migration. One to two birds observed between 5/10/92 and 3/12/92 in mangroves between 33 Marsh and Main Lagoon, however there appeared no evidence of breeding.

Grey Fantail

*Rhipidura fuliginosa*

Widespread throughout most of Australia except for the arid interior, also occurs in New Caledonia and New Zealand. Resident throughout most woodland types in the Sydney area, although nomadic outside of the breeding season. Sightings of single birds in wooded areas of Newington and parkland at Bicentennial Park.

## Willie Wagtail

*Rhipidura leucophrys*

A sedentary species found throughout the Australian continent and also New Guinea. Occurs in most habitats in the Sydney area. Common throughout the study area in open woodland and parkland where suitable cover was available for the birds to take refuge from predators.

## Clamorous Reed-warbler

*Acrocephalus stentoreus*

Widespread throughout Australia and found anywhere in reeds of swamps. Also occurs through Indonesia and southern Asia to north-east Africa. Birds of southern Australia migrate northwards during winter. NSW birds remain over winter but are noticeably quieter. In Homebush Bay this species was located in all areas of Cumbungi (*Typha* sp.) including small clumps within the rough grasslands of Newington and fringing drains and creeks.

## Little Grassbird

*Megalurus gramineus*

Occurs in south-east Australia from Eyre Peninsula through coastal and inland as far as south-east Qld. Also in south-west Australia and Tasmania. Common throughout the Sydney area in dense vegetation bordering swamps, lagoons and sedge-flats. Also found in low-growing mangroves at Homebush Bay.

## Golden-headed Cisticola

*Cisticola exilis*

Found throughout the Sydney area in rank vegetation on the borders of swamps, lucerne paddocks, soaks in sand dunes and in sedges in saline and freshwater or thickly vegetated open areas (Hoskin, 1991). Numerous in all rough grasslands and emergent vegetation of fresh and brackish swamps in Homebush Bay.

## Superb Fairy-wren

*Malurus cyaneus*

A sedentary species found in south-eastern Australia and Tasmania. Occurs in most areas around Sydney where sufficient low scrub and thick undergrowth occurs. The most widespread of all woodland birds in Homebush Bay. Found in Mangroves, rough grasslands which have sufficient cover and open woodland. Commonly observed in family groups which often share in the rearing of young.

## White-browed Scrubwren

*Sericornis frontalis*

Found throughout coastal and adjacent mountain areas of Australia from Cairns, southwards, around southern Australia to Shark Bay in south-western Australia. A largely ground-feeding bird of forested areas. Found throughout the Sydney area, where it is a breeding resident, in areas of thick vegetation.

## Brown Thornbill

*Acanthiza pusilla*

Found in coastal regions of south-east Australia in forest, woodland and parklands. Occurs throughout the Sydney region particularly in thick low vegetation in sandstone areas but less common in the Shale. Only one observation was made of this species, during the study period, in the mangrove woodland at Bicentennial Park on 2/12/92.

## Yellow-rumped Thornbill

*Acanthiza chrysorrhoa*

Ranges throughout open forest, grassy plains and parklands of much of the southern two thirds of Australia. Once a common species in the Sydney area its numbers have been reduced by development (Hoskin, 1991). Small groups of up to 10 birds frequently observed in open parkland and on one occasion in the mangrove woodlands at Bicentennial Park. Up to 4 birds occasionally observed in the grasslands, where there were adjacent trees at Newington.

Yellow Thornbill

*Acanthiza nana*

A sedentary species found throughout south-east Australia in a variety of habitat from dry scrub of the inland to woodlands of the coastal region, but avoiding rainforest and high country. Found throughout the Sydney area where it shows a preference for wattles, paperbarks, casuarinas, turpentine or mangroves (Hoskin, 1991). In the Homebush Bay area this species was found extensively throughout the mangrove and casuarina woodlands. Nesting observed at Corner Marsh where birds were using fibres from Pampas grass-heads for nesting material to build in nearby mangroves.

Red Wattlebird

*Anthochaera carunculata*

Occurs throughout forest and woodland areas of the coastal region of south-east, southern and south-western Australia but excluding Tasmania. A common bird in woodlands and parks of the Sydney area where it is a breeding resident. Occasionally observed at Newington eucalypt woodland apparently coinciding with flowering gum species. Up to 11 birds observed September, January and May.

Brush (Little) Wattlebird

*Anthochaera chrysoptera*

Occurs in coastal heathlands and woodlands of south-eastern Australia. Common in sandstone heathlands, coastal scrub and areas of Banksia, notably *B. ericifolia* and *B. integrifolia*. Regularly observed in small groups (up to 7) at Newington eucalypt woodland coinciding with flowering gums. One or two birds observed occasionally in eucalypts or Casuarinas at Wilson Park, Newington Casuarina woodland and Mason Park.

Noisy Miner

*Manorina melanocephala*

A common bird of the dry sclerophyll woodlands and parklands of eastern Australia ranging from tropical Qld south to Tasmania and South Australia. A common resident of the Sydney area where it is seen in parks, gardens, open forest and partly cleared lands, particularly in shale country. This species is particularly aggressive to small birds and may exclude many small woodland species if insufficient thick scrub or understorey is present. Up to eight birds observed at Newington eucalypt woodland and up to five at the Newington casuarina woodland.

Yellow-faced Honeyeater

*Lichenostomus chrysops*

Occurs in the coastal region of eastern Australia from the Atherton Tableland in Qld to the Flinders Ranges in South Australia. Found largely in the denser dry sclerophyll and wet sclerophyll forests or along creeks but may occur in a wide variety of habitats during winter and while on migration. A large proportion of the population migrates northward into NSW and Qld between March and May each year. Widespread throughout the Sydney area with an influx of birds from southern states in autumn and winter. Infrequent visitor to Newington eucalypt woodland during this study. A passage of birds through the area was observed on 6/5/93, most likely migratory birds, when up to 20 were counted at one time.

White-plumed Honeyeater

*Lichenostomus pencillatus*

Common in open forest and woodland in the vicinity of water and in parks and gardens throughout most of Australia except coastal north and north-eastern Australia and southern coast of WA. Considered to be a straggler to the Sydney area prior to the 1950's but now widely distributed as a resident in parks and suburban gardens in some municipalities (Hoskin, 1991). Abundant in Newington eucalypt woodland throughout the study period. Also observed in small numbers at Bicentennial Park, Mason Park, bordering Brickworks Pond, adjacent to 2SM pond, Casuarina woodlands at Newington and Wilson Park and at Abattoir Woodland.

## Brown Honeyeater

*Lichmera indistincta*

A common bird over much of its range which covers a major proportion of the continent, except south-eastern Australia south of Sydney. Migratory in the southern portion of its range. Small numbers occur in the Sydney area where the bird is most often found nesting in mangrove woodlands. Birds observed within the Homebush Bay during this study were restricted largely to nesting territories in mangrove woodlands of Newington (2 pairs) and Bicentennial Park (1 pair).

## New Holland Honeyeater

*Phylidonyris novaehollandiae*

Occurs within the coastal regions of south-eastern and south-western Australia where it is found in open woodlands and coastal heathland. Common throughout the Sydney area except in shale country (Hoskin, 1991). A single observation in was made of one bird in trees adjacent to Mason Park during this study.

## White-fronted Chat

*Ephthianura albifrons*

Fairly common in southern Australia and Tasmania in low dense cover where there is moist herbage or on the fringes of swamps and lakes. Homebush Bay is one of only two areas in the Sydney area which have significant populations of White-fronted Chats, the other area being Towra Point Nature Reserve. The population at Homebush Bay is estimated at between 60 and 100 birds with the vast majority being within the Commonwealth property at Newington. This would be substantially larger than previously estimated. Hoskin (1991) for example has suggested that only a small group were managing to survive at Homebush Bay.

## Spotted Pardalote

*Pardalotus punctatus*

Found throughout the coastal regions of eastern and south-eastern Australia and small area of south-western Australia. Common in the Sydney area where it is often observed feeding on scale and other insects among the foliage of eucalypts. Observed on three occasions at the Newington eucalypt woodland and on one occasion at Abattoir Woodland.

## Silvereye

*Zosterops lateralis*

Common throughout Tasmania and most of coastal and adjacent areas of the mainland except north and north-west. A common bird in the Sydney area where it is found in most types of woodlands, parks and gardens. Common throughout the more densely wooded areas of Homebush Bay including mangroves usually in small parties. Flocks of up to 30 birds observed in the mangroves at Bicentennial Park.

## European Goldfinch

*Carduelis carduelis*

An introduced species from Europe. Common throughout the settled agricultural lands of temperate south-east Australia, including Tasmania. Small feral populations in south-western Australia. It is thought to be less common in the Sydney area than 20 years ago (Hoskin, 1991). At Homebush Bay it is a common species observed in groups of 2 to 35 birds during this study over rough grasslands and in mangrove areas at Bicentennial Park, Newington and Mason Park. This species appeared to feeding on various weed species and in the upper canopy of mangrove woodlands.

## House Sparrow

*Passer domesticus*

An introduced species from Europe during the 1850's and early 1860s. Now common throughout eastern and south-eastern Australia. Widespread throughout the Sydney area where there has been an extension in its range over the past 20 years according to Hoskin (1991). Common

around residential, commercial and industrial areas. Small numbers around buildings and adjacent open grasslands at Newington and at Abattoir Woodland.

Red-browed Firetail

*Emblema temporalis*

Common throughout most of its range along the coastal region of Australia from north Queensland to the eastern border of SA. Widespread in the Sydney area where dense grasslands are located close to scrubland, trees or bushes. Occasionally observed in flocks of up to 20 birds in and around the casuarina woodland and up to 4 at the eucalypt woodland at Newington and in nearby scrub.

Zebra Finch

*Poephila guttata*

Common throughout Australia except in wet coastal forests. Once well distributed and common in shale areas and in the Hawkesbury Swamps. Now uncommon and only seen in a few locations in the Sydney area. (Hoskin, 1991). Regularly observed in small groups (up to 12) at Newington at the Middle Fill Site and Abattoir Woodland. Two birds observed at Mason Park.

Double-barred Finch

*Poephila bichenovii*

Common in localised areas of eastern and northern Australia. It has been suggested that the range of this species has extended towards the coast where it has adapted to human settlement, however Hoskin (1991) states that it was formerly more common in the Sydney area although still well distributed. Observed in small groups (up to 12 birds) on a regular basis throughout the study period at Newington on open grasslands, road verges and the edge of the woodlands. Also observed on a visit to the Brickpits on 1st October 1993 feeding on the ground.

Nutmeg Mannikin

*Lonchura punctulata*

Introduced to Australia, being a native of India, China and Burma. Localised populations in coastal Qld and NSW. According to Hoskin (1991) this species has increased substantially over the past 20 years in the Sydney area and large flocks can be seen during autumn and winter. Commonly observed in small flocks of 10 to 20 birds, occasionally up to 40 birds, feeding on grasslands or taking refuge in nearby trees throughout most of Homebush Bay parklands and at Newington.

Common Starling

*Sturnus vulgaris*

Introduced to Australia from Europe. Now common in south-eastern Australia extending from central Qld to Tasmania and SA. Isolated populations elsewhere. This species competes with other hole nesting species, including small native parrots (see under Red-rumped Parrot, this report). However Hoskin (1991) has suggested that the related Common Mynah is currently increasing in numbers faster than the Common Starling, successfully competing for nest sites. Widespread throughout the study area especially in residential areas and open parklands. Flocks of 30–40 observed on a regular basis on wetlands and open grasslands at Newington and up to 500 at Bicentennial Park. Observed nesting in viewing towers at Bicentennial Park, Bunkers and in tree hollows at Newington. Starlings were observed chasing Red-rumped Parrots away from nesting hollows at Newington Woodland.

Common Mynah

*Acridotheres tristis*

An introduced species from India. The Common Mynah has increased in recent years in the Sydney area and in other parts of NSW. This species was observed in small numbers throughout the study area feeding largely on open ground. Nests in trees hollows and in buildings where suitable nest sites can be found. In Newington Woodland this species was observed to evict Red-rumped Parrots from nesting hollows.



## Olive-backed Oriole

*Oriolus sagittatus*

Range includes coastal regions from Broome through forested areas of northern, eastern and southern Australia as far as Adelaide. Occurs in small numbers throughout the Sydney area where it is a breeding resident. Occasional observations were made of solitary birds at Newington eucalypt woodland during this study.

## Spangled Drongo

*Dicrurus hottentottus*

Occurs in coastal regions from Kimberley to Arnhem Land and from Cape York Peninsula to north-east Vic. In the Sydney area this species was a rare visitor prior to 1948 but now a regular visitor in small numbers but rarer in shale country. Although recorded for most months of the year, it has not been recorded as nesting. It has apparently increased in numbers in recent years (Hoskin, 1991). There were Single observations at Newington eucalypt woodland and Abattoir Woodland.

## Australian Magpie-lark

*Grallina cyanoleuca*

Widely distributed and common in most parts of Australia, usually near water, but avoids heavily forested areas. Common and widespread in the Homebush Bay area in open woodland, grasslands and near water margins. Nesting recorded at Newington Woodland on 6th October 1993.

## Dusky Woodswallow

*Artamus cyanopterus*

Range includes coastal regions from Atherton Tableland to South Australia and Tasmania and also the extreme south-west Australia. Occurs throughout the Sydney area in open forest, the borders of forests, heaths and cultivated farmland. The Dusky Woodswallow was observed nesting at Newington Woodland during the 1992 and 1993 breeding seasons and up to 9 birds were observed at any one time during transect counts. This species was not observed elsewhere in the Homebush Bay area, other than foraging over nearby grasslands, during the study period.

## Grey Butcherbird

*Cracticus torquatus*

Common in a wide variety of wooded country throughout much of Australia but excluding arid regions and Cape York peninsula. Found in forest country in most parts of the Sydney area.

Up to two birds observed occasionally in Newington eucalypt woodland and a single bird in Newington Casuarina woodland.

## Australian Magpie

*Gymnorhina tibicen*

Three sub-species are found widespread throughout most of Australia. Common in the Sydney area. Observed in small numbers at Bicentennial Park and Newington in open woodland and grasslands. Occasionally observed at Newington in groups of up to 23 birds.

## Pied Currawong

*Strepera graculina*

Widespread throughout the coastal region of eastern and south eastern Australia from Cape York to Victoria. Frequently observed in small numbers in wooded areas of Newington and the mangrove areas of Bicentennial Park. One pair observed sitting on a nest 6th October 1993 at the Newington eucalypt woodland where it was previously observed robbing nesting material from Magpie-lark's nest.

## Australian Raven

*Corvus coronoides*

Common throughout NSW, Vic, Qld (except coastal), much of South Australia and south-western Australia. Observed in at all sites during this study with flocks of up to 50 birds on the grasslands of Newington and old tip sites. A large proportion of these birds would be non-

breeding birds as this species generally mates for life and maintains a territory throughout the year. The large flocks are an indication that insufficient nest sites/territories are available. Nests are usually situated 10 metres or higher in a tree within a territory of 100 ha or more.

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# WETLANDS AND BENTHOS STUDY

# Wetlands and Benthos

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March 1993

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## 1 METHODS<sup>1</sup>

The most appropriate sampling design for an exploratory survey is based on grid sampling rather than random sampling, in order to remove the irregularities and inconsistencies of scale (Williams, 1971). This design gave the best coverage of the areas of interest and allowed us to locate areas with probable high and low diversity, identify problem areas and the sites in need of further study.

### 1.0.1 *Benthos*

In the study of the benthos an imaginary grid was used to divide the Bay into squares of approximately 130 metres by 130 metres. The grid defined 36 sampling sites in Homebush Bay (Fig. 1). A sample of 0.05m<sup>2</sup> of sediment was taken at the centre of each grid square using a Van Veen grab operated from a small boat at high tide. The centre of each grid square was located with the assistance of the Global Positioning System and marker buoys. Each sample was sieved through a 1mm mesh, preserved in 7% buffered formalin and later transferred to 70% ethanol. The samples were sorted in the lab using a stereomicroscope, and the macrofauna was identified and counted at species level where possible.

Four grab samples were taken in Haslam's Creek (Sites 37–40) and four in Powell's Creek (Sites 41–44). A voucher collection has been deposited with the Australian Museum.

### 1.0.2 *Epifauna of the wetlands*

The epifauna of the wetlands was studied at the following sites.

Code	Site	Description	Grid squares
B2	Newington Armament	North Newington wetland	6
D2	Haslam's Creek	2KY aerial	2
D3	Haslam's Creek	2SM aerial	2
E2	Brickworks	Brickworks mangroves	2
F1	Bicentennial Park	Waterbird refuge	2
F2	Bicentennial Park	Saltmarsh	2
F3	Bicentennial Park	Mangroves	6
G1	Mason's Park	Mason Park Wetland	2
<b>Total</b>			<b>26</b>

The codes were taken from Webster & Kachka 1992, Figure 1.2.

At each site an imaginary grid was used to divide the area, and at the centre of each grid square, the epifauna within a 0.25m<sup>2</sup> quadrat was identified and counted. In the saltmarsh one vegetated and one unvegetated quadrat was sampled at the centre of each grid square. Mobile species, such as amphipods, were estimated. Most of the epifauna were identified and counted in the field except the small molluscs and amphipods. The site was briefly surveyed and any additional species noted.

At the centre of each grid square a general site description was made, ie. the species of mangroves present, tree height and canopy cover estimated, and the presence or absence of salt marsh noted.

1. A number of detailed appendices accompany this report and are available upon request. Appendices 1 & 2 have been converted to Tables 1 & 2.



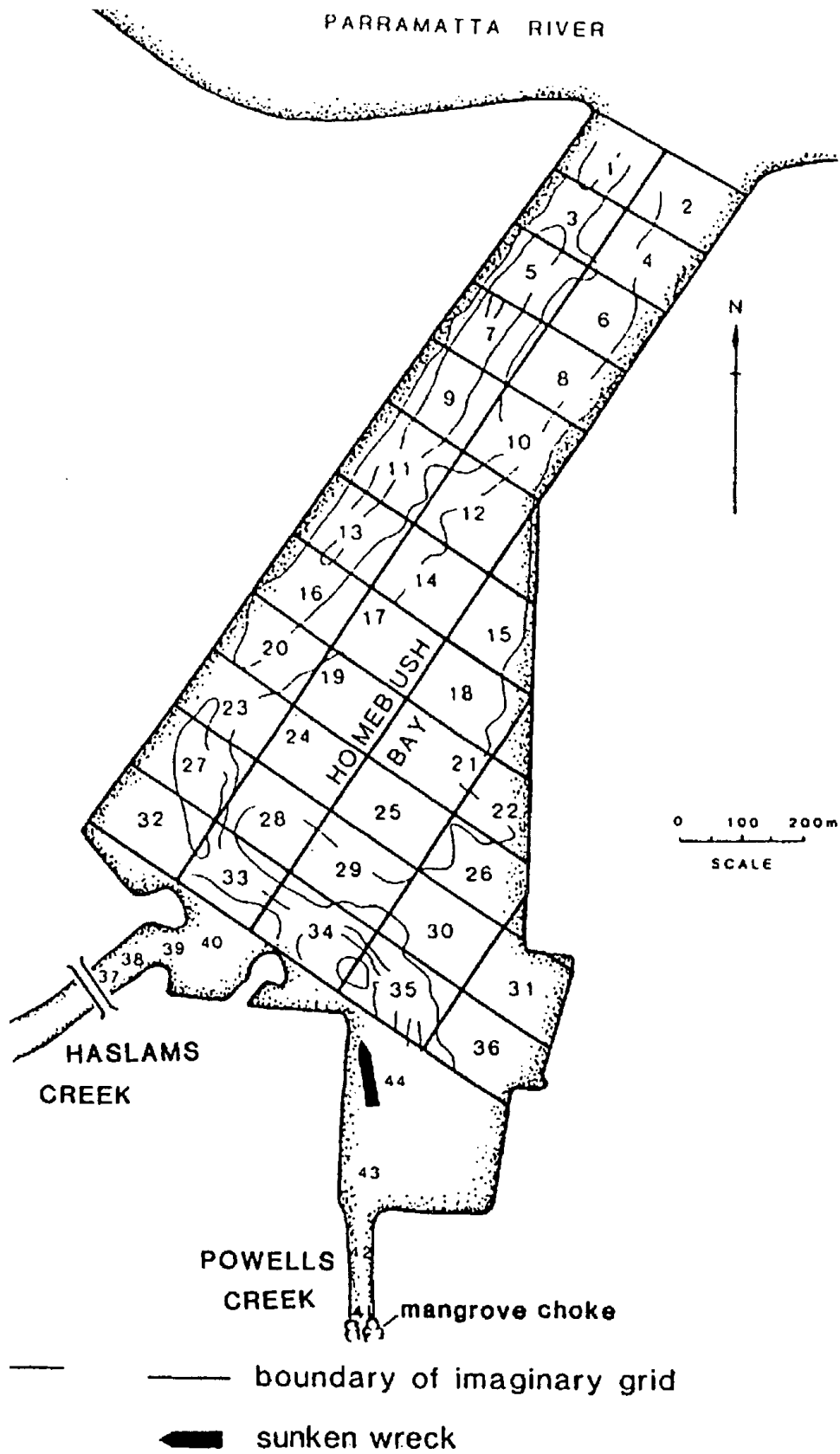


Figure 1. Sampling sites in Homebush Bay.

## 2 RESULTS

### 2.0.1 *The benthos of Homebush Bay*

A total of 42 species of polychaetes, molluscs and crustaceans were found in the benthos at Homebush Bay. The highest numbers of species (10–12 species per grab) were found in the grabs from four areas:

- (i) Haslam's Creek
- (ii) Powell's Creek
- (iii) in the Bay, in the channel along the western shore at sites 3, 5 and 7
- (iv) in the Bay, in shallow water (less than 1.0 metre depth) towards the southern end of the Bay at sites 18, 20, 21 (Fig. 1).

The benthos of Homebush Bay was dominated by (ie. species that were abundant in most grabs, see Table 1) the polychaetes *Nephtys australiensis* and *Prionospio yuriel*, the amphipod *Victoriopisa australiensis*, and the bivalves *Spisula trigonella* and *Tellina deltoidalis*.

The water depth varied from 0.5 metres to a maximum of 5.6 metres in the channel along the western side of the Bay. The Bay was turbid on all sampling days and macroalgae were not observed.

### 2.0.2 *Description of wetland areas*

#### 2.0.2.1 *B2 Newington wetlands*

The Newington wetlands were a mosaic of salt marsh (including *Sarcocornia quinqueflora*, *Suaeda australis*, and *Juncus kraussii*), mangroves (*Avicennia marina*), and areas that remain submerged at low tide. The pond in the north eastern corner had many dead tree stumps and appeared to be eutrophic with lots of algae floating on the surface of the water. There was a great deal of litter in the mangroves and salt marsh. In the mangroves the surface of the mud was covered by a layer of decomposing leaves and was anoxic beneath the leaves. Many amphipods (*Paracalliope australis*) were found among the decomposing leaves. There were very few crab holes in the mangroves and none was observed in the quadrats or the surrounding areas. In wet areas the surface of the mud was covered with an oily sheen. Mosquitoes were abundant in the mangroves. The pneumatophores lacked algal cover.

Six areas were sampled by quadrat (Fig. 2), three in mangroves (B2/2, B2/5 and B2/6) and three in saltmarsh (B2/1, B2/3 and B2/4). There were no unvegetated areas in the saltmarsh so only one quadrat was sampled at each area. Because large areas of the Newington wetlands were covered by water, the area was mapped in sectors radiating from the clearing at the Muster Point in Naval Zone 5.

Eight species of molluscs and crustaceans were identified at Newington wetlands. The most abundant species was the amphipod *Paracalliope australis* which was found on the leaf litter and at the base of the saltmarsh plants. There were no crab holes in any of the quadrats or surrounding areas, although *Sesarma erythroductyla* was observed near B2/5.

#### 2.0.2.2 *D2 2KY Aerial*

An area of saltmarsh and mangroves (*Avicennia marina*) was found along the eastern side of the site designated as D2. Two grid squares were sampled in the mangroves (D2/1 north and D2/2 south). There was a great deal of rubbish in the mangroves and there were no crab holes in either quadrat or in the surrounding areas. There was a thick layer of leaf litter throughout the mangroves.

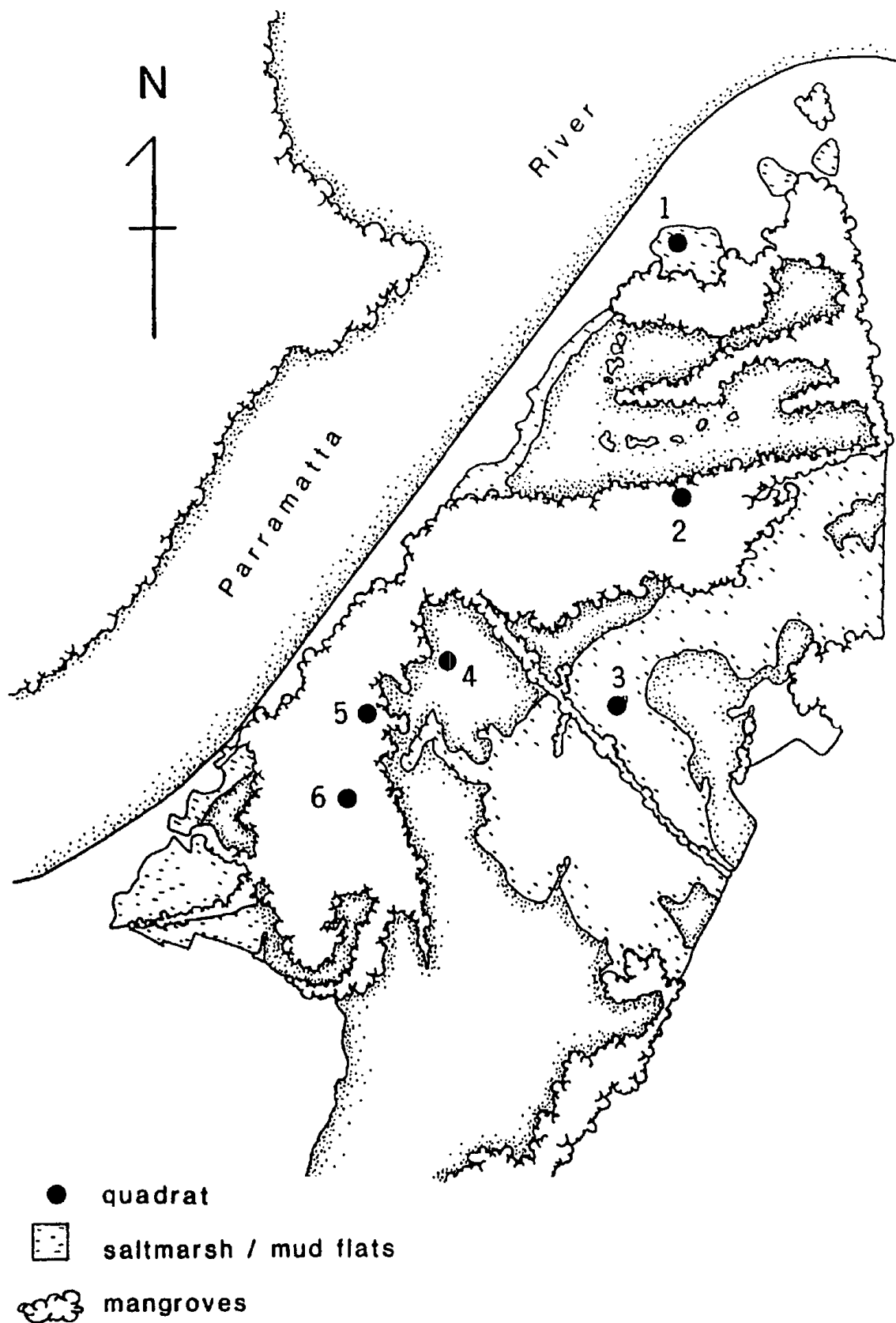


Figure 2. Sampling sites in Newington Wetlands.

Table 1 Species list of epifauna sampled at Homebush Bay mangrove and saltmarsh study sites.

MOLLUSCA		
BIVALVIA:	LEPTONIDAE	<i>Arthritica helmsi</i> (Hedley, 1915)
	MONTACUTIDAE	<i>Mysella</i> sp.
	MYTILIDAE	<i>Xenostrobus securis</i> (Lamarck, 1819)
GASTROPODA:	ASSIMINIDAE	<i>Assiminea buccinoides</i> (Q & G, 1834) <i>Assiminea siennae</i> (Tenison-Woods, 1877)
	AMPHIBOLIDAE	<i>Salinator solida</i> (Von Martens, 1878)
	ELLOBIIDAE	<i>Ophicardelus quoyi</i> H. & A. Adams, 1854
	HYDROBIIDAE	<i>Ascorhis victoriae</i> (Tenison-Woods, 1878)
		<i>Tatea huonensis</i> (Tenison-Woods, 1876) <i>Tatea rufilabris</i> (A. Adams, 1862)
CRUSTACEA		
CIRRIPIEDIA:	BALANIDAE	<i>Balanus amphitrite</i> Darwin, 1854
AMPHIPODA:	PARACALLIOPIIDAE	<i>Paracalliope australis</i> (Haswell, 1880)
	PODOCERIDAE	<i>Podocerus</i> sp.
	TALITRIDAE	<i>Orchestia</i> sp.
ISOPODA:	ARMADILLIDIIDAE	<i>Armadillidium vulgare</i> Latreille
	LIGIIDAE	<i>Ligia australiensis</i> Dana, 1853
	PHILOSCIIDAE	Philosciid sp.
	PORCELLANIDAE	<i>Porcellio scaber</i> Latreille, 1804
	SPHAEROMATIDAE	<i>Cymodetta gambosa</i> Bowman & Kuhne, 1974
		<i>Syncassidina aestuaria</i> Baker Sphaeromatid sp.1
SCYPHACIDAE	<i>Deto marina</i> Chilton, 1884	
	Scyphacid sp.1	
BRACHYURA:	GRAPSIDAE	<i>Paragrapsus laevis</i> Dana, 1852
		<i>Sesarma erythroductyla</i> Hess, 1865
ARTHROPODA		
ARACHNIDA:	PISAUROIDAE	
INSECTA		Unidentified insect larvae
ANNELIDA		
POLYCHAETA:	NEREIDIDAE	<i>Nereid</i> sp. (v. small)
	CAPITELLIDAE	<i>Capitella</i> sp.
OLIGOCHAETA		

Two species of amphipods and one species of isopod were the only crustaceans recorded at the 2KY aerial site. There were no molluscs found. The most abundant species was the amphipod *Paracalliope australis* which was found on the leaf litter in the mangroves.

#### 2.0.2.3 D3 2SM Aerial

This site includes mangroves (*Avicennia marina*), saltmarsh and a pond. Two grid squares (D3/1 and D3/2) were sampled by quadrat in the mangroves because this was the dominant habitat type. The mangroves were in fruit at D3/1 and crab holes were found. At D3/2 there were no crab holes and the surface of the mud appeared oily.

Eight species of molluscs and crustaceans were identified at the 2SM aerial site. Molluscs dominated the fauna at this site and in particular the mytilid bivalve *Xenostrobus securis* which was clustered at the base of the pneumatophores, and the small hydrobiid gastropod *Ascorhis victoriae* which was found among the leaf litter and at the base of the pneumatophores. There were no crabs or crab holes at D3/2, but there were some crab holes near D3/1 and *Paragrapsus laevis* was found near the quadrat.

#### 2.0.2.4 E2 Brickworks Mangroves

Along the edge of Haslam's Creek there was an extensive stand of mangroves (*Avicennia marina*) including some within the old Brickworks site. Two grid squares were sampled by quadrat in the mangroves (E2/1 east and E2/2 west). The mangroves were backed by an embankment of bricks. At these sites crab holes were abundant and mosquitoes were few. The surface of the mud was not completely covered by leaf litter and wet surfaces had an oily sheen.

Ten species of molluscs and crustaceans were found at the Brickworks mangroves. The most abundant species were the mytilid bivalve *Xenostrobus securis* and the sphaeromatid isopod *Cymodetta gambosa*. Two species of crabs, *Sesarma erythroductyla* and *Paragrapsus laevis* were found near the quadrat. The barnacle *Balanus amphitrite* was found on the base of mangrove trees near the edge of Haslam's Creek. Mosquitoes were not abundant in the mangroves.

#### 2.0.2.5 Bicentennial Park - F1 Waterbird Refuge

This large pond of salt water (salinity 35ppt) appeared to be eutrophic with green algae covering the surface of the mud. The anoxic layer was exposed by wading and disturbing the surface of the mud. Because the area was submerged, epifauna could not be counted and two hand held cores (depth 200mm, diameter 52mm) were taken in each grid square (F1 north and F1 south, Fig.3). No animals were found in the core samples.

#### 2.0.2.6 Bicentennial Park - F2 Saltmarsh

The saltmarsh was dominated by *Sarcocornia quinqueflora* with a few unvegetated areas and some other saltmarsh species such as *Juncus kraussi*. There were some areas of higher ground with *Casuarina* sp. and terrestrial plants. Two grid squares were sampled (F2/1 east and F2/2 west), and a vegetated and unvegetated quadrat sampled in each grid square (Fig .3). At both sites the vegetated quadrat was covered by *Sarcocornia*. There were no animals recorded in the salt marsh .

#### 2.0.2.7 Bicentennial Park - F3 Mangroves

Four grid squares (Fig. 3) were sampled in mangroves west of Powell's Creek (F3/1, F3/2, F3/3, F3/4), and two grid squares on the eastern side of Powell's Creek (F3/5 and F3/6). The billabong in F3 east is full of dead tree stumps. It appears to be eutrophic with algae floating on the surface of the water and sheets of dead algae draped over the pneumatophores at the edge of the water. A

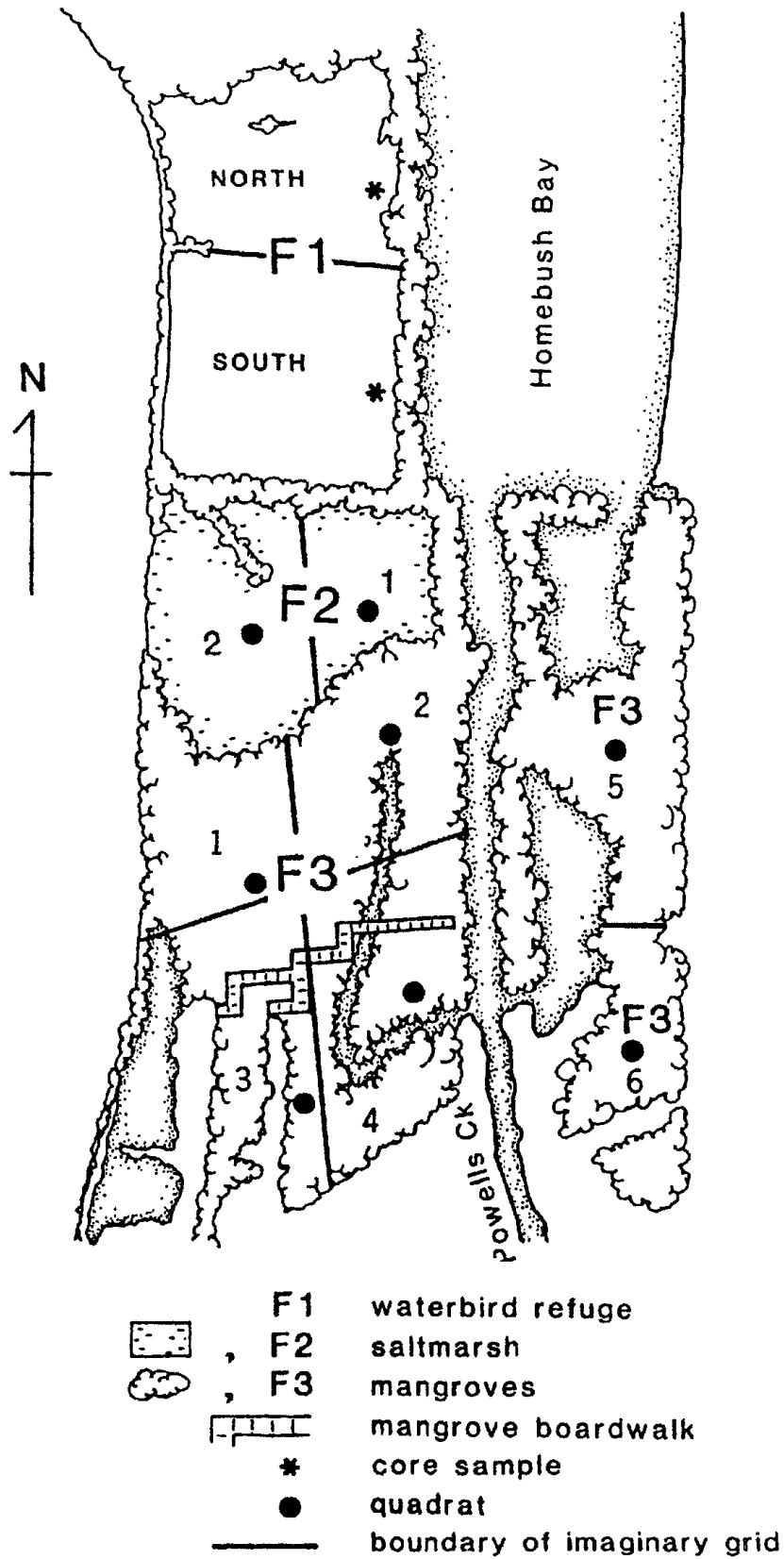


Figure 3. Sampling sites in Newington Wetlands.



total of twelve species of crustaceans and molluscs were recorded. Mosquitoes were very abundant in the mangroves. Crab holes were found at F3/3 and F3/4, and *Sesarma erythroactyla* was only recorded from F3/5 and in the vicinity of F3/3. The most abundant species was the amphipod *Paracalliope australis* which was found on the leaf litter in the mangroves. At F3/6 only three gastropods were found in the quadrat.

#### 2.0.2.8 G1 Mason Park

Two grid squares (G1/1 north and G1/2 south) were sampled in *Juncus kraussii* and *Sarcocornia quinqueflora* saltmarsh on the eastern side of Mason's Park. A vegetated and unvegetated quadrat were sampled in each grid square. There were no crab holes or molluscs in either quadrat, nor in the adjacent area, and fauna was only found at F1/2 which was dominated by philosciid isopods. *Orchestia* sp. was found at the base of *Juncus* in the area surrounding the quadrat.

### 3 DISCUSSION

#### 3.0.1 *The benthos*

The benthic macrofauna (see Table 2) was typical of the benthos of estuaries in south eastern Australia (Poore, 1982; Hutchings & Murray, 1984; Jones *et al.*, 1986), although fewer species were recorded at Homebush Bay than by Poore (1982) in Gippsland Lakes (90 species), or Jones *et al.* (1986) in the Hawkesbury River (133 species). The studies by Poore (1982) and Jones *et al.* (1986) were much more comprehensive and sampled larger estuaries with a greater range of habitats than in Homebush Bay.

Jones & Frances (1988) recorded 32 species of polychaetes, molluscs and crustaceans at Homebush Bay, and noted the absence of six common estuarine species. Four of the six were reported in the current study: *Lumbrineris latreilli*, *Nephtys australiensis*, *Australonereis ehlersi* and *Theora fragilis*. The increase in species richness reported in this study may reflect the greater sampling space, or it may indicate some improvement in the condition of the estuary. Jones & Frances (1988) sampled in October, and the current study was carried out in November and December, so it is unlikely that the observed difference was seasonal.

Seasonal changes in abundance were studied by Warren (1989) and most of his study species are reported in the current study.

#### 3.0.2 *The wetlands*

A total of 25 species of epifaunal molluscs and crustaceans were recorded in the wetlands at the sites at Homebush Bay. The greatest number of species were found at the Brickworks mangroves (10 species) and in the mangroves in Bicentennial Park (12 species). There were very few crabs or crab holes at any site. The most abundant species was the amphipod *Paracalliope australis* which was found on the leaf litter in the mangroves.

Robinson *et al.* (1983) found high numbers of the gastropod *Salinator solida* and the crab *Sesarma erythroductyla* in the mangroves along Powell's Creek. *Salinator solida* was found in reasonable numbers at two quadrats in Bicentennial Park but *Sesarma erythroductyla* was not abundant at any site surveyed. *Salinator solida*, is a common gastropod in mangroves and saltmarshes in the south-eastern Australia (Hutchings & Recher, 1974; Hutchings *et al.*, 1977; CSIRO, 1989) but was absent from the 2KY and 2SM sites and not found in any saltmarsh sites.

The hydrobiid gastropods *Tatea* spp. and *Ascorhis victoriae* are often found in dense assemblages in saltmarsh and mangroves (CSIRO, 1989; G. Clark, *pers. comm.*). *Ascorhis victoriae* was only abundant at two sites at Newington, and *Tatea* spp. were never abundant and were absent from some sites.

Clark & Benson (1988) reported 'a few *Aegiceras corniculatum*' plants in the mangroves however none was found during this survey.

Most of the sites surveyed, were affected by bund walls which restrict tidal flow. At Newington, the 2KY aerial, the 2SM aerial and one quadrat at Bicentennial Park, the pneumatophores were not covered with an algal turf, and this is indicative of poor tidal exchange (Clark & Benson, 1988).

Table 2 Species list of macrobenthos sampled at Homebush Bay.

MOLLUSCA		
BIVALVIA:	LATERNULIDAE	<i>Laternula creccina</i> Reeve, 1860
	LEPTONIDAE	<i>Arthritica helmsi</i> (Hedley, 1915)
	MACTRIDAE	<i>Nannomactra</i> sp. <i>Spisula trigonella</i> (Lamarck, 1818)
	MYTILIDAE	<i>Xenostrobus securis</i> (Lamarck, 1818)
	PSAMMOBIIDAE	<i>Sanguinolaria donacioides</i> (Reeve, 1857)
	SEMELIDAE	<i>Theora fragilis</i> A. Adams, 1856
	TELLINIDAE	<i>Tellina deltoidalis</i> (Lamarck, 1818)
CRUSTACEA		
CIRRIPEDIA:	BALANIDAE	<i>Balanus amphitrite</i> Darwin, 1854
MYSIDACEA:	MYSIDAE	<i>Mysid</i> sp.1
ISOPODA:	SPHAEROMATIDAE	<i>Cymodetta gambosa</i> Bowman & Kühne, 1974
AMPHIPODA:	COROPHIIDAE	<i>Corophium acherusicum</i> (Costa, 1851)
		<i>Erichthonius coxacanthus</i> Moore, 1988
	MELITIDAE	<i>Melita matilda</i> J.L. Barnard, 1972 <i>Victoriopisa australiensis</i> (Chilton, 1923)
CUMACEA:	DIASTYLIDAE	<i>Dimorphostylis colefaxi</i> Hale, 1945
CARIDEA:	ALPHEIDAE	<i>Alpheus euphrosyne richardsoni</i> Yaldwyn, 1971
		<i>Alpheus</i> sp.1
BRACHYURA:	HYMENOSOMATIDAE	<i>Hymenosoma hodgkini</i> Lucas, 1980
	OCYPODIDAE	<i>Macrophthalmus cf latifrons</i> Haswell, 1882
ANNELIDA		
POLYCHAETA:	CAPITELLIDAE	<i>Barantolla lepte</i> Hutchings, 1974
		<i>Capitella</i> sp.
		<i>Mediomastus</i> sp.
		<i>Notomastus chrysosetus</i> Hutchings & Murray, 1984
		<i>Notomastus estuarius</i> Hutchings & Murray, 1984
	COSSURIDAE	<i>Cossura</i> sp.
	EUNICIDAE	<i>Eunice</i> sp. <i>Marphysa sanguinea</i> (Montagu, 1815)
	HESIONIDAE	? <i>Parhensione</i> sp.
	LUMBRINEREIDAE	<i>Lumbrineris latreilli</i> Audouin & Milne Edwards, 1834
	NEPHTYIDAE	<i>Nephtys australiensis</i> Fauchald, 1965
	NEREIDIDAE	<i>Australonereis ehlersi</i> (Augener, 1913)
		<i>Ceratonereis aquisetis</i> (Augener, 1913)
	ORBINIIDAE	<i>Armandia intermedia</i> Fauvel, 1902
	PILARGIDAE	<i>Sigambra parva</i> (Day, 1963)

Table 2 Species list of macrobenthos sampled at Homebush Bay.

POLYNOIDAE	<i>Harmothoe praeclara</i> (Haswell, 1883) <i>Harmothoe</i> sp.
SABELLIDAE	<i>Desdemona aniara</i> Hutchings & Murray, 1984 <i>Euchone</i> sp 2.
SPIONIDAE	<i>Caraziella victoriensis</i> Blake & Kudenov, 1978 <i>Prionospio yuriei</i> Wilson, 1990 <i>Prionospio</i> sp.H <i>Pseudopolydora paucibranchiata</i> Okuda, 1937
OLIGOCHAETA	
NEMERTEA	
ALCYONARIA	

The epifauna of the wetlands at Homebush Bay is not abundant, although the total species list is comparable with other localities which are subject to a variable salinities such as the Lower Myall River (Weate, 1975), Brooklyn (Hutchings *et. al.*, 1977) and Fullerton Cove (Hutchings, 1983). Most sites did not have a number of common mangrove and saltmarsh species, and the species which were present were not abundant. The saltmarshes were particularly sparse with quadrats at Mason's Park and Bicentennial Park being devoid of fauna.

#### 4 LITERATURE REVIEW

A number of studies have been made of the estuarine flora and fauna of the Homebush Bay Study Area (area defined by Webster and Kachka, 1992, Fig. 1.2). These studies are comprehensively summarised by Webster and Kachka, 1992.

The fauna of the wetlands along Powell's Creek was qualitatively sampled by Robinson, van der Velde and Gibbs (1983), who presented a species list of invertebrates with an indication of presence and absence at the study sites. They concluded that the fauna was comparable with that of other estuarine habitats although noted the absence of some common molluscs.

Jones and Frances (1988) compared the benthos of Homebush Bay with that of nearby Bray's Bay and Ermington Bay, and examined the effect of urban runoff. They found that the benthos of Homebush Bay had some species of polychaetes, amphipods and molluscs common to estuaries in south-eastern Australia, but noted the absence others. They concluded that some of these differences may have been a result of urban runoff into Homebush Bay.

Johnstone Environmental Technology (1987) examined the distribution and abundance of the macrobenthos of Homebush Bay as a part of their study of the rehabilitation of the Union Carbide site at Homebush Bay. Their study sites were concentrated along the eastern shore of Homebush Bay near the mouth of the Bay. The benthos was dominated by the polychaetes *Minuspio cirrifera*, *Ceratonereis aequisetis* and *Capitella capitata*.

The only study of the seasonal abundance of intertidal and subtidal macrobenthos at Homebush Bay is that of Warren (1989). He described the seasonal changes in the density of the most common polychaetes, molluscs and crustaceans. He found an impoverished fauna in the mangroves and saltmarsh of Bicentennial Park, and in the subtidal benthos of Powell's Creek.

The macrobenthos of the lagoon at the 2SM aerial (D3) was studied by Gutteridge Haskins & Davey (1990), who recorded twelve species of invertebrates including a nemertean, cnidarian, polychaetes, oligochaetes, molluscs and crustaceans. They concluded that the lagoon was adversely affected by the restriction to tidal flow.

Clark and Benson (1988) surveyed the vegetation of Homebush Bay and described changes over the last two hundred years. They point out that the Homebush Bay site encompasses the largest estuarine complex in the Sydney Region with saltmarsh, mangroves, swamp oak and eucalypt forest.

## 5 SUMMARY

- This study represents the most comprehensive survey of the macrofauna of the estuarine environments of the Homebush Bay area. It is the first survey of all the wetland sites, including Newington wetlands, the 2SM and 2KY arials, the Brickworks mangroves, Bicentennial Park and Mason's Park. It is also the only survey that has mapped the macrobenthos of the entire Bay.
- The fauna of the mangroves and saltmarshes was depauperate, despite the apparent healthy appearance of the *Avicennia marina* trees and saltmarsh grasses. The absence of crabs and crab holes, oysters and barnacles at most sites was striking.
- The most abundant species in the mangroves was the amphipod *Paracalliope australis* which was found among the leaf litter.
- The ponds and billabongs appeared to be eutrophic with very little fauna.
- The macrobenthos in the Bay was diverse.
- The benthos of Homebush Bay was dominated by the polychaetes *Nephtys australiensis* and *Prionospio yuriei*, the amphipod *Victoriopisa australiensis*, and the bivalves *Spisula trigonella* and *Tellina deltoidalis*.



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# SALTMARSH VEGETATION STUDY

# **Saltmarsh Vegetation Study**

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## 1 INTRODUCTION

Coastal saltmarsh is defined by a combination of biological and physical attributes. It is most usually characterised as being

- intertidal
- dominated by herbs and/or low shrubs

These attributes serve to distinguish saltmarsh from mangrove, which is dominated by trees, but which also occurs in intertidal habitats. Saltmarsh is also distinguished from seagrass beds which are mostly subtidal. Where seagrass beds occur in the intertidal zone they are recognised by their characteristic species composition.

Vegetation identical in species composition to that of intertidal saltmarsh occurs on extremely exposed seacliffs (Adam, Wilson and Huntley 1988), while saline areas in the arid and semi-arid inland support vegetation physiognomically and floristically similar to that of coastal saltmarshes.

Much of the saltmarsh in the Homebush Bay study area is assigned to the habitat type by virtue of its floristic composition, rather than by its physical environment. There has been a long history of environmental modification (Clarke & Benson 1988) and none of the saltmarsh areas are in pristine condition. Large stands of vegetation, dominated by characteristic saltmarsh species, occur at sites which are not currently intertidal — either because they occur on filled areas now above the tidal limit, or because tidal exchange is prevented by bund walls. In the case of filled sites the species must have established after filling. Although surface water ponding on these areas after heavy rain is essentially fresh, the sediments are still saline, and this salinity is sufficient to exclude glycophytes. For the purpose of this report these non-intertidal areas are regarded as being saltmarshes.

### 1.1 SALTMARSH IN AUSTRALIA

The best available estimate of the total area of estuarine saltmarsh in Australia is 13 594 km<sup>2</sup> (Bucher & Saenger 1991) — the total area of coastal saltmarsh is unknown, but substantial areas occur on open coasts in northern Australia.

Although this total area is large, and exceeds that of mangrove, it is concentrated in the tropics. The areas in New South Wales is small, estimated by West *et al.* (1985) as 57 km<sup>2</sup> ha. In the New South Wales context, intertidal saltmarsh is one of the rarest of habitat types, and is poorly represented in conservation reserves.

There is considerable variation in the floristic composition of saltmarsh vegetation around the Australian coast. The least diverse marshes are those in the tropics, while the richest occur in Tasmania and Victoria. Along the New South Wales coast there is a gradient from the more species rich marshes on the South Coast (with strong similarities to Victorian marshes) to the more species poor North Coast marshes (Adam, Wilson and Huntley 1988; Adam 1990). The northern limit of extensive 'southern' marshes is Jervis Bay, but a number of southern species extend northwards to the Sydney region.

In structure and floristics (at the generic level) the marshes in south east Australia have strong similarities to those in South Africa, and South America as well as to temperate European and north Asian marshes (Adam 1990). Nevertheless there are some distinctive features which allow the recognition of a southern temperate Australian saltmarsh biogeographic region. Notable amongst these is the presence of the genus *Wilsonia* (Convolvulaceae). Three species occur in

Plant Species	Sp	Jk	Sarcornietum	Suaeda	Wilsonia	Lamp	Cy
<i>Paspalum vaginatum</i>	3	4					0000
<i>Samolus repens</i>	9999999-8	52-25	4-5	4	5	3	0000
<i>Sporobolus virginicus</i>	2	85	22-3	3	2		0001
<i>Avicennia marina</i>							00100
<i>Diplazne uninervis</i>							00100
<i>Solanum chenopodioides</i>							001010
<i>Typha sp.</i>							001011
<i>Actinoplex patula</i>							001011
<i>Chloris gayana</i>							001011
<i>Hypochoeris radicata</i>							0011
<i>Tetragonia tetragonioides</i>							0011
<i>Lythrum hyssopifolium</i>							01000
<i>Paspalum paspalodes</i>							010000
<i>Polygonum monspeliensis</i>							010001
<i>Juncus kraussii</i>							01001
<i>Sarcocornia quinqueflora</i>							01001
<i>Actinoplex prostrata</i>							01001
<i>Suaeda australis</i>							01001
<i>Juncus acutus</i>							01001
<i>Parapholis incurva</i>							01001
<i>Rumex crispus</i>							0101
<i>Cotula coronopifolia</i>							0110
<i>Triglochin striata</i>							01100
<i>Bolboschoenus caldwellii</i>							01100
<i>Polygonum arenastrum</i>							01101
<i>Altriplex semibaccata</i>							01101
<i>Cirsium vulgare</i>							0111
<i>Casuarina glauca</i>							100
<i>Halosarcia pergranulata</i>							100
<i>Sonchus oleraceus</i>							100
<i>Spergularia marina</i>							101
<i>Agrostis avenacea</i>							101
<i>Aster subulatus</i>							1100
<i>Polygonum aviculare</i>							110100
<i>Cyperus polystachos</i>							110100
<i>Lampranthus regens</i>							110101
<i>Plantago coronopus</i>							110101
<i>Plantago coronopus</i>							110101
<i>Loium rigidum</i>							110101
<i>Paspalum dilatatum</i>							11011
<i>Setaria sp.</i>							1110
<i>Centaurium tenuiflorum</i>							1110
<i>Senecio aff. laevis</i>							11110
<i>Wilsonia backhousei</i>							11110
<i>Plantago lanceolata</i>							111110
<i>Cynodon dactylon</i>							111111
<i>Bromus catharticus</i>							111111
<i>Foeniculum vulgare</i>							111111
<i>Foeniculum vulgare</i>							111111
<i>Melilotus sp.</i>							111111
<i>Tragopogon portifolius</i>							111111
<i>Verberna bonatiensis</i>							111111

Table 1. TWINSpan Analysis of plant communities at the site.

southern Australia, two of which occur on the South Coast of New South Wales, one of which *W. backhousei* is found in the Homebush Bay saltmarsh.

As well as broad geographic patterns of variation in the composition of saltmarshes there are also repeatable gradients between the more saline and brackish sites. The Homebush Bay study sites includes areas which are normally brackish and which support a characteristic flora and vegetation.

Compared with many terrestrial habitats, saltmarshes can be characterised by relative species paucity and the tendency for communities to be clearly dominated by single species. In addition many species have very wide geographic distributions (a number of saltmarsh species naturally occurring in Australia are found in the other southern continents, and in some case the northern hemisphere).

Thus, while most saltmarshes plant species can be characterised as 'rare', in the sense that their habitat is restricted in distribution, within saltmarshes most species are common and widespread. The number of species which are 'rare' in the context of the saltmarsh habitat is small.

## 1.2 SALTMARSHES IN THE SYDNEY REGION

Saltmarshes in the Sydney region have been substantially reduced in area since European settlement. The loss of saltmarsh has been far greater than that of mangrove and, as well as direct loss through reclamation there is evidence of loss through upward spread of mangroves (Mitchell and Adam 1989), although the cause of this mangrove spread is not well understood.

Although saltmarsh species are still very widespread along Sydney waterways, many stands are very small. The largest single area of saltmarsh is at Towra Point, in Botany Bay, with other major stands in the Georges River and its tributaries. In the Sydney Harbour system, the saltmarshes of the Lane Cove River have been relatively undisturbed while those of the Parramatta River and its tributaries Duck Creek/Duck River have been substantially reduced in area and remaining stands have been highly modified.

Nevertheless the Homebush Bay study region contains the second largest (after Towra Point) concentration of saltmarshes in the Sydney region and the northern Newington wetland is the second largest single saltmarsh site.

The history of saltmarsh reclamation and modification in the Homebush region has been documented by Clarke & Benson (1988) and Kachka (1992). The oldest narrative account of the saltmarshes (Meredith 1844) refers to ditches crossing them.

A comprehensive description of saltmarshes in the Sydney region (with considerable detail on Homebush Bay) was provided by Hamilton (1919). Wilson (1984) described plant communities on Sydney saltmarshes (see also Adam, Wilson and Huntley 1988). The saltmarshes of the Homebush Bay study region were described by Clarke and Benson (1988) and Kachka (1992).

## 1.3 THE CURRENT SURVEY

All saltmarsh, and areas with halophytic vegetation were sampled and the vegetation in seventy seven 2 x 2m quadrats was recorded. (The cover/abundance of all vascular species occurring in the quadrats was recorded on the ten point Domin scale). The quadrat data was subjected to two-way cluster analysis using the program TWINSpan, to allow the delineation of floristically defined communities.

These units can be related to those previously defined for south eastern Australia by Bridgewater (1982) and Adam *et al.* (1988), and also to the units adopted by Kachka (1992) in her mapping of the vegetation of the study area.

The quadrats record the vegetation at the time of sampling. Although most of the species in the vegetation are perennial, changes in relative abundance can occur over relatively short time periods, while the presence of abundance of annuals may vary markedly between seasons.



Spring and early summer 1992 were much wetter than the corresponding period in 1991. One obvious difference in the vegetation between the two years was the much greater extent and dominance of *Bolboschoenus* 1992. This may represent spread of the species over a year but it is more likely that there was vegetative die back in the 1991 drought, followed by resprouting from subterranean propagules. Kachka (1992) does not recognize a *Bolboschoenus* sedgeland in her mapping but there are extensive areas of brackish marsh occupied by such a community (particularly in the northern part of the Fire Testing Ground and in the Agistment area of RANAD).

In drier saline areas the introduced annual grass *Parapholis incurva* was wide spread and abundant in 1991. In 1992 it was much less common, but this is more likely to reflect between year fluctuations than a permanent decline.

#### 1.4 PLANT COMMUNITIES

The TWINSPAN analysis is presented in Table 1. Most of communities which can be recognized in the table can be equated with those described by Adam *et al.* (1988). However, because the present study is an intensive study of a limited area local variation is emphasised. Table 1 demonstrates the lack of congruity between communities defined by physiognomic dominants and those defined by full floristics, *Juncus acutus* and *Halosarcia pergranulata* occur across a wide range of floristic variation. This may reflect the relatively recent introduction of both species to the area.

##### 1.4.1 *Sarcocornietum quinqueflorae* Bridgewater, 1982; Saltmarsh Community, A Kachka 1992

Stands dominated by the low succulent chenopod, *Sarcocornia quinqueflora*. The community is widespread through the study area and is the major community in the northern Newington saltmarsh.

At first glance the most extensive stands look heterogeneous, because of the striking colour variation from bright green, through scarlet to purple, in patches of *Sarcocornia*. However, this colour variation does not seem to be consistently correlated with environmental variation, and the extent to which this phenotypic variation reflects genetic variation is unknown. Similar patterns of colour variation are shown in other succulent halophytic chenopods.

In previous accounts (Adam *et al.* 1988) three variants of the community have been recognized:

- sarcocornietosum — essentially dominated by *Sarcocornia* and some stands mono specific.
- triglochinetosum — in more poorly drained sites, with abundant *Triglochin striata*. The abundance of *T. striata* may vary seasonally, and declines with the onset of hypersalinity.
- sporoboletosum — in drier sites with a greater presence of *Sporobolus virginicus*.

In the present analysis all three sub associations could be recognized, but in the TWINSPAN table all fall within one block of quadrats.

The variation in abundance of *Triglochin striata* with minor changes in microtopography is particularly clearly seen in the northern Newington saltmarsh. As elsewhere on the New South Wales coast, where conditions are usually brackish *Cotula coronopifolia* may be a frequent member of the *Sarcocornietum*.

A number of stands of the *Sarcocornietum* have been invaded by *Juncus acutus*. The majority of these are drier sites, on the upper fringe of the main *Sarcocornietum*, but the highest abundance of *J. acutus* is in permanently wet sites.

1.4.2 *Sarcocornietum* — *Halosarcia pergranulata* variant.

*Halosarcia pergranulata* stands vary considerably in the density of *H. pergranulata*, from scattered shrubs to a dense canopy. As can be seen from Table 1 there is a gradation between the *Sarcocornietum* and dense *Halosarcia*. Kachka recognized a *Halosarcia* community (2C) with dominant *Halosarcia*. When the full floristic composition of the vegetation is considered this cannot be sustained, although pragmatically recognition of the *Halosarcia* dominated stands as a separate unit may have some practical benefits.

1.4.3 *Suaeda australis* community Bridgewater 1982,  
Community 2B Kachka 1992 (draft), not included in final report)

Dense stands of *Suaeda australis* occur on disturbed area and along banks and are widespread throughout the study area. They are also characteristic of the mangrove/saltmarsh interface. The community was illustrated by a photograph from Homebush Bay in Hamilton (1919).

The majority of stands are dry and well drained but *Suaeda* can grow luxuriantly in wet sites. The inclusion of quadrat 30 within the *Suaeda* community illustrates a wet occurrence of dense *Suaeda*.

However this quadrat is better assigned to a *Typha* community (*Typha* stands occur elsewhere in the study area but, as they are predominantly fresh water communities, were not sampled).

Kachka (1992 draft) records a *Swainsona* sp. in this community — this appears unlikely.

1.4.4 *Sporobolium virginicum* Adam et al. 1988;  
Community 2E. Kachka 1992 (Community 2G in the draft)

Grassland dominated by *Sporobolus virginicus* is one of the most widespread and extensive communities on Australian saltmarshes, but is relatively uncommon in the study area, where it occurs as relatively small, discrete patches in the northern Newington saltmarsh and in Bicentennial Park.

1.4.5 *Juncus kraussii* complex (see Adam et al. 1988;  
Closed rushland — community 4 Kachka 1992

*Juncus kraussii* is widespread in the study area and dominates extensive stands in two regions, Mason Park and in the northeastern part of the northern saltmarsh at Newington.

1.4.6 *Lampranthus tegens* community  
Community 2D Kachka 1992 (2F in the draft report)

Stands dominated by *Lampranthus tegens* are widespread throughout the study area, mostly occupying patches only a few m<sup>2</sup> in extent, but occasionally covering much larger areas. In some stands *Halosarcia pergranulata* is abundant.

1.4.7 *Wilsonia backhousei* community  
Community 2B Kachka 1992 (2D in the draft report)

Stands dominated by the low herb *Wilsonia backhousei*, ranging in size from 10m<sup>2</sup> to several 100m<sup>2</sup>. On fill areas in relatively well drained locations but in the northern Newington saltmarsh several stands are in wet locations.

#### 1.4.8 *Cynodon dactylon* grassland Adam et al. 1988

Fringing the upper saltmarsh at several locations. There is some doubt as to whether *C. dactylon* is native to Australia, but it is clear that most ecotypes are introduced. The material in the study area is typical of the widely planted forms and is almost certainly of introduced origin.

#### 1.4.9 Reedland

Kachka (1992) recognizes one reedland community, dominated by *Typha*. It would be appropriate to extend the physiognomically defined reedland to include a number of variants recognized by community dominant, including:

- *Typha* reedland — The number of small stands of *Typha* in RANAD increased between 1991 and 1992, but the main extent of this community is in the Fire Testing Grounds.
- *Bolboschoenus caldwellii* reedland — generally 60cm — 1m tall, covers extensive areas in RANAD.
- *Schoenoplectus litoralis* reedland — emergent in a number of ditches, scattered plants in other reedland communities.
- *Cyperus papyrus* reedland — Brickworks pond.
- *Phragmites australis* reedland in northern Newington saltmarsh.

### 1.5 OTHER COMMUNITIES

Kachka (1992 draft) recognized a *Tetragonia* community (2H) but this is not included in her final report — scattered patches of *Tetragonia* are found on ridges, the upper fringes of saltmarsh, and in the understorey to *Casuarina glauca* woodland.

Community 2E in Kachka (1992 draft) was defined by the dominance of *Cotula coronopifolia*, and corresponds to the *Cotula coronopifolia* community of Adam et al. (1988). The abundance of *C. coronopifolia* increases in waterlogged brackish sites and a number of stands of various communities have significant quantities of the species present (Table 1), however none of the quadrats recorded exactly corresponds to the *Cotula* community as previously defined, although a number of brackish pools have narrow fringes (c.50cm wide) of almost pure *Cotula*, and these could be regarded as examples of the community. In 1991 more extensive areas which could be assigned to the *Cotula* community were observed, particularly in the Agistment area. These areas in 1992 supported *Bolboschoenus* stands.

Annotations regarding vegetation have been made on a set of 1:2000 Orthophoto maps and on the vegetation map prepared by Kachka (1992). The major changes to Kachka's map are in the northeast corner of RANAD, with minor changes elsewhere. The most difficult area to map is the complex of communities on the Fire Testing Ground and adjacent Agistment area. This is a complex fine grained mosaic which has varied considerably between 1991 and 1992. It may be inherently unstable with the vegetation responding to rainfall, and as such, while the complex can be recognized there is little merit in attempting to produce a more detailed map.

### 1.6 IMPORTANCE OF SALTMARSH

The importance of saltmarsh can be assessed using a number of criteria.

Much of the emphasis in the international literature is on the role of saltmarshes as exporting ecosystems, particularly in terms of biomass (juvenile fish), detritus and certain key nutrients. The

validity of generalisations is open to question (Adam 1990); it is certainly the case that some saltmarshes are highly productive and are net exporters, but not all saltmarshes are highly productive and some have been shown to be net importers. In the case of Australian saltmarshes there are very few data on productivity and no detailed measurements of fluxes into and out of marshes. However, in the case of the saltmarshes in the study area it is unlikely that there is a major contribution to adjacent waters given that some stands on fill, are above the intertidal zone and that the hydrology of all stands has been highly modified.

More firmly established is the importance of saltmarsh as habitat. The value of the Homebush saltmarshes for birds is being addressed in a separate study. Saltmarshes have been demonstrated to be important nursery habitat for fish, but because of their modified hydrology this is unlikely to be a major feature of the study sites.

However, because of the nature of their physico-chemical environment saltmarshes support a range of taxa restricted (or virtually so) to that habitat. Thus saltmarshes make a significant contribution to biodiversity and conservation of the range of species restricted to the habitat requires protection of their environment — few saltmarsh species could be maintained naturally in non-saltmarsh habitat.

In the particular case of the Homebush saltmarshes there are important examples of a habitat type which is rare at both regional and state level. In addition they have a number of floristic features which result in species' assemblages which are unique in southern Australia.

If a single site were to be identified as being of greater importance it would be the northern Newington wetland complex of saltmarsh, mangrove and *Casuarina glauca* forest. This complex is, in the Sydney context, notable for its size, diversity and (relative) naturalness.

## 2 SPECIES OF SPECIAL INTEREST

### 2.0.1 *Diplachne uninervia*

This grass is found in wet saline depressions in Zone 3 and the adjacent Elcom easement at RANAD. In New South Wales it is known only from this site (Jacobs & McClay, in press). It is a native of America and is believed to be introduced in Australia.

### 2.0.2 *Gahnia filum*

*G. filum* is a tall, tussock forming sedge which is a prominent feature of upper saltmarsh vegetation in southern Australia. Currently the most northerly known sites are along the Georges River.

*G. filum* was recorded in the Homebush Study area in the environmental studies of the 2SM radio mast site (GHD 1990). A careful search was made of the site and no specimen was located. It is probable that this record was an error; nevertheless the close proximity of the Homebush area to known sites for the species suggests that it is not beyond the bounds of possibility that *G. filum* could be found in the area, and any future surveys should check for its presence.

### 2.0.3 *Halosarcia pergranulata*

The Homebush area is the only known locality on the New South Wales Coast for this shrubby halophytic chenopod. It was not recorded by Hamilton (1919), and given the thoroughness and accuracy of Hamilton's account it is improbable that such an obvious species could have been overlooked.

The source of *H. pergranulata* at Homebush remains unknown. It could be a natural introduction (possibly through the agency of birds) or it may have been introduced from inland sites by cattle through the abattoir. The date of introduction is also unknown, but is presumably post World War 1.

*Halosarcia* is a member of halophytic communities, both in coastal saltmarshes and inland saline sites. In the Homebush area *H. pergranulata* occurs over a range of environmental conditions, from well drained, frequently hypersaline sites in the Agistment area at RANAD to shallow brackish pools near the 2KY radio mast. In deeper pools on the 2KY site there is a number of larger standing dead *Halosarcia* plants. It is possible that prolonged flooding is inimical to *Halosarcia*.

### 2.0.4 *Lampranthus tegens*

This small member of the Aizoaceae is an enigma. *L. tegens* was described from Australian material but has been assumed to be an introduction from South Africa, possibly in ship's ballast (Willis 1972) Venning (1984) suggests that it may be identical with a species, *L. caespitosus*, subsequently described from near Cape Town but Jacobs & Highet (1990) state that attempts to equate *L. tegens* with any African taxon have been unsuccessful.

*L. tegens* is thus only known with certainty from the Sydney region and the Victorian coast near Melbourne. In the Sydney region its stronghold is in the Homebush study area where it forms dense patches — mostly on well drained saline sites, but occasionally spreading into wetter areas.

### 2.0.5 *Selliera radicans*

This creeping herb is characteristic of upper saltmarshes and the understorey of *Casuarina glauca* Woodlands on southeastern Australia and also occurs on exposed seacliffs. Although still

common on cliffs in the Sydney region, it is uncommon on saltmarshes and seems to have declined considerably since the early part of the century (*cf.* present distribution with that described by Hamilton 1919).

A small number of plants were located in the saltmarsh/*Casuarina* ecotone in the northern Newington wetland.

#### 2.0.6 *Wilsonia backhousei*

*Wilsonia backhousei* is one of the characteristic species of temperate saltmarsh in Australia. It was once relative abundant in the Sydney region (Hamilton 1919) but has declined considerably as a result of habitat destruction.

The Homebush study area contains the largest remaining stands in the Sydney region.

It is found in Mason Park, the 2KY radio mast site and at various localities in RANAD. Until the early 1980s it was found on the eastern side of Homebush Bay, but these small populations were destroyed during road construction.

The largest stands are in the northern Newington saltmarsh, forming dense carpets. More open stands are found on shelly fill in the Agistment area and at 2KY.

In December, 1992 most populations contained flowering specimens in contrast to 1991 when no flowering specimens were observed.

### 2.1 APPARENT ABSENCES, AND LOCALLY UNCOMMON SPECIES.

#### 2.1.1 *Baumea juncea*

This gregarious sedge frequently co-occurs with *Juncus kraussii*, or forms a distinct zone between *J. kraussii* and *Casuarina glauca* on central coast saltmarshes. Apparently appropriate habitat occurs in the northern Newington saltmarsh but no plants were observed.

#### 2.1.2 *Hydrocotyle bonariensis*

Kurnell Curse is an extremely widespread weed of coastal communities in southern Australia. Although recorded from the study area by Benson & Clarke (1988) it is not common, and was not recorded in any of the quadrats.

#### 2.1.3 *Paspalum vaginatum*

This grass is characteristic of brackish communities and is widespread on the New South Wales coast. It was recorded on the sides of the canal between Bennelong Road and the Elcom easement, and in shallow depressions on the easement. Other, apparently suitable, habitat is widespread in the study area.

#### 2.1.4 *Samolus repens*

*Samolus repens* is a frequently abundant member of the saltmarsh flora on the New South Wales coast. It is however, inexplicably locally rare in the Homebush study area, being most common in the northern Newington saltmarsh.

### 2.1.5 *Zoysia macrantha*

This grass is widespread in drier upper saltmarsh communities. In the vegetative state it can be difficult to distinguish from *Sporobolus virginicus* but is easily recognized when flowering.

Careful observation was made of suitable habitat but no plants were detected, although it was recorded by Clarke & Benson (1988).

## 2.2 SPECIES LIST

The following species were recorded as additional to those listed in Appendix 6.4 (Tab 3.2, 3.3) of Kachka 1992

### Monocotyledons

#### Cyperaceae

*Cyperus tenellus*

edge *Casuarina*  
northern Wetland, RANAD

#### Juncaceae

*Juncus cognatus*

Fire Testing Ground

*Juncus flavidus*

Fire Testing Ground

*Juncus microcephalus*

Fire Testing Ground with *Cotula coronopifolia*

*Juncus polyanthemus*

northern wetland, RANAD

*Juncus polyanthemus x mollis*

Fire Testing Ground

*Juncus subsecundus*

Elcom easement

#### Poaceae

\**Avena fatua*

widespread, RANAD

*Danthonia longifolia*

*Casuarina* forest, northern wetland

?\**Diplachne uninervia*

Zone 3, RANAD +Elcom easement, 2KY

\**Echinochloa crus-galli*

Waterbird refuge Bicentennial Park

\**Echinochloa crus-pavonis*

Waterbird refuge Bicentennial Park

\**Echinochloa utilis*

2SM, cover crop

*Ehrharta longiflora*

paths Bicentennial Park

*Eragrostis curvula*

widespread

\**Eriochloa pseudo-acrotricha*

paths, Bicentennial Park

*Lolium rigidum*

RANAD

*Paspalum vaginatum*

Elcom easement

\**Pennisetum macrourum*

Fire Testing Ground

\**Polypogon x littoralis*

RANAD, widespread

\**Sporobolus indicus* var. *capensis*

Widespread, RANAD, Bicentennial Park

#### Potamogetonaceae

*Potamogeton pectinatus*

canal beside Elcom easement

### Dicotyledons

#### Apiaceae

\**Ciclospermum leptophyllum*

Agistment area

#### Asteraceae

\**Carthamnus lanatus*

s. side Haslams Creek

*Epaltes australis*

*Casuarina* woodland northern wetland

*Senecio minimus*

*J. kraussii* saltmarsh northern wetland

#### Casuarinaceae

*Allocasuarina distyla*

Beaconsfield Road, Elcom easement

#### Chenopodiaceae

\**Atriplex patula*

2KY

*Dysphania glomulifer*



spp. <i>glomulifera</i>	Homebush Brickworks
Convolvulaceae	
<i>Convolvulus erubescens</i>	2KY
* <i>Ipomoea cairica</i> (white flowered form)	2KY
Euphorbiaceae	
<i>Ricinus communis</i>	nr. 2KY
Fabaceae	
<i>Dipogon lignosus</i>	south side Haslams Creek
<i>Amalanthus populifolius</i>	NE corner, RANAD
<i>Medicago sativa</i>	2KY
* <i>Trifolium tomentosum</i>	2KY, 2SM
Linaceae	
* <i>Linum trigynum</i>	widespread, RANAD
Lobeliaceae	
<i>Pratia concolor</i>	southern end Elcom easement
Malvaceae	
* <i>Abutilon grandiflorum</i>	near 2KY
<i>Pavonia hastata</i>	near 2KY
Myoporaceae	
<i>Myoporum boninense</i> ssp. <i>australe</i>	<i>Casuarina</i> forest, northern wetland
Onagraceae	
<i>Epilobium ciliatum</i>	Fire Testing Ground
Proteaceae	
<i>Grevillea linearifolia</i>	N.E. corner, RANAD
Scrophulariaceae	
* <i>Misopates orontium</i>	edges northern wetland
Solanaceae	
* <i>Nicotiana glauca</i>	2KY, Brickworks
* <i>Solanum sisymbriifolium</i>	Zone 3, RANAD
* <i>Lycium ferocissimum</i>	NE corner RANAD

### 3 MAJOR WEEDS

A large part of the total flora of the study area is made up of introduced species, many of which are, or have the potential to be, major weeds.

Particular attention is drawn to the following species:

#### 3.0.1 *Alternanthera philoxeroides* — *alligator weed*.

The major infestation is in the Fire Testing Grounds but scattered plants occur in the Agistment area and Zone 3.

#### 3.0.2 *Chrysanthemoides monilifera* — *bitou bush*

Occurs in the northern part of the Elcom easement and in the adjacent *Casuarina* forest in RANAD.

#### 3.0.3 *Cortaderia selloana* — *Pampas grass*

Pampas grass is widespread through the study site. A substantial, well established population occurs in the northern east corner of RANAD, and isolated plants are scattered elsewhere through RANAD. Large numbers of plants have established on fill on either side of Haslams Creek.

Pampas grass dominates communities in which it occurs and, in addition, represents a potential fire hazard.

#### 3.0.4 *Pennisetum clandestinum* — *Kikuyu*

Dense mats of kikuyu smother other vegetation, and build up a substantial fuel load.

#### 3.0.5 "Woody weeds"

Amongst the woody species a number are causes of some concern:

- *Ligustrum* spp. *Lycium ferocissimum* and *Olea europaea* ssp. *africana* occur in the *Casuarina* forest.
- *Cinnamomum camphora* - camphor laurel - dense groves of saplings are associated with several of the electricity transmission towers. It represents an innoculum for invasion of other areas.

## 4 NOTES ON OTHER HABITATS

### 4.0.1 Mangrove

The mangroves are monospecific *Avicennia marina* stands. Benson & Clarke (1988) report the presence of *Aegiceras corniculatum* but this no longer appears to be present.

### 4.0.2 *Casuarina glauca* forest

*Casuarina glauca* forest was formerly more widespread and extensive in the Sydney region. Although *C. glauca* as a species is still very common, good stands of the species are not. The *C. glauca* forest associated with the northern Newington wetland is one of the more significant stands of the community in the Sydney region.

The composition of the forest varies from the wet test sites, with virtually no understorey through areas with a scattered saltmarsh understorey, to a continuous dry grassland understorey in the north east corner of RANAD.

In some drier sites there are a number of shrubby weeds (*Lantana*, *Olea*, *Lycium ferocissimum*, *Ligustrum* sp.) but for the most part the community is in a good, relatively undisturbed condition.

### 4.0.3 Freshwater canal

The drain between the Elcom easement and Bennelong Road appears to support a diversity of macrophytic communities. There are dense beds of *Potamogeton pectinatus* and emergent stands of *Schoenoplectus litoralis*, *Typha* and *Juncus* spp. The presence of scattered *Avicennia* on the edges of the drain, and some patches of *Ruppia maritima* indicates occasional influence.

Although the tidal habitat is clearly artificial, it supports a range of freshwater plant communities which are relatively uncommon in the Sydney region.

[*Ruppia maritima* was much more abundant throughout the study areas than in 1991. It occurred in most shallow brackish pools.]

### 4.0.4 Kikuyu grassland

*Pennisetum clandestinum* is widespread throughout the area. However, very dense mats of kikuyu are a particular feature of Zone 3. These mats smother other species and accumulate substantial thicknesses of dead material. In dry conditions these represent a significant fire hazard.

## 5 ACKNOWLEDGMENTS

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# REMEDIATION STUDY

# **Embracing Risk Management: The Homebush-Newington Experience**

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## 1 INTRODUCTION

The issue of costs for rehabilitating contaminated land was a major problem for land managers in the relevant agencies in the State Government of New South Wales and the Department of Defence who had responsibilities for the Royal Australian Navy Armaments Depot at Newington and the adjacent lands in what is known as the Homebush Bay Development Area.

This paper describes how an appreciation of the levels of health and environmental risks in different parts of the area came to be developed and used to:

- Achieve consensus about remediation strategies among key stakeholders;
- Minimise costs for remediation while satisfying imperatives for environmental protection, liability management; and
- Define and limit constraints on land use.

In 1989 the Homebush Bay Development Strategy perceived the following constraints among others (see Figure 1):

- Over 50% of the area being reclaimed or filled;
- Landfill including hazardous materials and putrescible wastes;
- 60 hectares classified as unhealthy land under Section 55 of the *Public Health Act*;
- 4 sites subject to a Section 35 order under the *Environmentally Hazardous Chemicals Act*; and
- Culturally and/or ecologically significant natural and manmade landscapes buildings and structures. This included '*an intact sequence of plant communities ..... on the Newington Armaments Depot, changing in character between the saline Parramatta River, semi enclosed brackish ponds and the dry land vegetation of the Newington ridge forest*'.

The Strategy document recognised that "the management of environmental impact is likely to be a major issue both in the short term development phase and in the long term establishment of an urban setting. Specifically, control of stormwater runoff, soil erosion, groundwater contamination by leaching of chemical wastes, bank stabilisation and estuarine water quality must be addressed". Further it was anticipated that there would need to be a '*comprehensive clean up of the site which addresses all the toxic waste problems and the various hazards*'. To this end four recommendations were made, viz:

- A detailed programme for monitoring contaminated sites to be implemented;
- When implementing site works action be taken to contain or remove contaminated soil to eliminate likely hazards affecting people and the environment;
- No housing development be permitted on or near toxic contaminated sites; and
- The former brick pit be used for the disposal of contaminated soil.

By 1995 after a comprehensive rolling programme of investigation, evolution of development plans to cater for the 2000 Olympics facilities, the remediation strategy had become refined to:

- Consolidating all landfill materials into existing major landfill sites with well defined boundaries;
- Containing landfills with adequate capping, with drains to intercept leachate;
- Disposal of leachate partially to Lidcombe Waste Treatment Plant and partially by recycling into the landfill whence it came;
- Permitting only public purposes uses of land over landfills (eg: parkland, sports facilities) and ensuring that the managing agencies have in place adequate long term environmental management plans; and

- Ensuring that land which is destined for private ownership is fit for the planned uses. In particular that land destined for residential use has no encumbrances.

This strategy represents a considerable change from one of aiming to *eliminate* likely hazards, to one of risk reduction and management. How was this achieved?

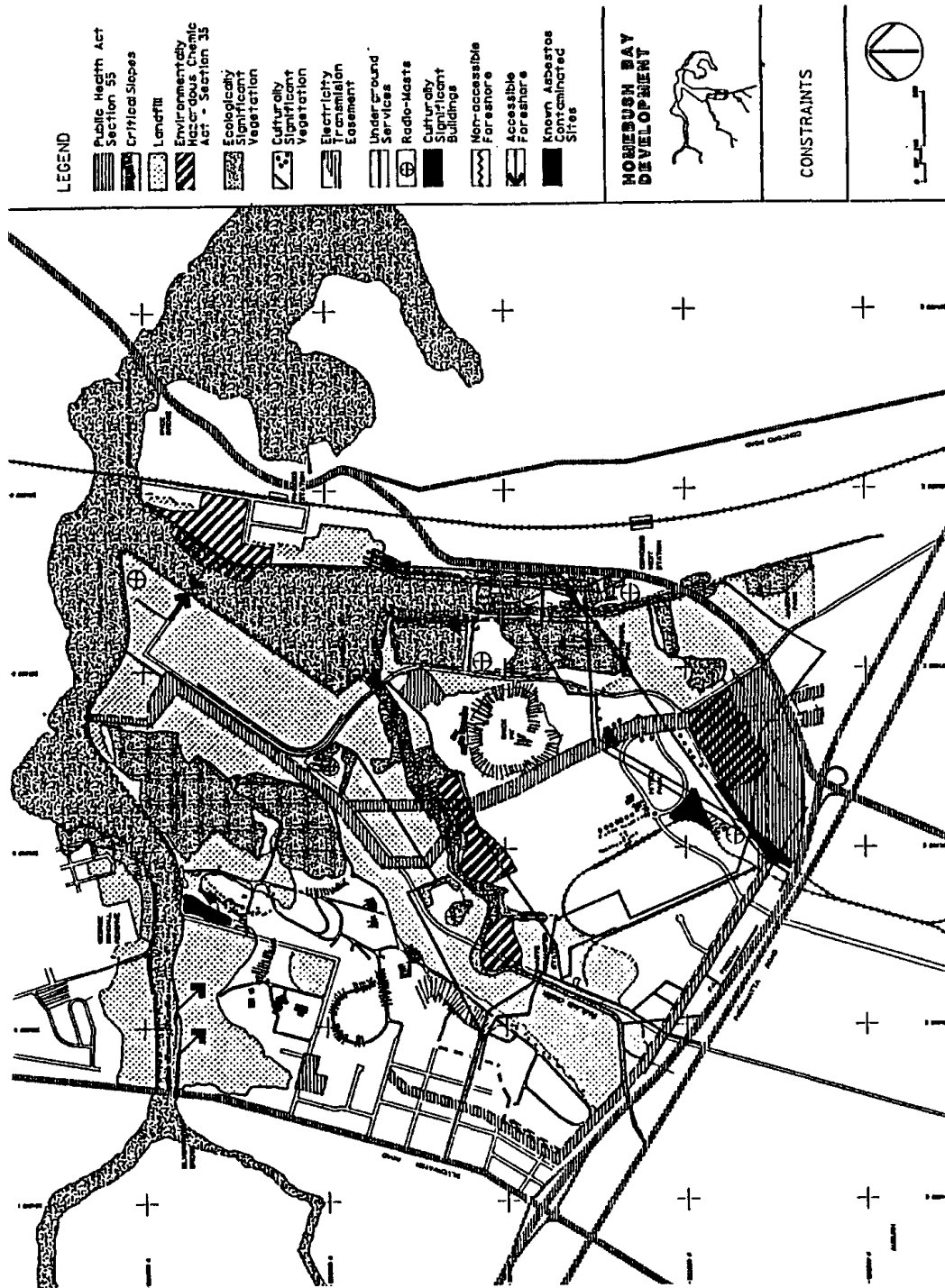


Figure 1. Embracing risk management.

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## 2 THE KEY ISSUES

In the period 1989–1991 the main concerns included:

- The potential for health risks by direct exposure to the wide range of chemicals in the landfills and other parts of the area;
- The adverse aesthetic and environmental impact from seeps from the landfills on the various wetland and surface water areas;
- The potential for the landfills to be leaking through the underlying clay or rock to contaminate groundwater, and so impact the environment;
- The potential for commercial and legal liabilities as a consequence of exposure to contamination, or contravention of relevant environmental laws and regulations;
- The potential occupational health and safety problems which would have to be prevented or mitigated in the construction works for the redevelopment of the area;
- The lack of certainty about the scale of the contamination and its potential impacts, which complicated the land use planning, design of redevelopments and thus the definition of the scopes of the construction works (and hence costs), the allocation of contractual risk between owner and contractor;
- The potential for significant time and cost over-runs.

### 3 HOW RISK MANAGEMENT REDUCED COSTS

#### 3.1 THE STATE LAND

It should be emphasised that the principal impetus for rehabilitating degraded parts of the area was the desire by the NSW Government to redevelop and regain productive use of the land assets.

There was never a realistic prospect that the degraded areas would have been rehabilitated for their own sake. This meant that in practice the scale and cost of rehabilitation would be constrained by the perceived value of the rehabilitated and redeveloped land. Likewise rehabilitation would have to wait until a realistic and therefore commercially viable redevelopment plan could be implemented.

Evidence for this assertion is provided by the five planning proposals which had been conceived between 1973 and 1986, before the 1989 *Development Strategy Report*. These had all recognised the potential for the site, and that a co-ordinated development programme was essential for its realisation. However none of them had found a catalyst which would compel political administrative and commercial interests to converge to the extent needed to make development happen (ie: make state and private sector spend significant money). The 1989 Strategy Report sought to find a trigger from '*the strategic needs to develop industry and commerce in the short term*', balanced by '*the long term provision of a site suitable for hosting major international sporting events such as the Olympic Games*'.

Its positive financial analysis and the persuasive strategic arguments could not outweigh significant uncertainties. Consequently the response to the 1989 plan was a decision to further examine the strategy, rather than to commit to implementation. Thus culminated in the August 1990 *Business Plan* prepared by the NSW Property Services Group.

This 1990 Plan is noteworthy for its explicit recognition of the need for a big enough trigger. Furthermore it was made clear that the specific trigger would have to be a successful outcome to the Sydney bid for the 2000 Olympics (decision expected in September 1993).

An examination of the 1989 Strategy Report, the 1990 Business Plan and the 1991 Report to the Commonwealth Government shows that the magnitude and uncertainty of potential costs of dealing with contaminated land were perceived to be a source of considerable financial risk which the development strategy had to accommodate.

Indeed estimates of these costs (just for the State owned land) were sufficiently high to be one of the reasons why the NSW Government could not accept the 1990 Business Plan. They had risen from \$12.4M in the 1989 Strategy Report to \$199M in the 1990 Business Plan.

The Government required a reassessment of the site remediation strategy to find one more acceptable (ie: involving lower costs and less financial risk). It should however be noted that other issues had also to be reassessed. One was the nature of the State Aquatic Centre, Stadium and Athletics Centre facilities and the sequence/staging of their construction so as to optimise utilisation (with or without Olympics), and minimise capital and recurrent costs. Another was the extent of development needed to be executed before the 1993 Olympic decision in order that Sydney could gain the confidence of the IOC that '*it had or was in the process of providing substantial facilities*'.

The 1989 estimate of \$12.4M was based on interpretations of advice from Camp Scott Furphy (1989) who assumed remediation would be achieved by interception and treatment of groundwater plus insitu isolation or microbiological treatment of landfill materials. They did not have the advantage of data from a sampling and analysis programme. Rather they were based on a review of historical information and aerial photos.

The 1990 estimate of \$190M developed by Rider Hunt, was based on advice from McLachlan Consultants/Dames & Moore and is made up of:

Stripping of contaminated fills and Brick Pit filling	\$44.2M
Contain and treat contaminated fill - Haslams Creek south	\$75.4M
Contain and treat contaminated fill - State Sports Centre east	\$26.1M
Contain and treat contaminated fill - Elcom	\$44.3M
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	<b>\$190.0M</b>

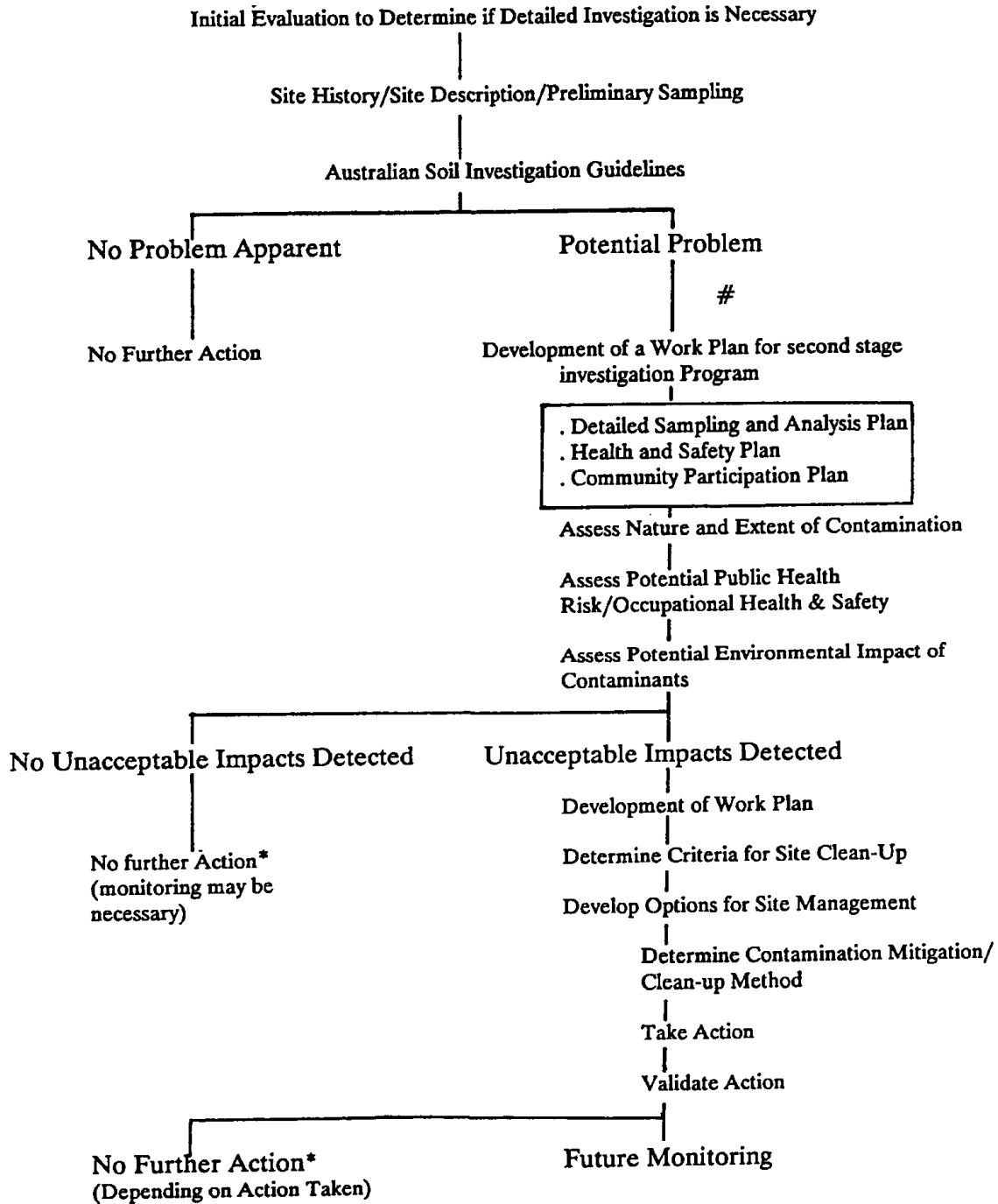
The estimated cost (in 1990) of \$190M did not include the RANAD Newington costs. In 1989 these had been valued at \$22.5M, and if the same pro-rata increase were to have applied they would have increased significantly.

One reason the original idea of placing the landfill materials into the Brickpit was thought to have merit is that it would have confined the contamination and hence all the uncertainties and potential for liabilities to one locality, freeing up constraints from contamination everywhere else within the area. However it became apparent in 1990/1991, after the initial investigations of the State owned landfills, that relocation would have entailed formidable health and safety risks, not to mention very high costs. Therefore the choices for remediation strategy in principle included:

- The creation of a number of 'Bank Vaults' at the several landfill sites, in which all materials would be contained by double liners, and caps, with leachate drains and gas collection and treatment systems. This would have the advantage of localising the sources of potential liability to the smallest aggregate area.
- Leaving the landfills in place (apart from tidying up their edges, or consolidating small areas into larger), but provide them with leachate drains, gas collection, and capping systems. This would mean that they would continue to leak to underlying ground water, but would be suitable for non-residential public purposes.
- Selectively segregating and treating the landfill materials to render them 'non-hazardous'. Placing untreatable materials in defined landfill areas. By mid-1990 a number of early reports from the investigations by Coffey Partners International were available. This enabled estimates of volumes of landfill with chemical concentrations exceeding the then Dutch 'B' guidelines to form the basis of costing the exercise of excavation and removal to the brick pit rather than insitu isolation.

It is interesting to note that the 1990 costs were not based on a risk management strategy even though it is clear that the thrust of advice in 1989 was for a risk management approach. Works by Mitchell McCotter, Camp Scott Furphy and Johnstone Environmental Technology had led to a brief (drafted by JET) for a soil and groundwater contamination investigation. The brief related specifically to Stage 1 of a 3 stage process. Stage 1 would '*generate additional information on the type, level and extent of contamination*' and set the scope for Stage 2. Stage 2 would entail '*more intensive and detailed investigation in some locations, further definition of contaminated areas and more emphasis on contaminated groundwater movement*'. It was expected to '*provide definitive information on the*

**Recommended Approach to the Assessment and Management of a Potentially Contaminated Site**



# decision to proceed directly to clean-up according to guidelines may be taken at a number of points in the following process sequence

\* provided land use remains as originally proposed

Figure 2. Recommended approach to the assessment and management of a potentially contaminated site.

*suitability of the various parts of the area for their planned use, the likely risk associated with the use in terms of health and safety*'. Stage 3 would *'determine the appropriate remediation strategies required to restore the land to a suitable condition for the development proposed'*.

This approach is essentially that espoused now by the ANZECC guidelines (1992) which provides the current benchmark for site assessment practice (see Figure 2). However in 1989 this approach was rare. Indeed SPCC guidance (1989) centred on grid sampling and comparison to a set of acceptance criteria based on the then Dutch guidelines which had at best a tenuous basis in risk assessment.

As it turned out, far from being based on the outcome of this 3 stage risk management approach, the 1990 remediation costs were based on incomplete results from the Stage 1 investigation, and adopted a strategy based on excavation and removal to form a secure capped landfill (in the brick pit) or capping and containment without any evaluation of costs, benefits and risks.

One reason for the deviation from the 3 stage investigation strategy was that the Stage 1 investigation work was incomplete by the time the 1990 estimates were needed, for a range of difficulties not relevant to this paper. The initial investigation at a 50m grid of locations in the State owned land had demonstrated two things. First that the extent of contamination within the landfills was highly varied, and could not be precisely quantified. Second that to extend this detail of investigation across the whole area would be very expensive. There was therefore a reluctance to embark on further work which was perceived likely to be expensive and of questionable value. It was not until later (in 1993) that the ICF risk assessment showed to the satisfaction of PSG and, importantly, the EPA, how it might be possible to use a progressive evaluation of hazards and then risks to manage the processes of investigation to minimise costs and yet provide adequate information to decide remedial objectives. Instead in late 1990 Dames & Moore were asked to make an assessment of the implications of soil and groundwater contamination for remediation strategies and costs. Their report (January 1991) is based on the data *"currently to hand from the Stage 1 investigations"* and the proposed redevelopment plans in the 1990 Business Plan.

Their remediation cost estimates were presented as a range \$20.6M to \$57.7M for the State owned/occupied land — a considerable drop from \$190M. The strategy for the lower end of the range entailed leaving fill in place, installing leachate interception systems and passive gas control in some cases. The upper estimates had in addition more substantial capping, internal leachate extraction, active gas control systems. However they excluded ancillary works such as, landscaping and road base preparation.

They advocated that *'the remediation strategy should reflect the proposed end use of the sites and the environmental impacts and health risks associated with the end use'*. This is a return to the concepts put forward in the 1989 brief. They also were of the view that excavation and haulage of contaminated materials should be minimised *'because of formidable health and safety problems'*.

However as of January 1991 no formal risk assessment had been performed to provide scientific justification for the adoption of the Dames & Moore concepts.

In the January 1991 report to the Commonwealth Government a budget of \$28.7M is allocated, presumably based on the Dames & Moore report, for:

- A programme of long term monitoring;
- Installing boundary cut off drains around landfills adjacent to the States Sports Centre and



- north of the brick pit; and
- Capping and preparatory works on the old SRA embankment.

These works were at that time scheduled to start mid 1991 and finish late 1992 with the majority of expenditure in 1992. They were part of the minimum works to be done in support of the Olympic 2000 bid, ahead of the 1993 decision.

The final adoption of a formal risk management approach was prompted by:

- A Strategic Value Management Study held in February 1992. The strategic value management study involved representatives from principal stakeholders meeting over 3 days to assess the proposed remediation programme. The outcome included endorsement of this programme, plus confirmation that agreement on site specific clean up standards was desirable and possible via the medium of risk assessment;
- Pressures from Government insurers concerned about the potential for future claims from past workers at the contaminated sites; and
- The recognition that in order to achieve consensual support parties for the selected remediation strategy from parties like trade unions, the EPA and local councils and the wider public there would need to be an explicit demonstration that health and environmental risks would be within acceptable bounds.
- Also by early 1992 the EPA had come to espouse a risk based approach, in line with the national guidelines issued in January (ANZECC, 1992). These guidelines had been in development since 1990; a process which entailed extensive consultation between State regulatory bodies, submissions from industry, representative business bodies, consultants and the public, and examination of the effectiveness of different approaches around the world. Thus external expectations had started to become conditioned to the concept of risk management. Consequently PSG was able to justify a budget for a health and risk assessment to USEPA protocols for the landfill sites within the State owned area. The work was commissioned later in 1992 and finished in 1993. The objectives achieved were (ICF 1993):
  - a) confirmation that remedial measures should focus on eliminating or closing selective pathways which generated significant potential human and environmental exposure;
  - b) identification of the level of risk to site workers from existing site conditions;
  - c) confirmation that the proposed remedial measures would reduce the risks adequately; and
  - d) identification of the significance of any sources of uncertainty in the assessed risks.
- By 1992 / 1993 two contrasting examples of remediation strategies had been implemented. The first was the creation of a secure landfill (Bank Vault approach) at the SRA embankment site (where the future Olympic swimming facility was to be built). On the other side of the embankment at the State Sports Centre, the remediation strategy entailed:
  - Consolidation of all landfills into one area within the Sports Centre site;
  - Relocation of a small creek so it ran to the south of and not through the landfilled area;
  - Provision of leachate interception drains, connected to sewer;
  - Provision of an adequate cap to prevent recharge by stormwater, and direct exposure of site users to landfill materials;
  - Rehabilitation and beautification of the small creek environment.

This strategy was made possible by a recognition that at this site leakage of contaminants to underlying ground water was minimal (by virtue of slightly artesian conditions), by the outcome of a value management study which showed that this would be a cost effective approach, and by a risk assessment ( using protocols which conformed with USEPA guidance) which convinced the EPA, Trades Unions representing workers health and safety interests, and the Property Services Group that it would deliver acceptably low health and environmental risks during and after the remediation works.

The experience of both strategies demonstrated their feasibility. However the strategy used for the State Sport Center site demonstrated significantly lower remediation costs (on a per cubic metre of landfill or per hectare of site area) could be achieved with workable contractual arrangements (ie equitable and practical sharing and management of the contractual risks between owner and contractor). Thus it became clear that provided the leakage of contaminants to groundwater under the landfills did not generate unacceptable health or environmental risks, a remediation strategy similar to the State Sports Centre site would be the most cost effective.

Moreover it became clear that the liability associated with deterioration and or failure of 'Bank Vault' secure landfill remained constant with time but its probability of occurrence increased with time as the facility aged. By contrast the leaky landfill would over time carry less liability as the quality of leachate eventually improved. Therefore it is an intrinsically more robust or resilient way of limiting risks.

### 3.2 THE COMMONWEALTH LAND

Meanwhile Department of Defence had been actively considering the RANAD Newington site. Initial attention was paid to the southern 84 ha. This had been declared for disposal in 1987, was initially offered to the State and then planned to be put on the open market for housing. In 1991 however the Commonwealth Government, following discussion with the State agreed to nominate the land for the Olympic Village.

This prompted the commissioning of an investigation by Thiess/AGC, the purpose of which was to produce a confident conclusion about the suitability of the land for residential uses, or the scope of work needed to achieve this. The idea was that Defence would sell an unencumbered site to the State.

The Department of Defence took advice from Unisearch (Prof. M. Knight) in order to develop a strategy and scope of this investigation which avoided slavish adherence to a 50m grid<sup>1</sup> for sampling locations, but which recognised the main features which controlled the disposition and migration of contaminants. It appears that EPA needed to be convinced that alternative strategy would be viable.

The outcome of this study in 1993 was that the 'uphill' areas were declared acceptable (except for a few locations) and that the downslope fill areas adjacent to Haslam's Creek should be capped as contained after fill materials had been consolidated into well defined areas.

The soil standards adopted at this time for residential use were the Dutch 'B' guideline values and USEPA threshold concentrations.

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1. *A rigid 50m grid had been used for the Coffey International Stage 1 investigation of the State owned/occupied land.*

On the basis of this investigation the remediation costs were extrapolated from \$6 to \$7M for the southern 84 ha to \$22.5M for the whole site. By 1993 this had reduced to \$20M.

However, between 1991 and 1993 attitudes within the specialist unit within Department of Defence handling contaminated land issues became much more accepting of a risk based approach to decision making.

This was largely driven by ballooning costs and timeframes needed to achieve 'highest and best' land uses at a number of its other sites. Thus Defence found it was spending more and having to wait longer to realise income from sale of an asset. They also, in this period, gained experience with the more sophisticated Auditor system in the State of Victoria for achieving "sign off" of the condition of land at the point of sale. This showed how it was possible to negotiate risk based strategies to achieve predictable outcomes.

As a result they came to the view that it should be possible to negotiate to sell the State the RANAD site in an unremediated condition (ie: with its contamination liabilities). Given the non-negotiable deadline of the 2000 Olympics this had commercial attractions which outweighed the benefits of first remediating the site and then selling it ready for development.

## 4 THE RISK MANAGEMENT PROCESS

In 1994 PSG and DoD agreed to fund jointly a phased programme of investigations from CH<sub>2</sub>M HILL and a team of sub-consultants, which would generate a risk based remediation strategy for RANAD and for State Land on the north side of Haslam's Creek, and would also address uncertainties identified by the previous ICF risk assessment. Figure 3 shows the investigation area and domains within it.

Figure 4 summarises the processes for the risk assessment work by AXIS which drove the scoping and priorities for investigative work, and which determined the objective for remediation. The principal steps were:

### 4.1 PRELIMINARY HAZARD ASSESSMENT

This drew on information provided by CH<sub>2</sub>M HILL concerning site history, past work practices, geology and hydrogeology, waste disposal practices and future development plans (Figure 5 shows the then proposed land uses). It divided the site into a number of domains of different landuse, dominant habitat or landform. The potential occurrence and concentrations of likely chemicals were combined with knowledge of their relative health and ecological toxicities to develop priorities for further investigation.

### 4.2 FINAL HAZARD ASSESSMENT

Following provision of data from the investigation to collate the highest priority information, the Hazard Assessment was reviewed and priorities and minimum scopes for the detailed investigation work were produced. Also, data quality objectives appropriate for risk assessment work were defined.

### 4.3 DEVELOPMENT OF SCREENING CRITERIA

It was decided to 'screen' each domain and decide which domain or media or chemicals merited a closer examination of the risks. Therefore, screening criteria were developed, using procedures which follow USEPA and ANZECC/NHMRC guidance, to separate confidently those areas of the site which present a negligible risk to human and/or ecological receptors, from those areas which need to be evaluated in more detail. The screening criteria were designed to be protective of human health under residential, public open space, commercial and construction land use scenarios, and also of the most sensitive of ecological receptors and the chemical pathways through which the greatest exposure may occur.

### 4.4 ASSESSMENT OF RISKS

The chemical sampling data arising from the initial and detailed investigations was provided by CH<sub>2</sub>M HILL and manipulated to compute the 'average' concentrations known as exposure point concentrations, for each domain/medium. These were then compared with the screening criteria and the level of and reasons for any exceedances above the criteria were investigated.

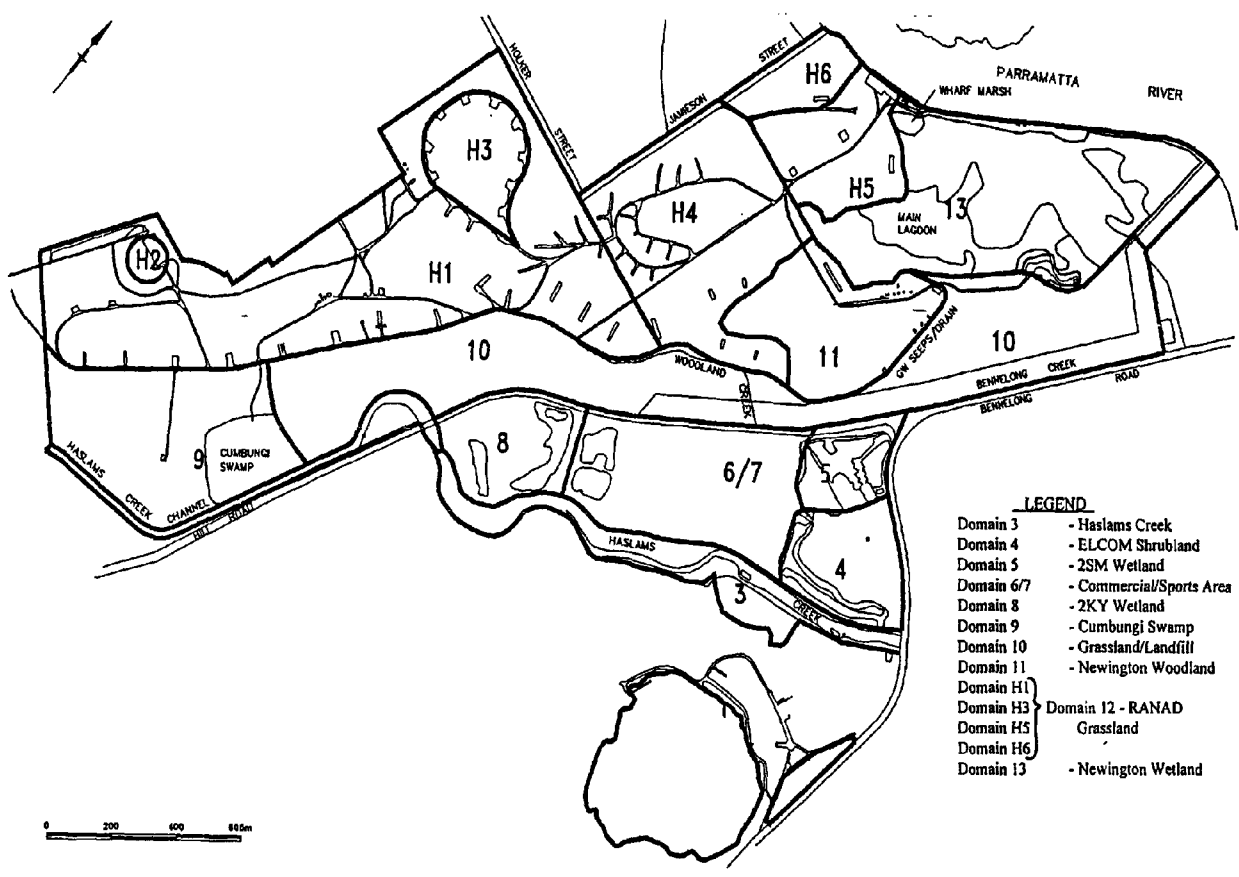
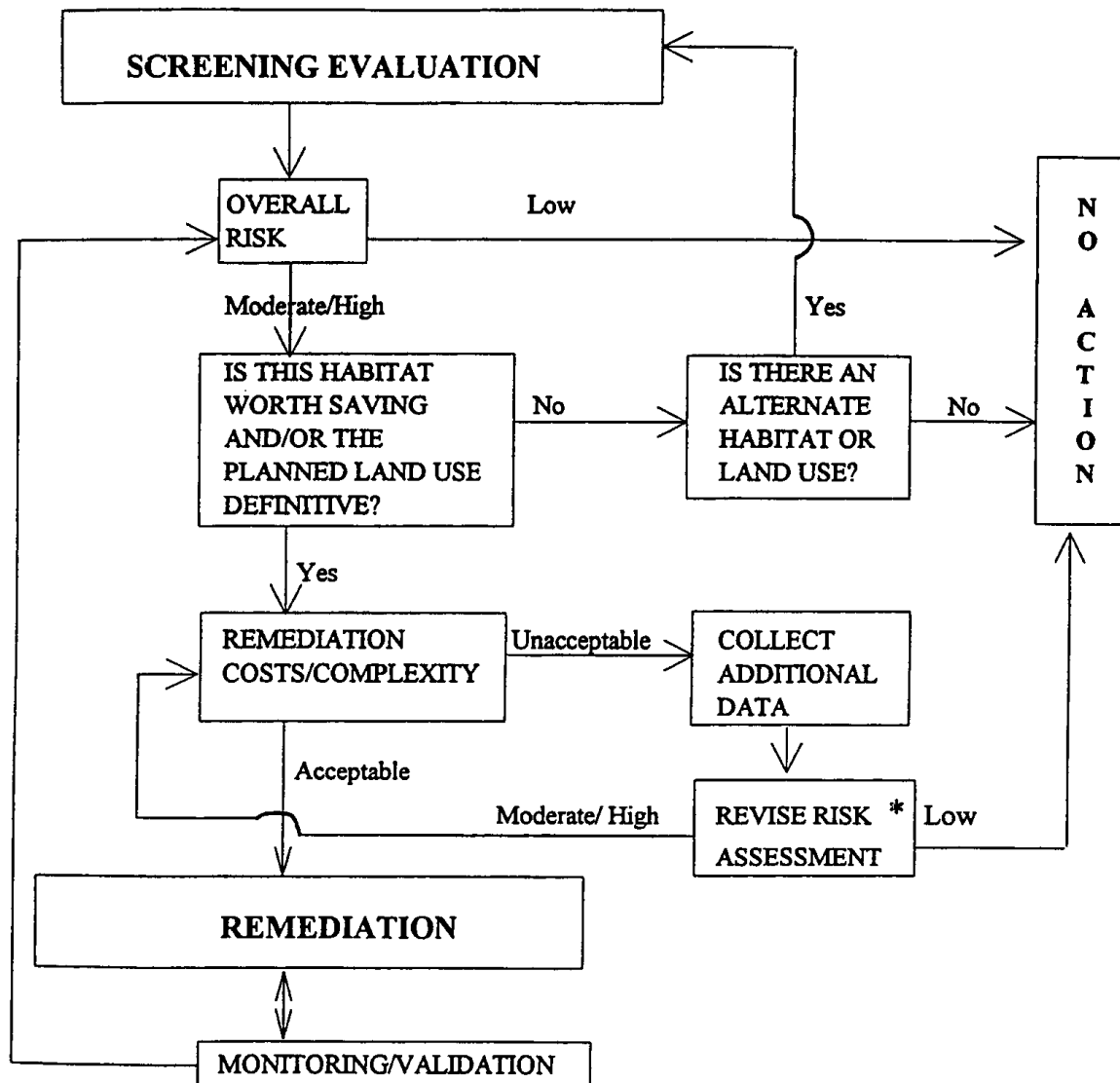


Figure 3. Domain Map for risk assessment.



\* At this stage a more stringent risk assessment would be performed based on additional data collected. If the remediation is too costly even after the conclusions from the risk assessment are reviewed it may be decided that no action will be taken.

Figure 4. Flow chart for consideration of results of risk assessment.

As a result, each domain/landuse/habitat was then given an overall rank of Low, Medium or High risk based on consideration of the magnitude of exceedance, the basis of the screening criteria, the extent of the contamination and the significance of the potential impact (see Figures 6, 7 and 8 for examples of risks to ecological receptors).

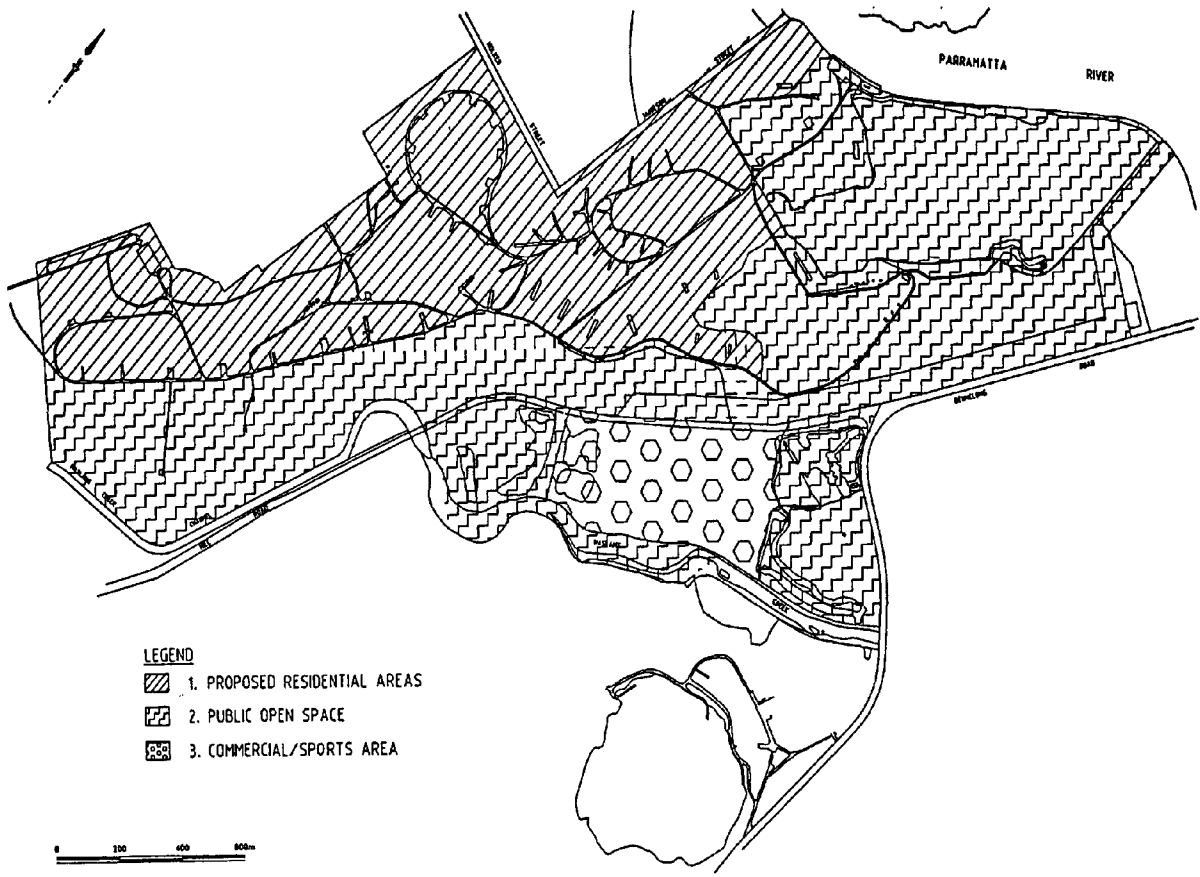


Figure 5. Proposed future land uses risk-based screening criteria.



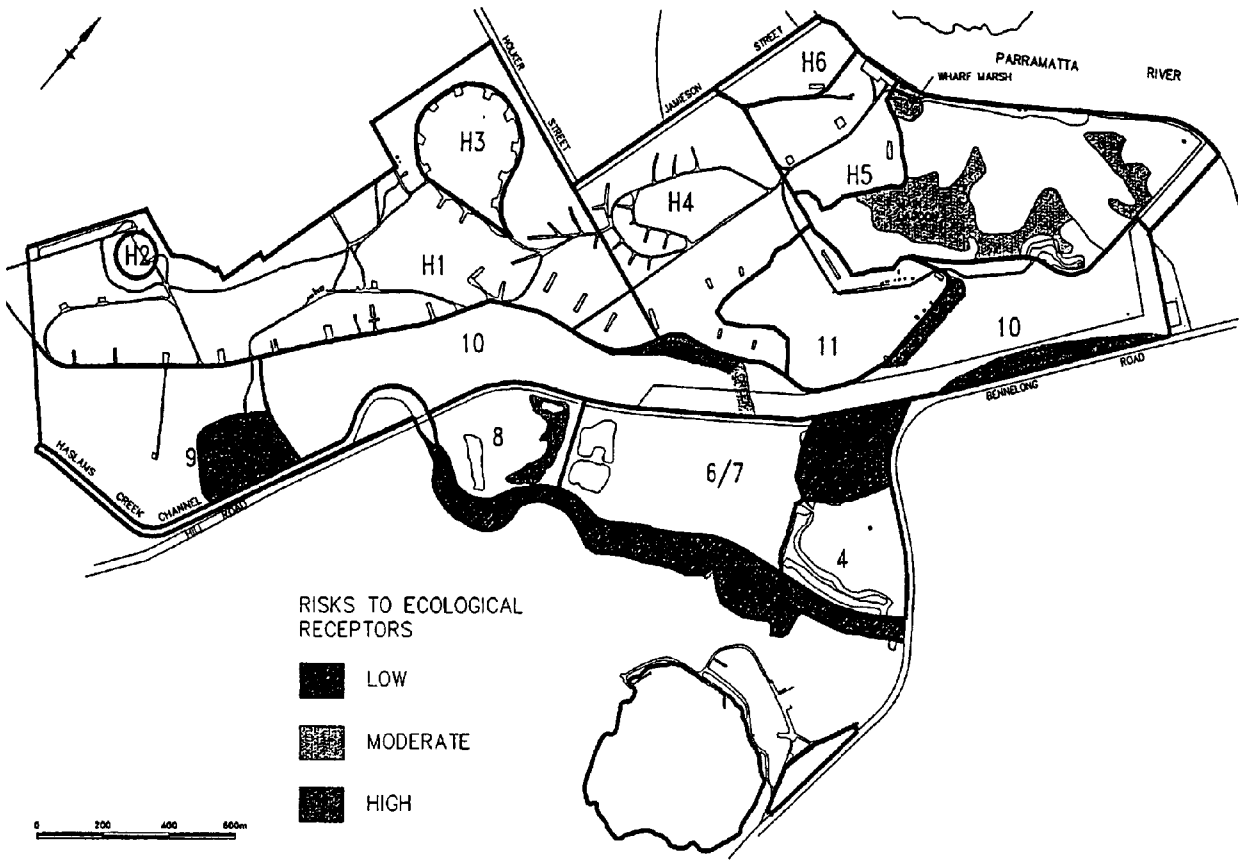


Figure 6. Risks to ecological receptors due to chemical contamination in surface water.

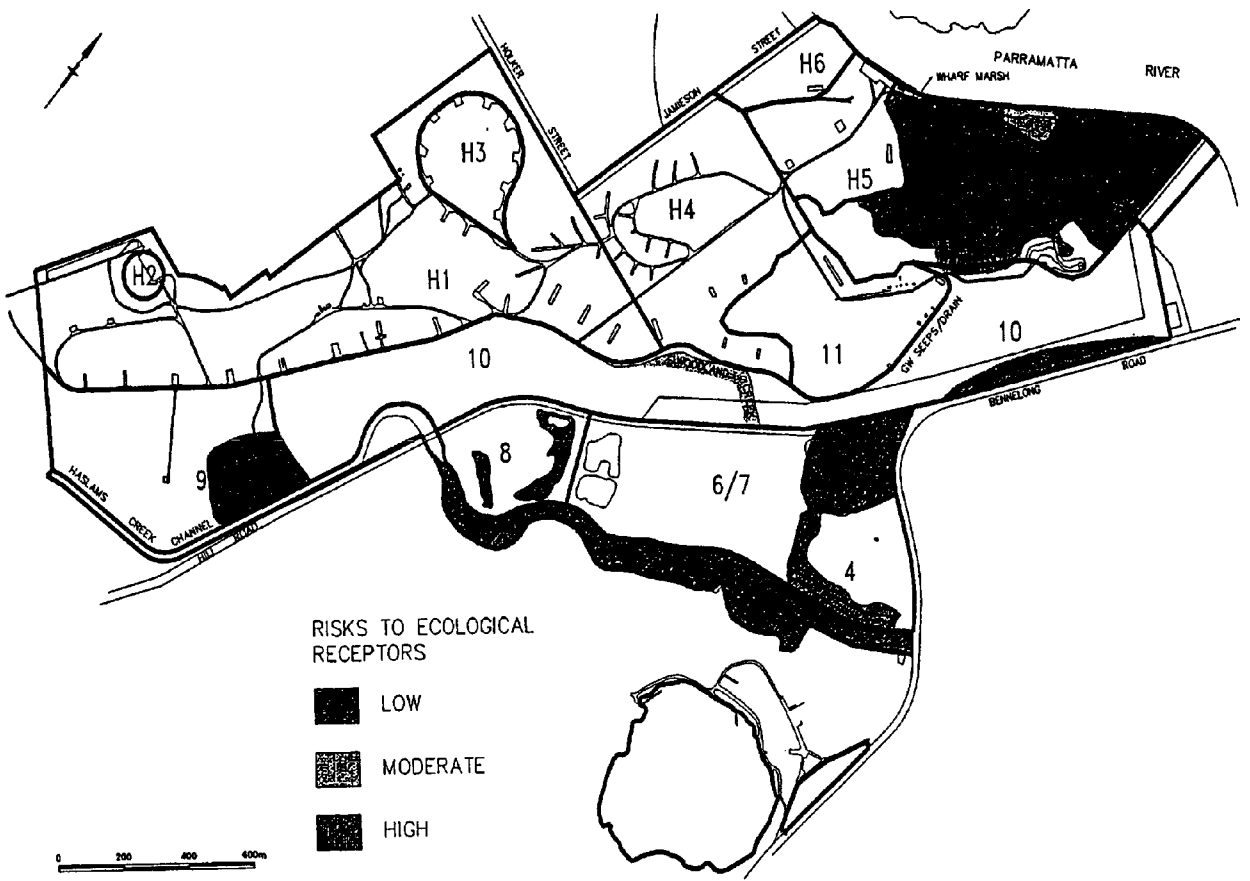


Figure 7. Risks to ecological receptors due to chemical contamination in sediment.

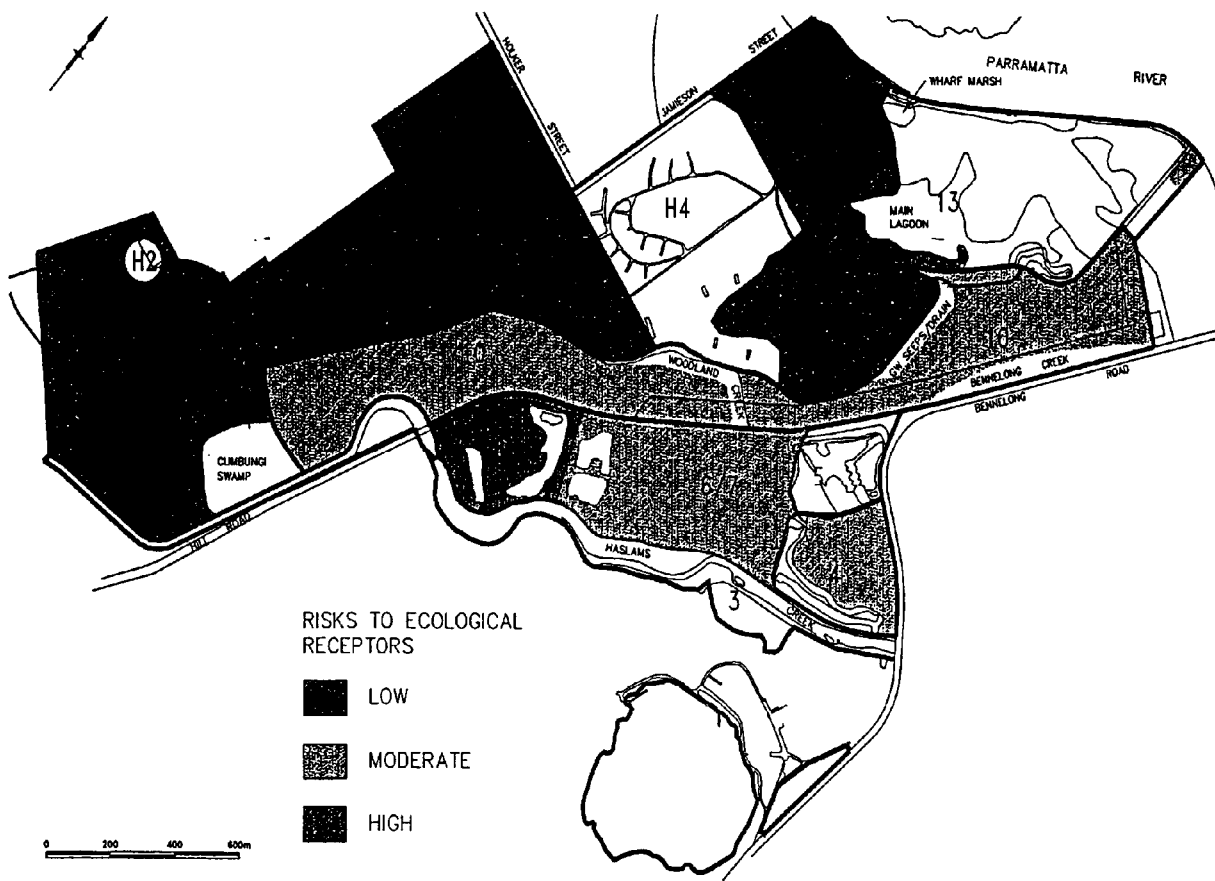


Figure 8. Risks to ecological receptors due to chemical contamination in surface soil.

#### 4.5 IDENTIFICATION OF REMEDIAL OBJECTIVES

The risk rankings reflect the need for remediation. A low ranking implies remediation is not essential, a moderate ranking implies remediation is considered important and a high ranking implies that remediation is considered essential. This study ranks potential human health risks on a domain basis. Therefore, future residential development within a small area of a domain should involve a review of the risk assessment to ensure that conclusions made on a domain basis are applicable to localised areas within that domain.

DOMAIN	MEDIUM	RISKS	REMEDIAL OBJECTIVES
Domain 8	Surface Soil	MODERATE RISK to Maintenance workers as a result of levels of a PAH, dibenz(a,h)anthracene	Combination of chemical remediation and OH&S precautions to prevent dermal/oral exposure
		HIGH RISK to terrestrial invertebrates, plants & woodland birds as a result of zinc, copper & PAHs	Prevent exposure of ecological receptors to soil via chemical remediation
Domain 9	Surface water	MODERATE RISK to investigators & construction/remediation workers as a result of PAH levels	Prevent exposure by means of OH&S precautions. Prevent dermal exposure by chemical remediation of 2 groundwater seeps OH&S precautions needed for investigations/remediation workers
		HIGH RISK to aquatic life & frogs as a result of ammonia, cadmium & copper levels	Prevent further migration of chemicals into swamp via surface water runoff & groundwater water seeps without reducing total water input
Domain 10	Surface water	HIGH RISK to child recreational users & all types of workers as a result of PAH and benzene levels	Prevent dermal exposure by chemical remediation of 2 groundwater seeps; OH&S precautions needed for investigation/remediation workers
		HIGH RISK to ecological receptors as a result of levels of ammonia, cadmium, copper, PAHs, toluene & benzene.	Prevent chemicals in surface water drain & ground water seeps along boundary of domain 11 & 10 from coming in contact with ecological receptors & from being released into Newington Wetland.
	Soil	MODERATE RISK to construction/remediation workers as a result of total PAH levels in the subsurface soil.	Prevent dermal/oral exposure by OH&S precautions

**NOTE: It is for Risk Managers to decide how best to achieve such objectives recognising all constraints and opportunities.**

Figure 9. Remedial objectives that encompass both opportunities and constraints.

In framing the remedial objectives the effect of uncertainties whether from limitations in methodology, results of investigations or toxicity values were also considered. This enabled the identification of where further data collections could materially benefit the robustness and reliability of our conclusions.

A selection of remedial objectives is presented in Figure 9 to illustrate what we mean.

#### 4.6 RECOMMENDATIONS FOR RISK MANAGEMENT

The risk assessment was used to develop an appreciation of the possible consequences of no action in areas of high or moderate risk (an example is shown in Figure 10). This together with the remedial objectives provided the basis for general and domain specific advice for risk management.

The general advice addressed such issues as:

- The need to review management plans to verify that levels of risk both during and after redevelopment works should be acceptable;
- The need to design and implement validation assessments for the purposes of final audit clearance of domains/areas judged either now or after remediation to be fit for use;
- The advisability of producing a coherent set of guidelines to ensure these validation assessments and clearance audits are performed to consistent standards;
- The prudence of conducting further investigation in sensitive areas (sensitive because of potential costs or difficulties or uncertainties) to exclude the possibility that risks had been understated or to minimise remediation costs; and
- The option of further monitoring the conditions of species in areas of assessed low to moderate risks as a means of ground truthing aggregate risk levels from all chemicals and possibly averting the need to remediate.
- The domain specific advice identified concerns and issues which were localised to each domain to assist risk managers decide what to do and how to reach the remedial objectives

DOMAIN	MEDIUM	CHEMICALS OF CONCERN	RECEPTORS AT RISK	POTENTIAL SIGNIFICANCE OF NO ACTION ON HUMAN HEALTH AND THE ECOSYSTEM
<b>AREAS OF MODERATE RISK CONTINUED</b>				
Domain 10 Grassland /Landfill	sediment and surface soil are of moderate risk to ecological receptors; surface, near and sub surface soil are of moderate risk to human receptors.	zinc PAHs asbestos chromium	- construction/remediation workers - all receptors (asbestos) - benthic species - wading birds - terrestrial plants - terrestrial invertebrates - woodland birds	- Construction/Remediation workers are at moderate risk from PAH in the subsurface soil due to levels of PAH. - All human receptors are at moderate risk from asbestos levels in the surface and near surface soil. Asbestos is assumed to present a similar risk to animals with comparable respiratory systems. - There is an additional localised risk to human health due to tar-like material on the surface in some areas of this domain. - Chemical levels of PAH and zinc present a moderate risk to ecological receptors, possibly decreasing the abundance and diversity of benthic species in Woodland Creek and reducing the food supply for wading birds. Chemicals levels unlikely to affect species in Bennelong Creek. - Chromium, zinc and PAH in the surface soil may decrease the diversity and health of the plant community and decrease the abundance of invertebrates in areas of greatest concentration. - Levels of zinc likely to impact woodland birds through bioaccumulation in plant food.

Figure 10. Demonstrates the possible consequences if no action is taken in high or moderate risk areas.

## 5 REMEDIATION STRATEGY DEVELOPMENT

The final remediation strategies adopted for the State owned landfills were (*pers. comm.* K. McCallum, Dames & Moore 1991 (as confirmed by later ICF and AXIS risk assessments):

### 5.0.1 State Sports Centre Landfills

- Consolidation of landfills into one area;
- Relocation of creek to the south so that all landfill materials are contained in one area to its south;
- Provision of leachate interception drains;
- Provision of an adequate cap to prevent infiltration, with stormwater drainage;
- Rehabilitation, beautification of the creek;
- Use of the capped surfaces for outdoor sports (baseball, athletics, hockey).

### 5.0.2 SRA Embankment Landfill

- Consolidation and isolation of all fill into secure landfill in one area provided with double liner, drainage systems and cap.

### 5.0.3 Haslam's Creek South landfills

- Provision of interception drain along the southern bank of Haslam's Creek, at the interface of fill and the alluvial/estuarine clay. Leachate entering the drain to be sent to sewer or recycled to the landfills;
- Capping and landscaping to improve surface drainage, provide for use of the sites for roads, car parks, public space.

### 5.0.4 Elcom ( Haslam's Creek North) Landfill

- Pull back fill from the edges of surface water bodies so that stormwater and bank erosion cannot move contaminated fill into them;
- Cap the fill so that it is fit for use as a Tennis Centre (buildings, car parks, landscaped areas).

The final remediation strategies for the RANAD land were (CH<sub>2</sub>M Hill 1995, to meet objectives arising from the AXIS risk assessment):

- Excavate waste fill in the East Landfill to accommodate flood routing and consolidate excavated material on North or East Landfills;
- Excavate localised soil contamination for consolidation on the North or East Landfills;
- Construct a secondary containment barrier around identified tar deposits in the North Landfill to prevent tar migration from wastes;
- Regrade and cap the three landfills with a low permeability cover to eliminate exposure of the wastefill to people and wildlife and to minimise rainfall infiltration into the wastefill and leachate generation;
- Install a leachate cut-off wall around East and North Landfills and convey collected leachate to the Lidcombe Aqueous Waste Treatment Plant for treatment; and
- Monitor the effectiveness of the remedial actions on the wetland ecosystems.

Figure 10 illustrates the recommended remediation strategy for the RANAD site.

It is interesting to compare these strategies with those previously advised, before the risk assessment was available.

At the 1989 Hazards Seminar, Mitchell McCotter advised to remove all contaminated fill to Brickpit. As discussed above, Camp Scott Furphy canvassed:

- Excavation and disposal in controlled conditions;
- Isolation by capping;
- Chemical or physical treatment; and
- Mixing to achieve dilution.

They preferred isolation by capping and adjustment of layout of proposed development so that *'most badly contaminated areas located beneath permanent hard cover'*.

The 1989 *Development Strategy* was based on the concept of removing landfill material to the Brickpit and capping it.

In 1990 JET advised remediation strategies which would leave fill in place, where significant gases were being generated and provide it with a suitable cap and gas extraction system. Elsewhere removal to a repository (ie: the Brickpit) was proposed. In 1991, however, Dames & Moore considered that containment, in combination with the contaminants in ground and surface water, and with landfill gas control measures are the preferred remediation strategies. This was because in their view:

- *'the remediation strategy should reflect the proposed end use of the site and the environmental impacts and health risks associated with that end use.*
- *remediation, wherever possible does not involve movement of contaminated materials outside the project area;*
- *because of the formidable health and safety problems, the excavation and haulage of contaminated materials should be minimised'.*

This view echoed that expressed by JET in 1990. The technologies considered by Dames & Moore included:

- active and passive gas control;
- leachate cut-off and collection by use of a slurry wall;
- leachate cut-off and collection by use of an interceptor drain;
- leachate extraction; and
- capping systems — either a 1.0m thick cap comprising drainage, clay seal, fill layers and marker membrane, or a 0.5m thick clay seal.

In developing their recommended remediation strategy, CH<sub>2</sub>M Hill examined in detail several alternatives to identify which might achieve the following objectives for the RANAD land most cost effectively:

- prevent human exposures to contaminated cover soils and landfill contents;
- prevent migration of contaminants from the landfills by surface drainage and groundwater discharge to sensitive ecological systems (ie: Depot site wetlands and Haslams Creek);
- prevent long-term adverse impact of contamination on the viability of important ecological systems;
- prevent human exposures to localised soil contamination, with particular emphasis in areas to be used for residential purposes; and
- avoid remedial actions which may be unacceptably destructive in their implementation.

It is interesting to observe that their conclusions (for the RANAD landfills) and those of Dames & Moore (for the State owned landfills) are in essence very similar.

## 6 THE FINAL BUDGETS FOR REMEDIATION COSTS

Following on from the risk management advice both PSG/OCA and DoD were able by November 1995 to develop and agree budgets for the remediation of the Newington land. PSG/OCA were also able to review their budgets for remaining activities in the State owned land. These are:

Remediate whole of former Commonwealth owned land (RANAD)	\$58M
Remediation of State owned/occupied land	\$69M <sup>2</sup>
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<b>TOTAL</b>	<b>\$127M<sup>3</sup></b>

This is a lot less than the \$190M once estimated for the State owned land alone even though the costs for RANAD have increased significantly from \$20M. The current figures also include for additional work such as landscaping the works to upgrade the north end of Bicentennial Park and relocate the former rail loop which were previously budgeted separately.

Moreover the level of uncertainty has been much reduced, the key stakeholder interests have been satisfied and there is a rational basis for the detailed planning and design which lies ahead. There is also the ability to adjust the details of remediation measures in response to changes in details of land uses.

Advice from OCA and DoD indicates that the total cost of investigations to date, including the risk assessment costs is:

Former Commonwealth land (RANAD)	\$2.2M
State owned/occupied land	\$5.0M
	-----
<b>TOTAL</b>	<b>\$7.2M</b>

This represents about 5% of the budgeted remediation costs, and less than 10% of the reduction achieved in budgeted costs for the whole development area. Thus it was money well spent.

Furthermore, the unit cost per hectare of the RANAD Stage 2 investigations is significantly less than that for the initial investigations of the State owned land. With the benefit of hindsight some significant savings could have been achieved in the earlier investigations had the scope of works been phased to allow adjustments in response to a progressive evaluation of hazards and risks based on information as it was obtained.

It is also worth noting that by virtue of acceptance of the risk based approach and the concept of leaving the fill in place, investigative attention could be focussed on the contaminants migrating from the landfill rather than on the detailed disposition of contamination within the landfills. This also reduced scope and costs of investigations.

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2. *Of which \$53M has been spent, on remedial and ancillary works such as landscaping, road base preparations etc.*
  3. *This represents capital costs only*



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## 7 CONCLUSIONS

What has the project demonstrated? The principal conclusion is that although the need for a risk based approach was recognised early on, it could not be utilised:

- Until the less sophisticated ideas of somehow locking up the contaminated materials in one or more defined containment areas started generating unacceptable costs and commercial uncertainties which threatened the perceived viability of the redevelopment plans. These costs and uncertainties related to estimates of fill volumes, OH&S difficulties associated with the excavation and removal of fill containing putrescible and industrial wastes and the high costs of clean replacement fill;
- Without a regulatory framework which encouraged risk assessment as a tool to relate choices for future land use to standards for clean up;
- Until there was acceptance that effective and safe use of the land could be achieved without moving landfill unnecessarily;
- Unless land management organisations had the in-house capability to understand and integrate health and environmental risk management concepts with other constraints from planning, social, OHS, financial, legal, political issues as they formulate land management/development strategies;
- Until the environmental consulting profession had the technical capabilities to use risk assessment to devise, adjust optimise priorities and scopes of assessment work, and to interpret the results in terms meaningful for land managers, and other stakeholders, including the public (ie: non specialists); and
- Until there were effective mechanisms in place to involve and consult with stakeholders at milestones in the assessment process.
- Until people were convinced that contracts for the remediation works would minimise and share equitably the commercial risks and uncertainties entailed by a scope of works which could not be defined precisely up front, but which would vary in light of conditions uncovered by the works.

Once these elements were established, risk management has been able to produce significant cost savings in both investigation and remediation, and provide adequate assurance that public health and the environment is being not only protected, but also enhanced.

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## 9 ACKNOWLEDGEMENTS

Discussions with the following individuals:

Mr E Johnstone	Johnstone Environmental Technology
Ms K McCallum	Olympic Co-Ordination Authority
Mr A Mamelis	Director, Environment and Heritage Department of Defence
Mr R Lister	McLachlan Consultants
Mr J Morandini	NSW Premier Department
Ms S Arthur	Department of Defence
Dr M Knight	Unisearch
Mr J Libby	EPA
Mr M Lane	AXIS (formerly Environmental Project Officer with Department of Defence)
Mr R Hartley	Kinhill (formerly Director Defence Environment Review Department of Defence)
M Heazlett	Department of Defence
Mr H Best	Department of Defence

# FAUNA IMPACT STATEMENT

# Fauna Impact Statement

Dr. Hal Cogger  
with extracts from FISs prepared by  
Dr Allen Greer and Dr Graham Pyke  
Australian Museum Business Services  
November 1995

## CERTIFICATION

I certify that this Fauna Impact Statement (FIS), prepared by the Australian Museum, has been prepared in accordance with the requirements of Section 92D (I) of the National Parks and Wildlife Act (1974) as amended by the Endangered Fauna (Interim Protection) Act (1995) and with regard to the requirements notified by the Director-General of NSW National Parks and Wildlife Service.

Harold G. Cogger MSc PhD

Date: 16 November, 1995

## 1 SUMMARY

The Green and Golden Bell Frog (*Litoria aurea*, Figure 1) is an endangered species which has a highly significant population within the Homebush Bay Development Area ("the study area") managed by the Olympic Co-ordination Authority. This population occurs primarily within the disused Homebush Bay brickpit. It also occurs widely throughout the remainder of the area but mostly in ephemeral habitat in which only isolated individuals or small, non-self-sustaining sub-populations are maintained as a result of periodic emigration from the brickpit during periods of suitably warm, wet weather. It is the only species on Schedule 12 of the *National Parks and Wildlife Act (1974)* as amended by the *Endangered Fauna (Interim Protection) Act (1995)*, likely to be impacted upon by developments within the Homebush Bay Development Area (Pyke 1995; Greer *et al.*, 1995).

Proposed developments in association with preparations for the Olympic Games in Sydney in the year 2000 and the relocation of facilities for the Royal Agricultural Society (RAS) will result in the destruction and/or disruption of much of the ephemeral frog habitat outside the brickpit, and has considerable potential to impact deleteriously on the Green and Golden Bell Frog's core habitat in the brickpit unless appropriate protective and ameliorative measures are taken and maintained. Such measures will be required until such time as new habitat is created elsewhere on the site and occupied and utilised by the Green and Golden Bell Frog at levels (including reproduction) at or greater than existing population levels in the brickpit.

Until this occurs impacts of development elsewhere on the site will be mitigated within the brickpit by maintaining it in its present form, with a buffer zone around its rim, while limiting access to the area by enclosing it within a secure perimeter fence (already in place) and ensuring that untreated urban runoff from developed areas is not allowed to enter the brickpit directly.

Outside the brickpit the impacts of the proposed developments in the Masterplan will be mitigated by the creation of artificial frog habitat between the new Loop Road and Haslam's Creek; by maintaining continuity of frog habitat by constructing either vehicular overpasses or frog underpasses (associated with appropriate fencing to funnel the majority of dispersing frogs to the underpasses) in order to prevent dispersing frogs from having to cross vehicular road surfaces; and by the erection of frog-proof fences between the brickpit and any road that runs near its rim. In addition, as many as possible of the frogs and/or tadpoles as can be located will be removed from areas slated for development just before development activity proceeds.

These ameliorative measures will be carried out under conditions required by two existing Section 120 (General) Licences to 'take or kill' endangered fauna (as defined by Section 5(1) of the *National Parks and Wildlife Act (1974)* as amended by the *Endangered Fauna (Interim Protection) Act (1995)*), issued by the Director-General of National Parks and Wildlife Service for the brickpit and for areas excluding the brickpit respectively, so that all areas covered by the new Masterplan are subject to an existing licence to 'take or kill' Green and Golden Bell Frogs. These licences (Nos. TS 0076 and TS 0103) together set out conditions which ensure that the brickpit population of frogs is maintained intact and that any frogs located in the path of proposed developments outside the brickpit are removed and relocated to existing suitable habitat, including restored or rehabilitated habits, elsewhere on the site, or utilised in any captive breeding programs approved by the Director-General of National Parks and Wildlife.

In addition, the existing licence conditions require that the developer will ensure that all runoff from developed areas will be directed away from the brickpit to holding ponds for subsequent treatment, and that secure fencing will be constructed and maintained between the brickpit, surrounding roads, and the Urban Core, until the existing licence expires or the licence conditions are varied or waived by the Director-General of National Parks and Wildlife. This fencing will be constructed to specifications which preclude entry by unauthorised persons and which will prevent the egress of Green and Golden Bell Frogs from the brickpit directly into the Urban Core.

As already indicated, the major impact of the proposed development on the Green and Golden Bell Frog is to reduce the total area of ephemeral habitat available to this species on the site and thus to limit its options for dispersal to other areas adjacent to the site or to recruit new individuals from those areas. Some ephemeral breeding areas will also be reduced only in the short-term.

These existing licence conditions are therefore aimed at ensuring that, while proposed developments in the study area will reduce the total area of ephemeral habitat available to this species, its core habitat in the brickpit will be maintained until reproducing frog populations are established in rehabilitated habitat elsewhere on the site.

This will ensure that the impacts of the development on the local conservation status of the Green and Golden Bell Frog should be sustainable and not result in any long-term decline in the frog's populations on the site. Hence there should not be any significant impact on the regional or Statewide conservation status of the species.

Consequently the overall strategy adopted in this document is to maintain in its present form and conditions the core environment essential to the maintenance of the existing frog populations on the study area, and to permit developments on ephemeral habitat which, while destroying some areas of frog habitat, will be replaced by the creation and rehabilitation of both ephemeral and core frog environments elsewhere on the site.

Monitoring of frog populations will ensure that the brickpit environment is maintained intact until the newly-created habitats are naturally and effectively colonised by Green and Golden Bell Frogs at a sustainable level equivalent at least to current levels.

## 1 INTRODUCTION

Within the Homebush Bay Development Area, two endangered fauna species (listed as 'Threatened' or 'Vulnerable and Rare' on Schedule 12 of the National Parks and Wildlife Act (1974) as amended by the Endangered Fauna (Interim Protection) Act (1995)), the Osprey (*Pandion haliaetus*) and the Green and Golden Bell Frog (*Litoria aurea*), have been reported (Straw 1993, 1994; Greer 1994). Since any proposed development within this area has the potential to significantly impact on either or both of these species (see below), a General licence for the proposed development is required from the Director-General of the NSW National Parks and Wildlife Service under Section 120 of the *National Parks and Wildlife Act* (1974) as amended by the *Endangered Fauna (Interim Protection) Act* (1995). This Act also requires that a Fauna Impact Statement (FIS) accompany an application for such a licence.

In 1994 an FIS (Greer 1994) was prepared for the Property Services Group which is now operating as the Olympic Co-ordination Authority, to cover the impacts of proposed developments in the Homebush Bay brickpit on any Schedule 12 fauna, and on the 24th November 1994 a Section 120 licence was issued by the Director-General of National Parks and Wildlife Service to 'take or kill' Green and Golden Bell Frogs under a suite of conditions laid down in the licence.

Subsequently in 1995 an FIS (Pyke 1995) was prepared by AMBS for the Olympic Co-ordination Authority to cover the impact of proposed developments outside the Homebush Bay brickpit on any Schedule 12 fauna, and in November 1995 a Section 120 licence was issued by the Director-General of National Parks and Wildlife Service to 'take or kill' Green and Golden Bell Frogs under a suite of conditions laid down in the licence. A copy of these licence conditions are also attached.

In September 1995 the NSW Government issued a new Masterplan (Figure 2) for the development of the Olympic site at Homebush Bay in which many of the developments on which the previous two Fauna Impact Statements had been based were modified or changed. However while the nature and individual locations of the new Masterplan developments vary from those specified in a previous Masterplan (August 1994), the impacts of these variations on Schedule 12 fauna remain largely unchanged.

The retention of the brickpit in its original state as core habitat for the Green and Golden Bell Frog, limiting access to the brickpit by enclosing it within a perimeter fence (already in place), and proposing no change in the location and extent of open spaces (including spaces set aside for the creation of new frog habitat), has significantly reduced the impacts of the development on the Green and Golden Bell Frog in the medium term and increased the prospects for its survival on the site in the longer term.

Conversely, some changes in road and rail locations and parking lot proposals in the new Masterplan will create new impacts on the Green and Golden Bell Frog's ephemeral habitat, and these will be considered below.

The two previous FISs covered both the Green and Golden Bell Frog and the Osprey and were prepared in accordance with specifications listed in Section 92D of the *National Parks and Wildlife Act* (1974) as amended by the *Endangered Fauna (Interim Protection) Act* (1995) and with additional requirements of the Director-General of the NSW National Parks and Wildlife Service (for details see Greer 1994 and Pyke 1995).





Figure 1. The Green and Golden Bell Frog, *Litoria aurea*. *Top*: an adult from level 1 of the brick pit; *Bottom*: a tadpole from level 2 of the brick pit.



Because it was determined in both cases that proposed developments would not impact in any significant manner on the Osprey (*Pandion haliaetus*), the latter was removed from any other consideration and Section 120 licences were issued only for the Green and Golden Bell Frog. This Masterplan FIS also addresses the Green and Golden Bell Frog as the only Schedule 12 species impacted on by the developments proposed in the 1995 Masterplan.

## 2 DESCRIPTION AND LOCATION OF THE STUDY AREA

The Homebush Bay Development Area lies within the Sydney suburb of Homebush, is about 12 km west of the Sydney Harbour Bridge, and is surrounded by highly urbanised parts of Sydney (Figure 3). It is an area of 760 ha, much of which is planned to be used for development for sporting, recreational, residential, commercial and exhibition purposes. The area will also be the site of the Olympic Games in the year 2000.

For the purposes of this FIS, the Homebush Bay Development Area is that area indicated in Figure 2. It includes the brickpit covered by a previous FIS (Greer 1994) and most of the area covered by a second FIS which excluded the brickpit (Pyke 1995), but excludes those areas of Commonwealth-owned land known colloquially as the 'Newington site' and consisting of Commonwealth lands which contain the Royal Australian Navy Armament Depot on the northern side of the Homebush Bay arm of the Parramatta River. This FIS covers much of the land which is within the boundary specified in Regional Environmental Plan No. 24

Within the area south of Haslam's Creek, including the brickpit, there are few undisturbed sites and presently little vegetation which could be considered to approximate what would be 'natural' for the area (i.e., the vegetation that would have occurred in the area before European settlement) (Clarke & Benson 1988; Webster & Kachka 1992; Kachka 1993). In addition to sites occupied by buildings, roads, carparking and paths, this part of the site contains five permanent freshwater ponds, three relatively ephemeral ponds, regions of mown grass, regions of unmown grass and herbs (mostly introduced species), regions of disturbed soil that presently lack vegetation and regions with a few trees and/or shrubs (Pyke 1995 figures 5-9).

The brickpit itself is also a highly disturbed site (Greer 1994 figures 6 & 7), being a 16.4 ha excavation (Greer 1994). Excavation of this site ceased in 1988 (Kachka 1993). The brickpit vegetation, which is described in Greer (1994) and Adam (1993b), is relatively sparse. Many freshwater ponds, some quite large, form in the brickpit after rain and the total pond surface area may reach about 5.4 ha (Christy, *pers. comm.*).

Aquatic plant species, including *Typha domingensis*, occur in some of the ponds (Adam 1993b). With the exception of a large and quite saline pond in the deepest part (level 3 in Figure 6) of the brickpit (Jewell 1993), almost all of the ponds in the brickpit are ephemeral.

The most undisturbed and "natural" areas within the area south of Haslam's Creek but outside (though adjacent to) the site which is the subject of this FIS are in Bicentennial Park. These include areas of mangroves, saltmarsh, estuarine wetland and open water (Clarke & Benson 1988; Webster & Kachka 1992; Adam 1993a; Kachka 1993; Straw 1993; Taylor 1994). For the most part, these areas are not discussed in the present document because they are not included within the habitat of the Green and Golden Bell Frog (see below).

An individual of this species has, however, been found in a small freshwater area with much *Typha domingensis* near the Administration building (Pyke 1995).

The area north of Haslam's Creek is also highly disturbed, consisting mostly of regions of mown grass, regions of unmown grass and herbs (mostly introduced species), and a region of degraded wetland dominated by *Typha domingensis* (Pyke 1995 figures 10-12). Extensive regions within this area have been used as landfill sites for contaminated material ([Pyke 1995 figures 10-11]; Australian Construction Services 1993; Greer 1993; Straw 1993, 1994). This area also contains

a number of ephemeral ponds, most of which have abundant *Typha domingensis* (Pyke 1995 figures. 12 & 13).

North of Haslam's Creek there are also a few small regions with trees and shrubs and one relatively large region of eucalypt woodland. (Pyke 1995 figure. 10). This woodland region has been little disturbed except for some mowing of the understorey, is about 19 ha in size and is the last remnant of mixed eucalypt woodland on Wianamatta Shale along the Parramatta River. It consequently has high conservation value (Webster & Kachka 1992; Greer 1993; Flannery *et. al.* 1993; Straw 1994). This area also contains regions of saltmarsh and mangroves (Pyke 1995 figure 14).

Although presently degraded, these provide important habitat for many species of shorebird, some of which are included in International Agreements and Conventions which are designed to protect them and their habitats (Straw 1993; Taylor 1994). These habitats are discussed in detail in Kachka (1993a), Adam (1993), Straw (1993) and Taylor (1994). They are not discussed further here because they are not used as habitat by the Green and Golden Bell Frog.





Figure 2. Homebush Bay Masterplan

### 3 DESCRIPTION OF PROPOSED DEVELOPMENT

The developments proposed for the site are shown in Figure 2, while a list of the major developments is given in Table 1. In the south, adjacent to the brickpit, there is an urban core district which will contain most of the facilities required for the Olympic Games to be held in Sydney in the year 2000. This area also contains the site for the proposed facilities for the Royal Agricultural Society, replacing those currently operated by the Society at Moore Park in inner eastern Sydney. These facilities will, by and large, mirror those at the present RAS Showground at Moore Park and are scheduled for completion in 1998.

On the western boundary of the site an Olympic Village will be built, while the eastern and northern parts of the site will be largely open space for passive and active recreation and environmental conservation (for further details of these developments see below).

However each of these developments will be linked by transport corridors and infrastructures such as parking areas, roads and rail links to Sydney's main heavy rail system (Figure 4). The continuity of the open spaces will undoubtedly be compromised by some of these infrastructures, and by some outlying sporting facilities, and these impacts are discussed below.

Because the Urban Core is immediately adjacent to the core habitat of the Green and Golden Bell Frog (the brickpit), the potential for significant impacts to be visited on this species is considerable. Consequently there will need to be a number of caveats applying to development in the Urban Core to ensure that impacts on the population of Green and Golden Bell Frogs in the brickpit are minimised.

Development and/or activities in the Haslam South sub-area of the study area are presently proposed to occur in the following 'precincts': Sports precinct, Australia Centre, Showground

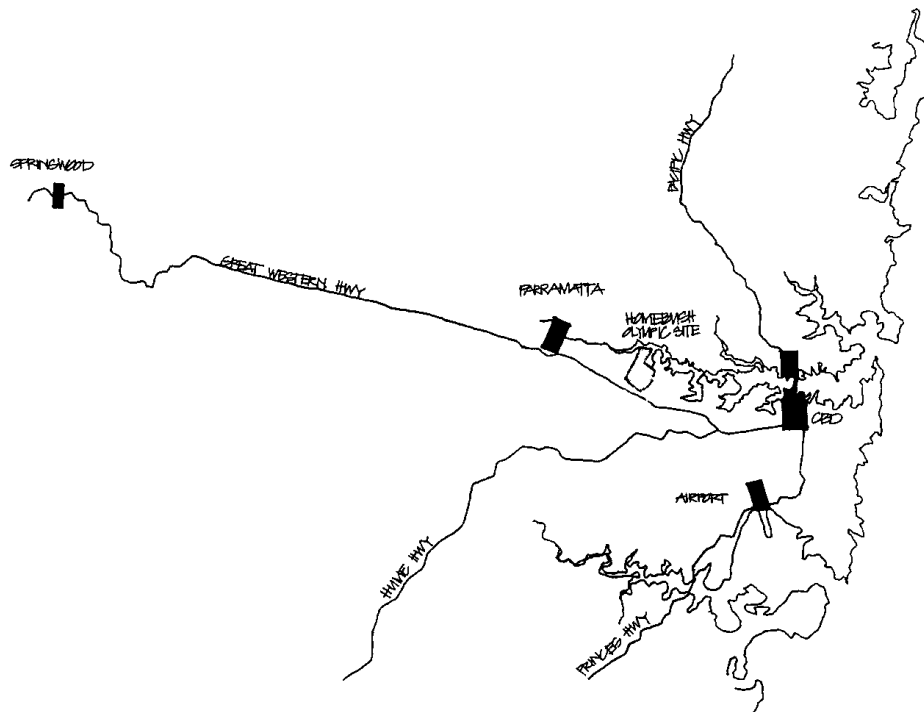


Figure 3. Regional Plan





Figure 4. Transport Summary Plan





Figure 5 Design plan for urban core precinct



Area. However, a management plan has been developed for the use of fertilisers, herbicides and other pesticides and this is expected to result in the maintenance of reasonably high water quality throughout the Area. Pollution from automobiles will also be minimised.

Frog habitat in the area may experience increased numbers of people walking near and through it. There may also be increased numbers of frogs killed by vehicles on the various roads in the area. Such effects as these may adversely affect the Green and Golden Bell Frog unless appropriate remedial actions are implemented.



Figure 6. Green and Golden Bell Frog Habitat Distribution and Levels of Brickpit

*Homebush Bay Masterplan 1995*. This proposed development includes enlarging some roads, building new roads, and extension of the heavy rail system into the area (Homebush Bay Transport Strategy 1995).

Proposed development in the Haslam North sub-area of the study area will occur in three 'precincts'. These are the Residential (North and South Newington) and Remediation Precincts. Proposed development in each is described below. The Residential Precinct will be developed as an urban residential area. It will consequently consist mostly of buildings, roads and associated structures. It will include the Olympic village during the Olympic Games and be sold as public housing after the Games.

The Remediation Precinct occupies the low lying land to the north of Haslam's Creek that has previously been used for contaminated landfill. This precinct has been 'remediated' through a process which involves removal and relocation of some of the waste fill material, construction of perimeter leachate collection drains and capping of the area with a minimum of a 1m deep layer of clean clay fill. This development has resulted in the initial disturbance of some of the salt and freshwater wetland habitats. However, subsequent development will include regeneration of these habitats which are presently polluted by leachate from the landfill.

The remainder of the Haslam North sub-area will be protected from development and managed as Environmental Conservation Precincts. These will include the remnant eucalypt woodland and the extensive wetlands in the northern part of the sub-area.

As a result of the proposed development, the effects of human disturbance will generally increase throughout the study area, especially during the time of the Sydney Olympics. Such increased disturbance could, for example, affect the quality of water in the Homebush Bay Development Area. However, a management plan has been developed for the use of fertilisers, herbicides and other pesticides and this is expected to result in the maintenance of reasonably high water quality throughout the Area. Pollution from automobiles will also be minimised.

Frog habitat in the area may experience increased numbers of people walking near and through it. There may also be increased numbers of frogs killed by vehicles on the various roads in the area. Such effects as these may adversely affect the Green and Golden Bell Frog unless appropriate remedial actions are implemented.

#### 4 PREVIOUS FAUNA STUDIES

Given the highly disturbed nature of the Homebush Bay Development Area and its isolation from relatively natural areas, it is not surprising that throughout most of it few native species of animal are encountered.

The relatively few parts of the area that are most likely to support native fauna (i.e., birds, mammals, reptiles, frogs) are the remnant woodland on the north side of Haslam's Creek and the various regions of saltmarsh, mangrove and associated estuarine environment. These regions have in fact been well surveyed and found to contain many native fauna species (Flannery *et. al.* 1993; Greer 1993, 1994; Straw 1993; Flannery & Gullick 1994; Straw 1994; Taylor 1994).

The brickpit has also been surveyed for fauna species present (Greer 1994). Besides the Green and Golden Bell Frog it contains a small number of native animal species (Greer 1994).

Only two fauna species that are considered 'endangered' (i.e., that are listed on Schedule 12 of the *National Parks and Wildlife Act (1974)* as amended by the *Endangered Fauna (Interim Protection) Act (1995)* have been detected during previous fauna surveys within the Homebush Bay Development Area. These are the Osprey, *Pandion haliaetus* (Straw 1993, 1994) (listed as 'Vulnerable and Rare'), and the Green and Golden Bell Frog, *Litoria aurea* (Greer 1994) (listed as 'Threatened').

Although the Homebush Bay Development Area is generally unsuitable habitat for the Osprey, a single Osprey was observed flying overhead in July 1993 (Straw 1993, 1994). The Osprey was discussed in reasonable detail in a previous FIS (Pyke 1995) where it was concluded that the proposed developments will have no impact on this species. Consequently this species is not considered any further in this FIS.

Prior to surveys carried out in association with the previous FISs cited above, the Green and Golden Bell Frog had been found in a number of locations throughout the Homebush Bay Development Area (Greer 1994). Many of these records were from the brickpit, which clearly contained (and continues to contain) a large and self-sustaining population of the species (Greer 1994).

Previous records of the species from outside of the brickpit are widely scattered and include several records of breeding (Greer 1994; Pyke 1995). All existing records for the study area are shown in Figure 7.

Since many of the sites where breeding by the Green and Golden Bell Frog has been recorded are within Precincts in which major developments are intended to occur, some of these developments are likely to have a significant impact on the habitat and population of the species and could result in the killing of individual Green and Golden Bell Frogs. A licence from the Director-General of National Parks and Wildlife Service is therefore required for the proposed development as specified in Section 120 of the *National Parks and Wildlife Act (1974)*, as amended by the *Endangered Fauna (Interim Protection) Act (1995)*.





Figure 7. Green and Golden Bell Frog Potential Dispersal Corridors

## 5 PROJECT TEAM

Preparation of this Fauna Impact Statement was undertaken by Australian Museum Business Services for the Olympic Co-ordination Authority. The text was prepared by Dr H.G. Cogger, in large part from text and data existing in Fauna Impact Statements previously prepared by AMBS (Greer 1994; Pyke 1995) for the same site but under earlier development proposals.

The data in this FIS derive from field surveys of frogs carried out since 1992 by Dr Allen Greer, Dr. Arthur White, Ms. Michelle Christy and Dr. Graham Pyke. Members of the NSW Frog and Tadpole Study Group provided additional records of the species from the study area.

## **6 DIRECTOR-GENERAL'S REQUIREMENTS FOR THE CONDUCT OF THIS FIS AND THE DEVELOPER'S RESPONSES TO MEETING THOSE REQUIREMENTS.**

Some of the requirements of an FIS are listed in Section 92D of the *National Parks and Wildlife Act (1974)* as amended by the *Endangered Fauna (Interim Protection) Act (1995)*. This Act also enables the Director-General of National Parks and Wildlife Service to impose additional requirements in response to written advice concerning a proposed development or activity.

The full requirements of the Director-General of National Parks and Wildlife Service for the conduct of this FIS were issued on 12 October, 1995. In the remainder of this section the Director-Generals requirements are listed in sequence, in italics, and the Developer's response to meeting these requirements follows each in turn.

The Director-General advised that '*the Fauna Impact Statement (FIS) must meet all of the requirements of section 92D(1) of the National Parks and Wildlife Act, (1974) as amended by the Endangered Fauna (Interim Protection) Act (1995). Pursuant to section 92D(3), and in addition to the basic requirements set out in section 92D(1), (which are repeated below in bold lettering), I require the following:*

### **6.1 REPORT REQUIREMENTS**

**"92D(1) A Fauna Impact Statement must:**

a) **be in writing; and"**

**RESPONSE:** this requirement has been fully complied with.

b) **be signed by the person who prepared it; and"**

**RESPONSE:** this requirement has been fully complied with. (Certification page 2).

c) **include to the fullest extent reasonably practicable, the following;"**

### **6.2 DESCRIPTION OF THE FAUNA**

**"i full description of the fauna to be affected by the actions and the habitat used by the fauna;"**

**RESPONSE:** Previous studies, including surveys of the study area (Greer 1994; Pyke 1995) have shown conclusively that only two endangered species of fauna (i.e. species listed on Schedule 12 of the *National Parks and Wildlife Act, (1974)* as amended by the *Endangered Fauna (Interim Protection) Act (1995)* are currently known to occur in the study area: the Green and Golden Bell Frog (*Litoria aurea*) and the Osprey (*Pandion haliaetus*). These two studies concluded that because the Osprey is a casual visitor to the study area, and does not utilise the area as permanent or critical habitat, any proposed developments in the study area will not have any deleterious impacts on local, regional or statewide populations of this species.



Consequently the remainder of this FIS confines its attention to the only endangered species in the study area on which the proposed developments have the potential to impact significantly, viz. the Green and Golden Bell Frog (*Litoria aurea*).

The habitat occupied by, or utilised by the Green and Golden Bell Frog in the study area has been defined in detail elsewhere (Greer 1994; Pyke 1995), and may be summarised as follows:

All known sightings of individuals specimens of Green and Golden Bell Frog in the study area are shown in Figure 7. Because surveys have now been conducted on a regular basis since 1992, it is reasonable to assume that areas from which Green and Golden Bell Frogs have not been recorded constitute unsuitable, or at best marginal habitat for the species. However a characteristic feature in the behaviour of this species (as with many other species of frogs) are dispersal events associated with certain conjunctions of climatic conditions, usually those associated with extensive rainfall in warm weather during the period from late spring to early autumn, but especially following summer storms.

Two kinds of dispersal events may be identified: those by adult individuals seeking new areas to colonise, especially permanent or ephemeral breeding sites, and those by metamorphlings leaving their home ponds to seek suitable long-term habitat. These two types of events may coincide during the later phases of the reproductive season.

Consequently for the Green and Golden Bell Frog, the study area contains a variety of environments which fall into three broad habitat categories:

- a) **“Core habitat”**, which may be defined as permanent or long-term habitat in which frogs are usually present at all times of year; such habitat, which includes most successful breeding sites, is essential to the long-term survival of the species and carries relatively low risk for frogs occupying such habitat.
- b) **“Ephemeral habitat”**, which may be defined as that which, because for long periods conditions are inimical to the frog's survival, cannot sustain a permanent frog population. Such habitat may be utilised (perhaps because of temporary ground cover) as dispersal routes between areas of core habitat, or it may provide temporary breeding sites after extensive rain. However occupation of this habitat, whether for dispersal or breeding, carries medium to high risks for the frog because it is usually subject to rapid desiccation when rain ceases, leaving metamorphosed frogs isolated from suitable long-term habitat, and breeding sites liable to drying out before tadpoles can complete their development through metamorphosis.
- c) **“Inimical habitat”**, which may be defined as those environments from which frogs have not been recorded despite several years of field survey, and which on the basis of existing knowledge of the biology and ecology of the Green and Golden Bell Frog it can be assumed constitute areas of habitat in which the frog is unable to survive. Nevertheless such habitats may be utilised for both dispersal and breeding when climatic conditions are especially favourable, although the survival chances for any frogs utilising these habitats are probably very small, i.e. these constitute very high risk areas for individual frogs.

The distribution of these three broad categories of habitat is shown in Figure 6.

### 6.3 FAUNA SURVEY REQUIREMENTS

"In addition to this requirement::

- "a fauna survey is required to be conducted in the area proposed for the development and surrounding areas likely to contribute to fauna habitat (study area). Sampling methodology should specifically target endangered species known or likely to occur in the study area. This will include but is not restricted to the:  
Green and Golden Bell Frog *Litoria aurea*  
Previous fauna studies may be incorporated as part of this work."

**RESPONSE:** As indicated in previous FISs covering the areas which constitute the present study area (Greer 1994; Pyke 1995), extensive surveys have been conducted across the entire study area since 1992 for all fauna, including Schedule 12 species. These FISs, and the surveys on which they were based, concluded that the only endangered species impacted upon by the proposed developments in the study area is the Green and Golden Bell Frog (*Litoria aurea*).

- "a full description of the methodology used in the fauna survey (eg. dates of survey, weather conditions, number of traps, configuration of traps etc.). Identification of reptiles, frogs and bats should be confirmed by a recognised authority (eg. Australian Museum) for species of taxonomic uncertainty."

**RESPONSE:** Details of all surveys, including methodologies, on which this FIS are based were detailed in previous FISs already cited above (Greer 1994; Pyke 1995).

In relation to the Green and Golden Bell Frog, these details may be summarised as follows:

In 1994 Dr Allen Greer reported that a total of approximately 27.5 person hours had been spent surveying *Litoria aurea* in the brickpit at Homebush Bay. Site visits were made on 12 and 27 May, 11 and 28 June, 22 July, 5 and 16 August, 2 and 13 September, 16, 20, and 29 October, 12, 16, 19, 21, 26 November, 7, 10, 12, 13 December 1993. Site visits were conducted during both the day and the evening, and in both clear weather and during and after rain.

The method of searching was to walk through the entire site looking for both exposed and sheltering frogs, listening for calling males, and searching water bodies for eggs and tadpoles. Only the most superficial terrestrial shelter sites could be examined, and these sites represented only a tiny fraction of the huge number of places where frogs could have been hiding. Therefore, counts based on both exposed and uncovered frogs are likely to seriously underestimate the total number of frogs at any one time.

Furthermore, in that ideal conditions for calling males were not encountered (severe thunder and lightning storms with heavy rain followed by warm, humid and still conditions), the maximum number of males heard calling at any one time is likely to have underestimated the total number of mature males present.

The highest count for frogs for a particular part of the brickpit prior to the appearance of the 1993/94 season's metamorphs was taken as the minimum likely number of frogs in that area for the period up until the appearance of the 1993/94 metamorphs. It was also assumed that the number of mature females equals the number of calling males heard at any one time, and that the frequency of immatures (42 percent) and matures (58 percent) in a total of 24 frogs counted on



Figure 8 Map Showing Distribution of Artificial Ponds

one survey on 20 October, 1993 before the 1993/94 season's metamorphs had appeared and when age cohorts were still evident, was indicative of the ratio for both the whole and any subsection of the population just prior to the 1993/94 recruitment of this life stage.

The largest number of transformed individuals seen on one sweep of the brickpit prior to the appearance of the 1993/94 metamorphs was 32, on 12 November. Although age cohorts were no longer evident at this time, using the percentages in the preceding paragraph, at least 18 of these may have been adult. The largest number of calling males (counted in a two day period, 19 and 21 November, in separate sections of the brickpit) was 23–28. Under the assumption that the number of mature females equals the number of mature males, this would indicate a breeding population of 46–56. The largest number of transformed individuals seen on one sweep of the brickpit after the 1992/93 metamorphs had appeared was 39 on 26 November (12 of the 39 metamorphs — 31 % — had just transformed). The largest number of tadpoles seen in any one pool is conservatively estimated at 100 (most northerly pool on level 2 on 12 December; (Greer 1994 fig. 6 F).

It was Dr Greer's impression that a conservative estimate of the total number of adult *Litoria aurea* in the brickpit at the beginning of a spring/summer breeding season such as occurred in late 1993 would be in the order of the mid-tens to low hundreds, say, between 55 and 110.

The total number of adult *Litoria aurea* found in the Homebush Bay area exclusive of the brickpit in the entire time that Dr Greer was working in the area (see Greer 1994 Appendix 2) was between 42 and 51. Taking 50 as the number seen but assuming that less than half the adults may have been detected, a range of 50–100 adults outside the brickpit was considered to be a reasonable estimate. Most of the individuals detected were in small pockets of habitat and many of these pockets are slated for development.

Combining the estimates for both inside and outside the brickpit, the total number of adult frogs at the beginning of the 1993/94 activity season for the entire Homebush Bay area was estimated to be in the order of 100 to 200.

Subsequently further surveys of the Homebush Bay Development Area, but excluding the brickpit, and targeted at the Green and Golden Bell Frog, were carried out by Dr. Arthur White during November and December 1994 and during January and February 1995.

The areas covered by these surveys are shown in Pyke (1995, figure 16). They include all sites considered to be possible or likely locations where the Green and Golden Bell Frog might occur.

Identification of frogs was based mostly on visual inspection and no specimens were collected. Identification was also based on the unique nature of the call of the species whenever they were heard calling.

Rainfall before and during the frog surveys had a significant effect on the results obtained. Very little rain had fallen in the study period for many months before the first of Dr White's surveys was carried out on 10 November 1994. At this time much of NSW was declared to be drought affected and conditions throughout the Homebush Bay Development Area were very dry.

A little local rain fell between this survey and the second on 14 November 1994. General conditions, however, remained dry for this second survey. The third survey on 4 December 1994 followed reasonably heavy rain over the previous two days. It was not, however, until the first two



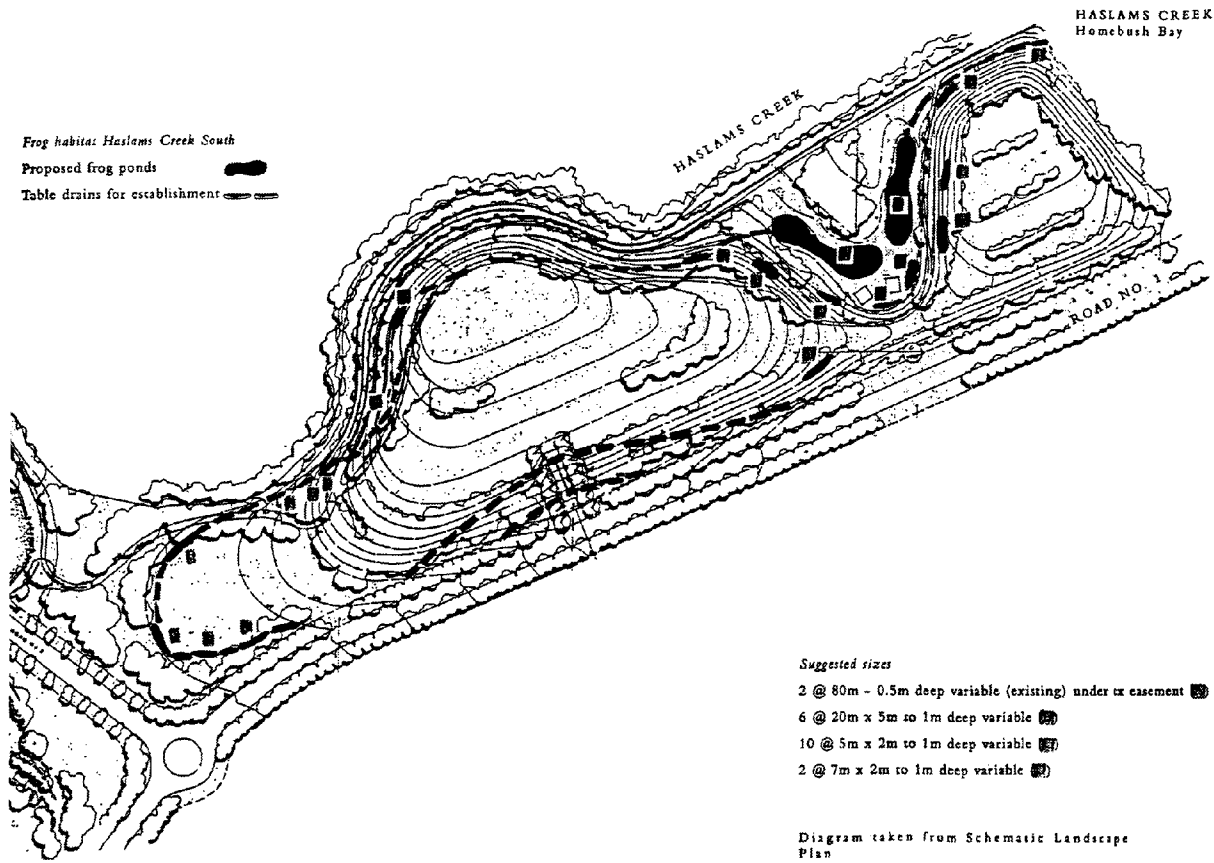


Figure 9 Specifications (diagrammatic) of pond design and layout

weeks of January 1995 that there was consistent heavy rainfall in the area. The fourth survey followed this rainfall and took place over the two day period of 13 and 14 January 1995. Early in February the area experienced another two weeks of regular showers and drizzle. The final survey followed this period and occurred on 17 February 1995.

Survey methodology included daytime searches by hand looking for sheltering or basking frogs, nighttime searches for calling frogs, and the use of broadcasting prerecorded calls of the species in attempts to elicit calling by male frogs that are present (the so-called 'playback technique').

Details of frog surveys in terms of times of day, methods employed and weather conditions at the time are presented in Pyke (1995, Table 1).

In addition, during the 1994/95 summer, a number of observations of Green and Golden Bell Frogs in the study area were obtained opportunistically by Drs. Allen Greer, Graham Pyke and Arthur White, Ms. Michelle Christy and members of the NSW Frog and Tadpole Study Group.

#### 6.4 WATER QUALITY

- *"any description of Litoria aurea habitat should include an assessment of the water quality (heavy mineral contents, level of contaminants etc)."*

**RESPONSE:** Because the brickpit constitutes core habitat for the Green and Golden Bell Frog in the study area, including core breeding habitat, quantitative water quality assessment has been largely confined to the water bodies (temporary and permanent) within the brickpit. Breeding has occasionally taken place in ephemeral bodies of water in areas classed as ephemeral habitat in section 7.2 above, but these constitute marginal, high-risk habitat.

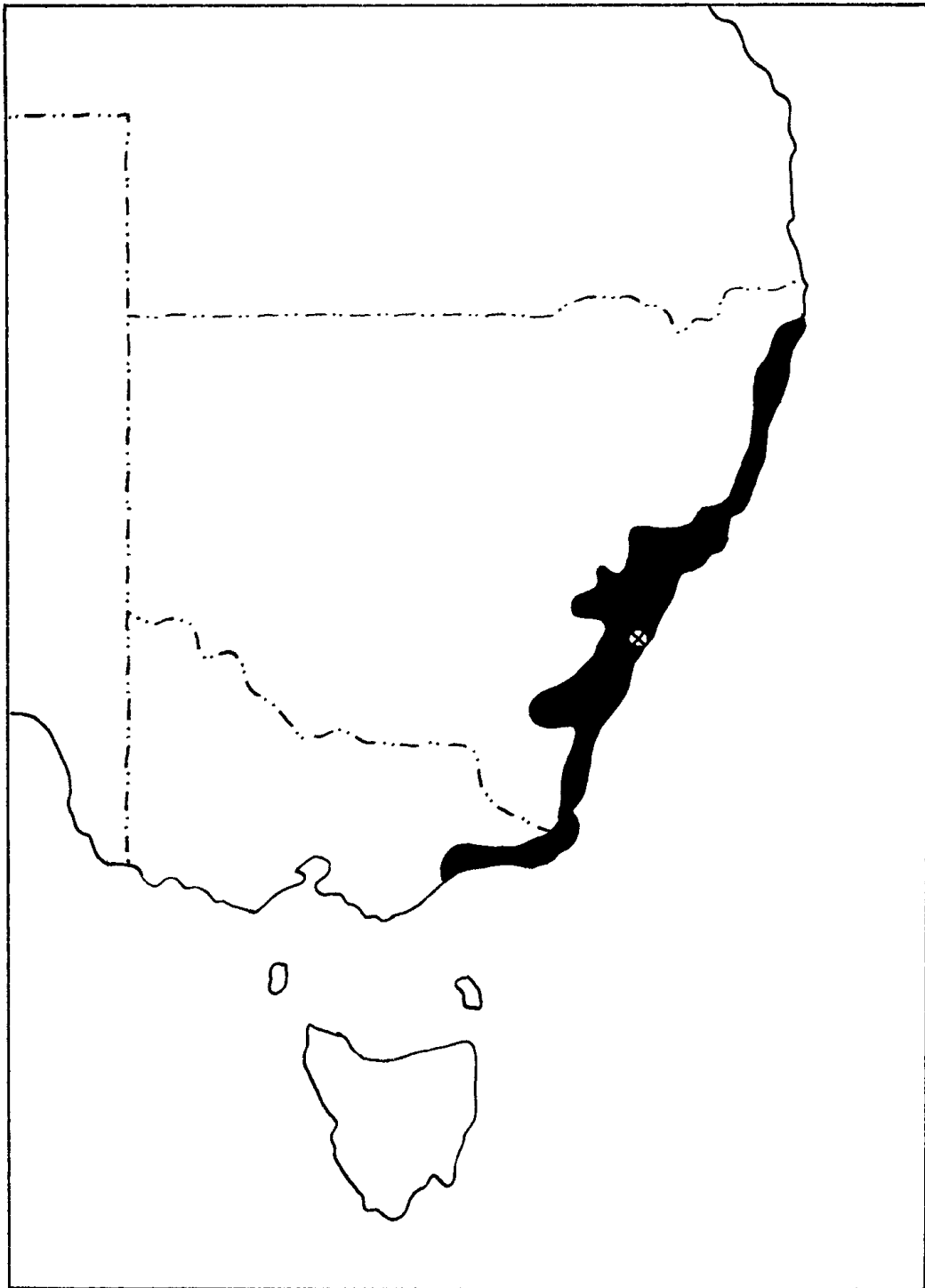
A water quality monitoring program is proposed for the newly-created ponds shown in Figure 9, so that direct comparisons may be made (and actions taken to modify water quality as necessary in these ponds) with water quality in the brickpit water bodies in which successful breeding occurs.

Water quality in the brickpit ponds, as determined by Greer (1994) may be summarised as follows:

Water enters the brickpit via: rain; surface run off, and ground water seepage along the natural fissures in the shale walls of the mezzanine and level 1 (figure 6 in Greer 1994) and in the sandstone walls of levels 2 and 3. Water leaves the brickpit by natural evaporation and by two artificial pumping stations, one on level 1 and the other on level 3. Pumping on level 1, which is automatic from a sump hole cut into the sandstone bedrock, almost certainly hastens the drying of surface water on level 1. Pumping on level 3, which is manually activated, hastens the drying out of level 3 (Greer 1994 fig. 6 G-H) and thereby leads to the increased concentration of the salts of the remaining water which can become highly conductive (up to 38.5 millisiemens). If all pumping were to cease, it is not clear what water levels would be achieved on either levels 1 or 3.

The survey of the water quality in the brickpit has shown that:

- i "there is no evidence in the measured concentrations of ammonia, nitrate or phenols of contamination by landfill leachate";
- ii "heavy metals are uniformly below the quoted reporting (detectable) limits", i.e., As < 0.01 mg/l; Cd < 0.005 mg/l; Cr < 0.01 mg/l; Cu < 0.01 mg/l; Hg < 0.0001 mg/l; Pb < 0.01 mg/l, and Zn < 0.05 mg/l;



- Distribution of the Green and Golden Bell frog within Australia
- ⊗ The approximate position of the Homebush Bay Olympic Site

Figure 10 State-wide distribution of *Litoria aurea*



- iii conductivity measurements (an indicator of salinity) vary from 1.3–38.5 millisiemens (sea water is about 50 millisiemens), and
- iv the salinity arises from the groundwater passing through rock and not from infiltration from the nearby brackish water bodies (Jewell, 1993).

It may be noted that adult frogs have been found in water bodies in the brickpit with conductivities as high as 16 millisiemens (C. Jewell and A. Greer, *pers. obs.*).

## 6.5 DISTRIBUTION AND HABITAT

- ii **“an assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them;”**

**RESPONSE:** Greer (1994) and Pyke (1995) have previously provided such assessments for the Green and Golden Bell Frog in relation to the study area, and these may be summarised as follows:

Previously the Green and Golden Bell Frog was common and widespread in and around the southern tablelands area of NSW and along the coast and ranges of eastern Australia from just south of the NSW-Queensland border to East Gippsland in Victoria (Cogger 1992; figure 10).

During the last two decades it has, however, disappeared throughout much of its range, especially in NSW, and it now appears to be restricted in NSW to only about 40 coastal locations (White & Pyke 1995). It is apparently extinct within the southern tablelands of NSW and there are no recent records in this State west of the coastal plain. During the last 5 years the species has been detected as far north as about Byron Bay and, in NSW, as far south as about Eden (White & Pyke 1995).

About half of the known sites in NSW where the species has been reported during the last 5 years are in the Sydney metropolitan area. Since 1990 the species has been reported from 19 such sites, of which the nearest to Homebush Bay is some 3-4 km distant, at Greenacre (White & Pyke 1995).

In relation to environmental pressures, the decline of the Green and Golden Bell Frog within NSW has apparently resulted from a number of factors. To date the factors which have been the most implicated are the introduction and spread of Mosquito Fish (*Gambusia affinis*), destruction of wetland habitat, modified patterns of water drainage, and pollution of water (White 1995). This decline appears to be continuing (White & Pyke 1995).

**“In addition to this requirement, further assessment should include:**

- ***a description of the local distribution and abundance of endangered fauna known or likely to occur in the study area, and any environmental pressures on them and their habitat.”***

**RESPONSE:** Greer (1994) reported that at that time *Litoria aurea* had been found or was known to have occurred recently at a number of scattered sites in the Homebush Bay area. At several sites calling males were heard, and these sites were presumed to be potential breeding sites. However, tadpoles and recently metamorphosed individuals, evidence of successful recruitment, have been found to date only at three sites on the State Government lands (Figure 7 and below). At several sites, often of marginal habitat quality, such as artificial drains and traps, gullies, and small isolated seeps and pools, only single or a few individuals, presumably transients, have been found. Many of these sites, including the three where breeding is known to occur, are slated for re-development.

At that time the number of adult individuals of *Litoria aurea* was difficult to estimate because ideal conditions for surveying calling males (the least disturbing method of surveying adults, assuming the number of females equals the number of males) were not experienced during the survey period. Greer (1994) reported that from experience at Homebush Bay in November 1992, these ideal conditions appear to include a severe thunder and lightning storm with heavy rain followed by warm temperatures, calm air, and nocturnal or cloudy conditions. The maximum number of individuals actually seen or heard to date at various localities in the Homebush Bay area are given in Figure 7. The total number of adult *L. aurea* likely to be in the brickpit at the beginning of the activity season (September) was estimated to be, conservatively, between 55 and 110 (see earlier discussion in Section 7.3 and Greer 1994, Appendix 2).

Within the brickpit, local densities can be very high. For example, in some of the dense stands of bulrushes, the density of frogs is in the order of  $1/m^2$ . In one remarkable instance, seven individuals were found under one piece of sheet timber approximately a metre square beside the transient pool next to the weather station on level 1 (Greer 1994 Figure. 7 D). The total number of adult *L. aurea* likely to be at all other localities at Homebush (i.e. exclusive of the brickpit) at the beginning of the 1993/94 activity season was thought to be, conservatively, between 50 and 100 (see Greer 1994, Appendix 2).

Of the sub-adult stages of the species, tadpoles have been found to date in the brickpit (all levels), the manure pond (Greer 1994 figure. 8 A) and 'Lake Domis' (Greer 1994 figure. 8 C-D), and 1993/94 metamorphs were found in the brickpit (levels 1 and 2) and 'Lake Domis'. Neither eggs nor amplexing (mating) adults were found during these surveys.

The fact that on the Commonwealth Government lands in Homebush Bay area, *Litoria aurea* males have been heard calling from small, transient bodies of freshwater which are apparently far from either permanent shelter or water, suggests that under ideal conditions, such as after heavy thunderstorms and prolonged warm temperatures, there may be a number of widely scattered sites at which breeding may be attempted.

Pyke (1995) reported that prior to his 1994/95 survey Green and Golden Bell Frogs had been recorded from 25 known locations outside of the brickpit (Pyke 1995 figure. 17). These observations were widely scattered throughout the Homebush Bay Development Area, and included five breeding records (sites 5, 7, 24, 25 & 27 in Pyke 1995 figure 17), with the remaining records being of sheltering, basking or moving frogs. Of this latter group of sites, two have been destroyed by past development (i.e., sites 22 & 29; Pyke 1995 figure. 17). In addition, one of the breeding sites (the 'Manure Pond') was bulldozed, and although it subsequently accumulated water again it is not known whether or not it is again suitable for breeding by this species.

From the many surveys of Green and Golden Bell Frogs in the brickpit (e.g., Greer 1994; Pyke & White, *unpubl. obs.*; Christy, *pers. comm.*), it is clear that the species has a relatively large and self-sustaining population in the brickpit. The species can always be found there and, over the course of a year, all stages in the life cycle are found there. It is also apparent that this population is the source of most or all frogs of the species which are found in the study area outside the brickpit (see below).

However, during the 1994/95 survey period reported on by Pyke (1995), Green and Golden Bell Frogs were detected at 12 sites within the Homebush Bay Development Area but outside of the brickpit (i.e., sites 2, 4, 7, 8, 11, 12, 14, 16, 18, 24, 25, 30; see Pyke 1995 Table 2 & figure. 17).

These sites included one new breeding site adjacent to the previous Manure Pond breeding site (i.e., site 24 adjacent to site 25; see Pyke 1995 Table 2). These sites also include 6 new sites where sheltering or moving frogs were observed (i.e., Pyke sites 8, 11, 12, 14, 16 & 18). These sites also include one at which a second breeding record was obtained (i.e., Pyke 1995 site 7) and 4 previously recorded sites for sheltering frogs (i.e., Pyke 1995 sites 2, 4, 25 & 30).

Pyke (1995) concluded that although the Green and Golden Bell Frog has been found throughout much of the area that is managed by the OCA outside the brickpit, the frogs which are found in this area do not apparently form a self-sustaining population. Most of the observations outside the brickpit have been of single individuals. At only one of these sites has the species been reliably found on more than one occasion (i.e., Pyke site 30). Furthermore, the species has not been detected during most visits to the known breeding sites, even after reasonable rainfall (Pyke 1995 Table 2). The one site outside the brickpit where the species can now be reliably found appears to be unsuitable for breeding by virtue of being permanent in nature rather than ephemeral (see below).

To date, metamorphling Green and Golden Bell Frogs (i.e., recently metamorphosed frogs which still have some visible tail) have been found outside the brickpit on only two occasions (i.e., Lake Domis during December 1993 and the tanks adjacent to the Manure Pond during February to April 1995) and so successful breeding outside of the brickpit is apparently a relatively rare event and unlikely to be sufficient to sustain the population of frogs found outside the brickpit.

It therefore appears that the presence of Green and Golden Bell Frogs outside the brickpit is primarily the result of emigration from the brickpit during warm, wet weather rather than of recruitment from, including reproduction by, populations residing outside the brickpit.

The species is known to have relatively strong dispersal abilities (White 1995) and has rapidly colonised suitable habitat outside the brickpit soon after such habitat was created despite the distances involved. One pond, which is referred to as the 'State Sports Centre Nutrient Pond', provides a good example of this impressive dispersal. This pond was created in late 1993 as a water detention pond at the edge of the golf driving range near Boundary Creek (Pyke 1995 figure 7). By March 1994 it had been colonised by adult Green and Golden Bell Frogs and at one time during the 1994/95 survey period there were at least 18 individuals of this species there (see table 2 in Pyke 1995). As no breeding by Green and Golden Bell Frogs has occurred in the State Sports Centre Nutrient Pond, all the Green and Golden Bell Frogs which have been found at this pond must have come from the brickpit, which is the nearest possible source and is about 700m away. To reach this pond these frogs must also have crossed over both Bennelong Road and Australia Ave.

It is not possible to accurately estimate the local abundance of Green and Golden Bell Frogs in any of the sub-areas at Homebush Bay. It is possible, however, to gain very rough estimates on the basis of how many are detected during surveys. That this number is only about 10-20% of the actual number of frogs present is suggested by observations made by Dr. Arthur White at another population of the species at Rosebery (see Cogger 1993; Fanning & White 1994 for details concerning this site). At this site the greatest number of Green and Golden Bell Frogs found during standard hand searches was only about five but, when much of the area which appeared to offer shelter for the frogs was excavated, 32 adult frogs were found (A. White, *pers. comm.*).

The number of adult Green and Golden Bell Frogs in the brickpit probably fluctuates between about 20-40 and about 250-500 depending on the season and how wet the previous several

months have been. At times during the recent drought, for example, extensive hand searches of the brickpit have yielded as few as 4 adults of the species (M. Christy, *pers. comm.*). On the other hand, after surveys carried out during a wetter period, Greer (1994) estimated that there were about 50 adults present. Multiplying these numbers by 5-10 gives abundance estimates of about 20-40 and 250-500 respectively.

The number of Green and Golden Bell Frogs outside the brickpit undoubtedly varies considerably with time of year and rainfall. However, this number must often exceed several hundred individuals. During the most recent hand surveys of the area, a maximum total of 49 adults of the species were found over a two-day period, including 5 road-killed individuals (i.e., 13-14 January 1995; see Table 2 in Pyke 1995). In addition, another 9 were found that had been killed by cars on Hill Road earlier on 6 January.

Given the difficulty in detecting all individuals in an area and the large size of the area in to which the frogs are dispersing, Pyke (1995) estimated that the actual number of adults of the species outside the brickpit was probably at least 10 times these numbers found.

During dry periods the number of Green and Golden Bell Frogs outside the brickpit would be expected to decrease with reduced emigration from the brickpit and increased mortality from desiccation, predators, cars and other factors. On the other hand, some individuals that reach and remain in favourable sites may survive there for a number of years.

Local environmental pressures outside the brickpit, resulting from continuing development of the area, are expected to reduce the extent of ephemeral habitat for the Green and Golden Bell Frog by approximately 13% and hence the abundance of the species in this area. Some of the sites where the species has been found are planned for destruction as part of the proposed development of the area and this will also reduce the opportunities for the species to disperse across the landscape (see below).

However, so long as the brickpit is adequately protected, and rehabilitated open spaces are developed which approximate the areas lost to development, then the proposed development outside the brickpit should have no long-term impact on the overall population of Green and Golden Bell Frogs at Homebush Bay. As discussed above, there is apparently no self-sustaining population of the species outside the brickpit and the great majority of the individuals found outside the brickpit are most likely to have originated in the brickpit and dispersed outwards.

- *“a description of the habitats and potential habitats of endangered fauna in the study area, describing habitat distribution within the study area and local distribution of these habitats. Habitat critical to essential behavioural patterns of the endangered species should be identified.”*

**RESPONSE:** As indicated in section 7.2 above, habitats utilised by the Green and Golden Bell Frog fall into two categories (Figure 6): core habitat and ephemeral habitat. The core habitat of the Green and Golden Bell Frog is almost entirely confined to the brickpit and its rim. This habitat has been described as follows by Greer (1994).

Over much of the first level of the brickpit there are scattered piles of debris and shallow bodies of freshwater of various size and permanence (Greer 1994 figure. 7). Much of the first level is also covered by grass and herbs and many of the water bodies have sedges. It is the vegetation-covered areas of the first level where most of the frogs have been found. The piles of debris and the rock crevices of the lower slopes of the pit walls probably provide shelter for the frogs, and the sedge-

filled ponds probably provide feeding and breeding sites. Scattered bits of 'trash' provide shelter on open ground away from vegetation and probably enhance movement of the frogs between areas of more suitable habitat. The widespread seeps and pools, and the scattered debris and trash in the brickpit are unsightly wasteland to many human observers, but they are 'home' for the frog.

The brickpit's open bodies of water are fed by rainwater, surface runoff, and ground water. Tests of the water in the pools shows that they range from about 1–2 millisiemens (very fresh) to about 38 millisiemens (approximately 75 percent of sea water).

The ephemeral habitat outside the brickpit, as previously indicated, consists of a wide variety of environments ranging from areas containing existing buildings, cleared earthworks, including pits and depressions which periodically hold rainwater and which are sparsely vegetated (often briefly, following rain) with exotic grasses and herbs, to remnants of native vegetation and saline wetlands adjoining Homebush Bay and Haslam's Creek. The distribution of these various habitat types is shown as open space in Figure 8, and all may be utilised by the Green and Golden Bell Frog during dispersal events, although none are known to constitute critical habitat, even for dispersal, because they are not believed to link one permanent population of Green and Golden Bell Frogs with another.

## 6.6 FAUNA CORRIDORS

- *"an assessment of dispersal or movement areas or routes of endangered fauna species known or likely to occur in the study area and any existing or future barriers to inter-breeding opportunities between populations of endangered fauna within the local area."*

**RESPONSE:** Surveys to date and limited recapture data from marked individuals of the Green and Golden Bell Frog have failed to identify unequivocal dispersal routes to or from the core habitat in the brickpit, although Pyke (1995) has used the term "dispersal corridors" to describe areas which, because of their ground cover and microclimate offer dispersing frogs a better chance of survival than other, more exposed areas. However it remains to be discovered, through appropriate monitoring of individual frog movements throughout the study area, whether frogs disperse from areas of permanent or breeding habitat in a random or non-random pattern.

However it is assumed that effective dispersal of frogs from one part of the study area to another will be limited to those open spaces maintained with natural vegetation and with the needs of the Green and Golden Bell Frog in mind. Such areas are shown in Figure 8, together with those developments proposed in the Masterplan which are likely to act as barriers to the dispersal of frogs along these corridors. The major barriers are:

- a) the Loop Road which circles the brickpit; this represents a major barrier to frogs dispersing from the brickpit to those open spaces to the north, northwest and east, but more especially to the new frog breeding ponds created between the brickpit and Haslam's Creek;
- b) the entire Urban Core, with its component developments; this area will form a continuous zone inimical to the survival of any frogs which invade or attempt to traverse the area;
- c) the new road on the southwestern boundary of the brickpit which links Underwood Road to Holker Street; this road will cross the open space between Haslam's Creek and the Urban Core and so has the potential to interfere with the movement of frogs between the frog breeding ponds created along the southern bank of Haslam's Creek.

The measures to be taken to ameliorate the effects of these dispersal barriers are discussed under section 7.8 below.

There is no known opportunity for Green and Golden Bell Frogs in the Homebush Bay area to interbreed with populations of this species elsewhere in the Sydney region.

## 6.7 DESCRIPTION OF ACTIONS AND EFFECT

iii "a description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term where long term encompasses the time required to regenerate essential habitat components;"

**RESPONSE:** As indicated in Figure 6 and table 1, in relation to the requirements of the Green and Golden Bell Frog the study area contains three categories of environments; each of these is discussed below with respect to requirement 92D(1)(iii) of the Director-General:

**Core Habitat:** As indicated in Figure 6, the core habitat of the Green and Golden Bell Frog is confined to the brickpit and its rim, and no actions currently proposed in the current site Masterplan will impinge directly on this core habitat. Under current S120 Licence conditions no development may take place in the brickpit until an equivalent or larger population of Green and Golden Bell Frogs is established in rehabilitated habitat established elsewhere in the study area. While such habitat is being established, and until monitoring of frog populations confirms that colonisation of this habitat has succeeded at the level specified above, the Olympic Co-ordination Authority has determined that no actions will take place in the brickpit, which is fenced and isolated from human activities other than those consistent with approved management plans for the frog population in the brickpit.

Under existing legislation any future developments within the brickpit, or impinging upon the brickpit environments and habitats, would require a separate Development Application, including a new Fauna Impact Study. Nevertheless developments adjacent to the brickpit could impact deleteriously on the frog populations in the brickpit unless measures are taken to ameliorate these impacts.

These ameliorative measures are dealt with in section 92D(1)(c)(iv) section 7.8 below, and will include:

- a) diversion of all runoff from the urban core to holding ponds.
- b) construction and on-going maintenance of a high cyclone wire fence (already in place) around the rim of the brickpit (as indicated in Figure 8).
- c) Entry to the brickpit, through locked gates, will be limited to essential maintenance personnel (subject to protocols) and those responsible for management of the Green and Golden Bell Frog population within the brickpit. Fencing adjacent to the urban core will be frog-proofed, to minimise the potential for dispersing frog to inadvertently directly enter this zone from the brickpit.
- d) Any artificial lighting on the perimeter of the urban core which could directly impinge upon the frog habitat in the brickpit will be shielded to prevent any floodlighting effects.
- e) Development of a Green and Golden Bell Frog management plan, including a monitoring program to detect any unexpected impacts, for the brickpit population of this species.

**Inimical Habitat:** A number of major developments are planned to occur in areas defined in Table 1 and Figure 2 as unused or unsuitable habitat or environments for Green and Golden Bell Frogs (i.e. no frogs have ever been found residing in these areas), but these will have no impact on the environment or behaviour of the Green and Golden Bell Frog. No ameliorative measures are proposed.

**Ephemeral Habitat:** In those areas outside the brickpit which represent ephemeral habitat (and viable dispersal routes) for the Green and Golden Bell Frog (Table 1) the proposed actions will have a permanent impact through elimination of part of this habitat, especially that to be taken up by developments in the Urban Core but also that ephemeral habitat lost to road construction.

The road network, when completed, will also have a periodic impact on the behavioural patterns of the Green and Golden Bell Frog by presenting potential physical barriers to dispersal. These impacts will apply only when climatic and other conditions combine to encourage frogs to disperse across the site, or to seek temporary pools in which to breed.

Consequently, the potential long- and short-term effects of the actions identified in Table 1 on the frog's environment and behaviour are as follows:

- destruction of three known past and potential breeding sites of the Green and Golden Bell Frog through development of the Urban Core;
- elimination of the movement corridor between the brickpit and these three breeding sites;
- disruption of the movement corridor between the brickpit and Haslam's Creek, and to areas further north and east by Parkways A1 and A2; and
- disruption of frog movement within the newly-created breeding pond complex on the south bank of Haslam's Creek by Avenue A4;

These impacts will reduce the medium-term availability of suitable habitat for the species outside the brickpit and will result in the deaths of individual frogs that are present as development proceeds. As a result, it is expected that there will be a reduction of the distribution and abundance of the species outside the brickpit until newly created or rehabilitated habitat becomes available and is colonised by natural dispersal from the core population in the brickpit or by translocation of frogs from elsewhere in the study area.

However, since no self-sustaining population apparently exists outside the brickpit, and it is proposed that there be no development within the brickpit precinct and that the brickpit will be protected by a buffer zone around it, the viability of the local population of Green and Golden Bell Frogs should not be compromised by the present proposal. The proposed development should therefore have no significant impact on the overall conservation status of the species within the Homebush Bay area.

**"In addition to this requirement:**

- *a description of the location, nature and extent of habitat degradation which may result from the proposed development and the likely effect on endangered fauna known or likely to occur in the study area.*
- *description of the possible effects of the development on species of endangered fauna known or likely to occur in the study area."*

**RESPONSE:** See response to the preceding Director-General's Requirement 92D(1)(iii), section 7.7.

- *"an assessment of the local distribution and abundance of Litoria aurea and the habitat to be affected by the proposed development."*



**RESPONSE:** An assessment of the local distribution and abundance of *Litoria aurea* has already been provided in response to the Director-General's requirement 92D(1)(ii), as has an assessment of the habitat to be affected by the proposed development.

- *"a description of the effects of the total destruction and/or removal of the population of Litoria aurea and how this would affect the local, regional and statewide distribution. Including the consideration of the population levels required to sustain the long-term survival of Litoria aurea populations on a local or regional scale, the need for genetic integration with other populations and the implication of the proposed actions on the long-term management requirements."*

**RESPONSE:** As indicated earlier in this report, the Green and Golden Bell Frog has apparently suffered a serious decline in range and numbers during the past four decades, so that it now exists as a series of geographically isolated remnant populations.

The Homebush Bay population is one of the most significant (in terms of population size) in the Sydney region and probably one of the more significant in the State.

Further, Greer (1994) pointed out that the brickpit population is likely to be very important, through emigration, in maintaining the size and genetic diversity of the smaller neighbouring populations within the Homebush Bay area. This may be especially important at times of environmental stress such as during severe drought when the peripheral populations could be reduced to very small size. Therefore the loss of the brickpit population without replacement would have a significant impact on not only the total number of frogs in the Homebush Bay area but also on the long-term viability of the other populations in the Homebush Bay area.

While destruction of the brickpit population would probably not lead to the immediate extirpation of the other Homebush Bay populations, the low number and frequency of successful reproductive events outside the brickpit would suggest that there is a very high probability that loss of the brickpit population would eventually lead to the extinction of the Green and Golden Bell Frog at Homebush Bay.

Considering the physical isolation of the Homebush Bay area due to the dense settlement of the surrounding region, it is unlikely that the loss of any population within the Homebush Bay area would have any effect on any other population either in the Sydney region or elsewhere. However, in that the brickpit population seems to be one of the largest populations in the Sydney region, its loss without replacement may be very significant to the long-term future of the species in the Sydney region. It would also mean the loss of a population large enough to provide for a long-term scientific study and public education, and for a seed stock for other areas.

It can be assumed that gene flow between geographically-isolated remnant populations is very low or non-existent, thus tending to reduce their genetic variability. Consequently, the effects of the total destruction of the Homebush Bay population of Green and Golden Bell Frogs are potentially twofold: it would eliminate one of the State's most important remaining populations of this endangered species and might well lead to an overall reduction in the State-wide genetic variability of the species. Further reductions in remaining populations of this species in NSW could also make the Homebush Bay population an important source of genetic material for maintaining genetic viability of other populations, despite the genetic distinctiveness of the Homebush Bay populations from some other populations in the Sydney region (Colgan, 1995).

## 6.8 AMELIORATION MEASURES

iv details of the measures to be taken to ameliorate the impacts;"

**RESPONSE:** the following measures are to be taken to ameliorate the impacts outlined in the preceding sections.

### 6.8.1 Barriers To Frog Dispersal/Movement

- a) the Loop Road (Parkways A1 and A2) which circles the northern and eastern rim of the brickpit represents a major barrier to frogs dispersing from the brickpit to those open spaces to the north, northwest and east, but more especially to the new frog breeding ponds created between the brickpit and Haslam's Creek

**Proposed amelioration:** It is proposed to ameliorate the impacts of the future road on frog movements between the brickpit and Haslam's Creek to the north by building underpasses potentially suitable for frog movement under the road and bicycle path (Figure 8). The precise number and location of these underpasses has not yet been determined. However it is anticipated that several will be constructed under these roads and that they will, in general, be located wherever there is a natural drainage line adjacent to the brickpit that goes from one side of the road to the other. These underpasses will be constructed according to design features which were presented in Appendix 2 of Pyke (1995), and will be accompanied by adjacent drift fences which will funnel dispersing frogs towards the mouths of the underpasses.

With these underpasses in place it is anticipated that movement by Green and Golden Bell Frogs should continue to occur between the vicinity of the brickpit and regions to the north. The monitoring program outlined in the original of this report will monitor the success of these underpasses and provide the necessary feedback for any modifications which might be required.

To prevent frogs from attempting to cross the roads that will run near to the brickpit, especially the Loop Road, and being at risk from passing vehicles, frog fencing will also be erected, as per guidelines specified in Pyke (1995), adjacent and parallel to all roads that run around the brickpit. It is proposed that this fencing will only be erected on the side of the roads facing the brickpit as available data suggest that most frog movement will be the result of emigration from the brickpit. As indicated above, these fences will also serve to 'funnel' any frogs which encounter them towards one of the underpasses.

- b) the entire Urban Core, with its component developments, will form a continuous zone inimical to the survival of any frogs which invade or attempt to traverse the area.

**Proposed amelioration:** Construction of a secure fence between the Urban Core and the brickpit. This fencing will be constructed to specifications which preclude entry by unauthorised persons and which will prevent the egress of Green and Golden Bell Frogs from the brickpit directly into the Urban Core.

- c) the new road on the southwestern boundary of the brickpit which links Underwood Road to Holker Street (particularly Avenue A4) will cross the open space between Haslam's Creek and the Urban Core and so has the potential to interfere with the movement of frogs between the frog breeding ponds created along the southern bank of Haslam's Creek.

**Proposed amelioration:** That part of Avenue A4 constructed between Haslam's Creek and the Showground Precinct will be built with a combination of underpasses and a bridge to ensure continuity of frog habitat along the southern bank of Haslam's Creek, linking those areas containing artificial ponds which have been constructed between the brickpit and Haslam's Creek.

### 6.8.2 *Direct Impacts Of Works On Resident Frogs*

In areas slated for development, proceeding earth and building works will not only destroy ephemeral frog habitat but could destroy any Green and Golden Bell Frogs sheltering on the site.

**Proposed amelioration:** It is intended to conduct surveys of each site immediately before development commences to remove as many as possible of Green and Golden Bell Frog frogs and tadpoles that might be residing on the site.

The following protocol will be adopted for removing frogs prior to development and subsequently maintaining them:

- i Areas that are within 50m of either the known breeding sites or the likely movement corridors and are scheduled for development will be targeted immediately before development proceeds (normally the week preceding, but timing will depend upon the availability of trained staff);
- ii Within the week immediately before development proceeds, each targeted area will be extensively hand-searched for Green and Golden Bell Frogs with excavation of likely shelter sites and all encountered frogs will be captured and retained;
- iii This intensive search and removal procedure will be repeated if weather conditions, including rain, are such as to encourage frog movements in the period between the initial survey and the commencement of development works; whether such conditions exist will be determined by movements being monitored in the brickpit management and monitoring program.
- iv All captured Green and Golden Bell Frogs will be released in newly-created or rehabilitated frog habitat in the study area or transferred, under protocols approved by the Australian Museum's Animal Care and Ethics Committee, to any Captive Breeding Program approved by the Director-General of National Parks and Wildlife Service.

### 6.8.3 *Securing The Integrity Of The Core Frog Habitat In The brickpit*

As indicated above, the brickpit represent the core habitat of the Green and Golden Bell Frog at Homebush Bay, and is the primary (if not the sole) source of recruitment of frogs to areas elsewhere in the Homebush Bay Development Area. For this reason, maintenance of the existing population of frogs in the brickpit is of paramount importance in the long-term conservation of the Green and Golden Bell Frog at Homebush Bay.

**Proposed amelioration:**

- a) diversion of all runoff from the urban core and other developments away from the brickpit to holding ponds.
- b) construction and on-going maintenance of a high cyclone wire fence (already in place) around the rim of the brickpit to form a buffer zone (as indicated in Figure 8).
- c) Entry to the brickpit, through locked gates, will be limited to essential maintenance personnel (subject to protocols) and those responsible for management of the Green and Golden Bell Frog population within the brickpit. Fencing adjacent to the urban core will be frog-proofed, to minimise the potential for dispersing frog to directly enter this zone from the brickpit.
- d) Any artificial lighting on the perimeter of the urban core which could directly impinge upon the frog habitat in the brickpit will be shielded to prevent any floodlighting effects.

- e) Development of a Green and Golden Bell Frog management plan for the brickpit population of this species, including a monitoring program to detect any unexpected impacts from adjacent works.
- f) erection of frog-proof fencing between the brickpit and any road that runs near its rim.
- g) temporary fencing to be constructed during road-building works adjacent to the brickpit to prevent the entry of spoil into the brickpit.

#### 6.8.4 *Creation Of New Breeding Habitat Outside The brickpit*

It is important to create new potential breeding habitat outside the brickpit for several reasons: to increase the total breeding habitat available to the Green and Golden Bell Frog at Homebush Bay and to provide a reserve of breeding frogs in the event of any catastrophic loss of the current brickpit population.

The creation of artificial habitat for the Green and Golden Bell Frog may also mitigate any impacts of future development within the brickpit as considered in the FIS prepared for the brickpit (Greer 1994) and the Decision Report prepared by the NSW National Parks and Wildlife Service in association with the section 120 licence granted for the site (NSW National Parks and Wildlife Service 1994b).

**Proposed amelioration:** The surveys carried out by Drs Graham Pyke and Arthur White of sites throughout NSW where the Green and Golden Bell Frog is known to have occurred have been utilised in preparing guidelines for the creation of artificial habitat for the species. (Appendix 1 in Pyke 1995).

At present it is planned to develop, using these guidelines, a total of about 20 artificial ponds suitable for breeding and long-term maintenance of the Green and Golden Bell Frog (Figure 9). Ten of these ponds (referred to as the Western Ponds) will be built just east of the large Western Water Quality Control Pond that is being developed to the north of the Waste Services facilities and south of Haslam's Creek. The other ten (referred to as the Gabion Ponds) will be built near the new gabion walls between the northwest corner of the brickpit precinct and Haslam's Creek.

It is also anticipated that additional frog breeding ponds (the "Eastern Ponds") will be developed around a future water retention pond to the north of the Loop Road and about 500m to the northeast of the Gabion Ponds.

#### 6.8.5 *Provision Of Movement/Dispersal Corridors*

As indicated above, the proposed developments in the study area will result in an overall reduction in the availability of ephemeral habitat for the Green and Golden Bell Frog. While much of the habitat lost will be replaced by rehabilitated habitat elsewhere in the Homebush Bay Development Area, the remaining open spaces become increasingly important as movement or dispersal corridors to allow frogs to colonise rehabilitated sites, whether for the first time or following periods of climatic conditions which result in a reduction in the total area of potential frog habitat.

**Proposed amelioration:** It is proposed to retain and/or develop several open-space zones as potential corridors suitable for movement by the Green and Golden Bell Frog as per the guidelines in Appendix 2 of Pyke (1995). These dispersal zones are shown in Figure 9.

### 6.8.6 Monitoring Programs

While all of the ameliorative measures identified above are designed to minimise the impacts of the Masterplan developments on the resident population of the endangered Green and Golden Bell Frog, the large number of variables involved makes it critical that the success of these ameliorative measures be monitored in order to take remedial action in the event of unexpected negative impacts.

**Proposed amelioration:** Implementation of monitoring programs to assess (a) the impacts of the Loop Road on the movement corridor between Haslam's Creek and the brickpit and the efficacy of the underpasses and drift fences; (b) the patterns of movement and reproduction of Green and Golden Bell Frogs within and outside the brickpit; (c) the impacts of the developments in the Urban Core on water quality in the brickpit; and (d) colonisation of, and reproductive success in the artificial breeding ponds.

## 6.9 HABITAT RESTORATION

"In addition to this requirement, detailed information should be provided on:

- *"any habitat restoration proposal for the study area, including the expected time taken to restore habitat, any proposals or opportunities to improve habitat and the likely impact on fauna, particularly during the time the habitat is being restored."*

**RESPONSE:** As already indicated above, there will be extensive habitat restoration to make all open spaces potentially available as habitat for the Green and Golden Bell Frog. In addition, new ponds have been constructed specifically in an attempt to provide additional permanent breeding sites for the Green and Golden Bell Frog along the southern bank of Haslam's Creek.

By conserving the core habitat of this species in the brickpit until all restoration works are completed and until the frog has successfully re-established itself in the restored habitats, there is not likely to be any significant impact on the Green and Golden Bell Frog during the time that habitat restoration is being carried out elsewhere in the study area.

- *"any measures proposed to reduce possible effects of the development on endangered fauna known or likely to occur in the study area."*

**RESPONSE:** The only endangered fauna impacted on by the proposed development is the Green and Golden Bell Frog (*Litoria aurea*). Measures proposed to reduce the possible effects of the development on this species are dealt with in section 7.8.

## 6.10 DISCUSSION OF OPTIONS

- *"a discussion of all the options available for the conservation of the population and habitat of Litoria aurea. These options should include leaving the population in situ and the relocation of the population."*

**RESPONSE:** All available evidence suggests that the population of Green and Golden Bell Frog on the study area is (a) isolated from other populations in the Sydney region and (b) self-sustaining only if the reproducing population occupying the core habitat in the brickpit is maintained. It therefore follows that conservation of the population and habitat of *Litoria aurea* at Homebush Bay ultimately depends either on maintaining and conserving the existing frog

habitat in the brickpit or creating new, rehabilitated habitat elsewhere in the study area which can be shown to maintain population levels and reproductive rates equivalent to or greater than those currently maintained in the brickpit.

Currently available data suggest strongly that Green and Golden Bell Frogs found outside the brickpit are dispersing individuals, mostly from the brickpit population, seeking to found new colonies wherever suitable conditions occur, whether ephemeral or permanent. The proposed monitoring program (see following section), involving the marking and recapture of all individual frogs encountered in the study area, aims to test the above assumptions.

#### 6.11 ON-GOING MONITORING OF AMELIORATIVE MEASURES

- “any proposed on-going monitoring of the effectiveness of those ameliorative measures.”

**RESPONSE:** As indicated in the previous section, it is proposed to put a monitoring program in place to monitor the efficacy of the range of ameliorative measures currently in place or still to be implemented. The monitoring program should achieve a number of objectives, but the two major ones are:

- a) a determination of the source(s) of dispersing frogs and whether frogs disperse in random or non-random patterns from such sources, and
- b) whether newly-created or rehabilitated frog habitat outside the brickpit is being effectively colonised and fully-utilised by Green and Golden Bell Frogs.

The monitoring program will comprise five separate but related components, viz:

- a) monitoring loop road and underpasses;
- b) monitoring frog movement patterns;
- c) monitoring populations in rehabilitated habitats;
- d) monitoring water quality in the brickpit;
- e) monitoring frog movements and reproduction in the brickpit.

The methods to be adopted in completing each of these components may be summarised as follows:

##### 6.11.1 *Monitoring Loop Road And Underpasses*

This component of the proposed monitoring program is based on the observation that the Green and Golden Bell Frog will readily make use of artificial shelter sites when encountered. Shelter sites consisting of square pieces of wood (1m x 1m) supported slightly above the ground with small bricks have been used extensively by the species around the State Sports Centre Nutrient Pond (see FIS) and within the brickpit (Christy, *pers. comm.*).

The design of this monitoring will be essentially as follows:

- i) Artificial shelter sites will be placed throughout those parts of the present movement corridor that should not be directly affected by development of the road and inspected at least once per week prior to the commencement of road development and immediately after any significant rain in the area.

This will provide baseline information on the extent to which this corridor is presently used as a movement corridor by the Green and Golden Bell Frog and on any patterns to this movement in terms of time of year or weather.

- ii Inspection of these shelter sites will continue through the development period of the road and for at least two years after the road is complete.  
This will enable comparisons between the periods before, during and after road development and hence provide a measure of the impact of the road with its underpasses.
- iii The underpasses will be inspected at the same times as the shelter sites.  
This will provide an indication of the extent to which the underpasses are used by the Green and Golden Bell Frog.

This component will involve a total of 50 shelter sites, placed along the likely dispersal route leading north from the brickpit to Haslam's Creek and the newly created ponds to the north of the brickpit (Figure 8). They will not, however, be placed within the area that will be directly affected by road works associated with the proposed road, but will instead be placed in two groups of 25 on either side of the proposed Loop Road.

Monitoring will involve regular inspection of:

- i these artificial shelter sites;
- ii any other shelter sites occurring along the corridor;
- iii the underpasses;
- iv the Loop Road and the area between the Loop Road and the frog fence;

Any frogs found will be examined, measured and sexed, if possible, and will receive a Transponder Tag for subsequent individual identification.

#### *6.11.2 Monitoring Frog Movement Pattern*

It is proposed to monitor remaining potential dispersal routes using the same approach and methodology as for the area likely to be affected by the Loop Road. In this case a total of 150 artificial shelter sites will be placed along the remaining dispersal corridors shown in Figure 8. The principal focus will be on the far northern route (75 shelter sites), because this corridor provides a potential avenue for movement between the newly created frog habitat just south of Haslam's Creek and known breeding locations to the north of Haslam's Creek (see Pyke 1995). The south-eastern zone, on the other hand, while providing the most likely means for frogs to get to the State Sports Centre Nutrient Pond, does not lead to any sites that are apparently suitable for breeding by the species. It will have 50 shelter sites. Similarly, the area bordering the southern boundary of the brickpit will have just 25 shelter sites.

#### *6.11.3 Monitoring Populations In Rehabilitated Habitats*

It is also proposed that the artificial breeding ponds and their surrounds will be monitored after they are completed. This should indicate the extent to which these ponds are able to support a population of Green and Golden Bell Frogs and also the extent to which this population is self-sustaining. This monitoring will be mostly by daytime hand searches for resting, basking or sheltering frogs and for eggs or tadpoles. Occasional night-time auditory surveys of the ponds when seasonal/climatic conditions are optimal will also be carried out to provide further indication of the levels of breeding activity.

It will be necessary to continue this monitoring until the degree of success of the ponds is clear or for the duration of the licence, whichever is the sooner.

This component of the proposed monitoring program will involve the same approach and methodology as adopted for the previous two components.



In this case it is initially proposed to employ a total of 250 artificial shelter sites, placed 10 at a time, around each of the newly-created frog ponds and around other pondage areas where the species is known or likely to occur. There are presently 16 newly-created ponds just south of Haslam's Creek, 3 pond areas north of Haslam's Creek (two of which have been used by the species for breeding), and 6 other pond areas south of Haslam's Creek (excluding the Manure Pond, Detention Pond and Lake Domis, all of which will be destroyed during the proposed development). This last group of ponds will not be monitored.

Further shelter sites will be placed around any additional artificial ponds as they are developed. Recorded during each inspection of these shelter sites and other nearby frog habitat the following will be:

- the water level for each water body;
- various properties of the water in each water body (e.g., pH, turbidity, temperature, ammonia, total nitrogen, total phosphorus);
- the densities of different microfauna and microflora present;
- numbers and locations of eggs, tadpoles or frogs;
- the size, sex and (if possible) identity of any frogs present;
- the behaviour exhibited by any frogs or tadpoles present.

In addition, any encountered Green and Golden Bell Frogs will be marked using the methodology described previously.

These data will provide important information in relation to how many frogs (or eggs or tadpoles) are present in each habitat area, where they came from (given that frogs throughout the study area will be marked for individual identification), and what they are doing there.

Besides constituting monitoring of the frog species outside the brickpit, this information will be fed back to the management program for the artificial habitat for the species in order to maximise its suitability for the species.

These data should also indicate the nature and extent of movement amongst the habitat areas outside the brickpit and, in conjunction with the separate monitoring program in the brickpit, the nature and extent of movement between the brickpit and areas outside the brickpit.

#### *6.11.4 Monitoring Water Quality In The brickpit*

It is proposed that the quality of the water in the brickpit will be monitored through regular measurements of the same water properties as carried out outside the brickpit. This will be done every month at an average of 10 locations (exact number depending on recent rainfall and water levels within the brickpit). This component of the monitoring program will be carried out mostly by Ms. Michelle Christy.

#### *6.11.5 Monitoring Frog Movements And Reproductive Activity/Success In The brickpit*

Monitoring of the brickpit is currently being carried out as a PhD project by Ms Michelle Christy.

It is proposed that the monitoring program described in this section be carried out initially for a period of 3 years, subject to annual review by an Expert Committee of frog specialists to be established in consultation with the National Parks and Wildlife Service, or for such period as

may be specified in S120 Licences issues by the Director-General of National Parks and Wildlife Service.

A protocol for the carrying out of this monitoring program has been prepared by Dr Graham Pyke and has been included in an Action Plan for the medium-term management and conservation of the Green and Golden Bell Frog at Homebush Bay prepared for the Olympic Co-ordination Authority by Australian Museum Business Services. A copy of this Action Plan is appended to this FIS as background information, together with the protocols and programs adopted for each action .

The proposed monitoring program has the following potential outcomes:

- i evaluation of the nature and extent of any impacts of the proposed development on the population of the Green and Golden Bell Frog at Homebush Bay;
  - ii valuation of the extent to which the development and maintenance of frog breeding habitat, frog movement corridors, road underpasses and frog-proof fences are successful;
  - iii modification of design parameters for frog breeding habitat, frog movement corridors, frog-proof fences and, to a very limited degree, the road underpasses.
- *"reference should be made to any alternative proposals and proposed habitat retention areas that would reduce the extent of any habitat degradation."*

**RESPONSE:** It is intended to retain the core habitat of the Green and Golden Bell Frog by physically isolating the frog's core habitat (the brickpit) and withholding all development within this area.

Indeed, existing S120 Licence conditions are aimed at ensuring that while proposed developments outside the brickpit will reduce the total area of ephemeral habitat available to this species, its core habitat in the brickpit will be maintained until reproducing frog populations are established in rehabilitated habitat elsewhere on the site.

- v **"details of the qualifications and experience in biological science and fauna management of the person preparing the statement and of any other person who has conducted research or investigations relied upon."**

**RESPONSE:** See appendix 7 in original report.

**"In addition to this requirement:**

- **all information cited, from which statements or conclusions are made, must be provided or fully referenced."**

**RESPONSE:** A full bibliography of sources and references cited has been included as section 9 of this report.

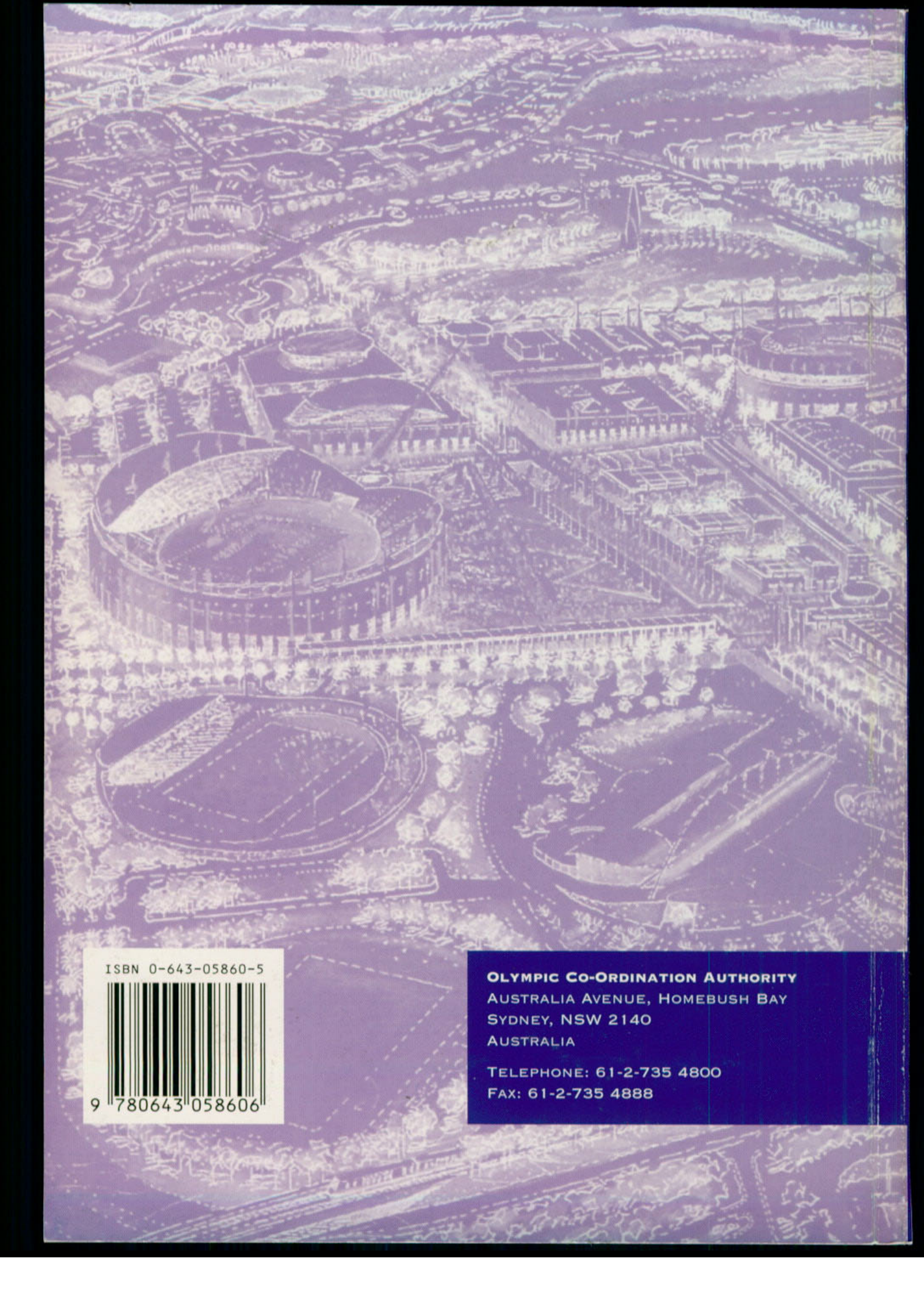
## **7 ACKNOWLEDGMENTS**

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