Wetland and migratory bird survey

Western Wildlife, October 2010. *Roe Highway Extension: Wetland and Migratory Bird Study, 2009 - 2010*. Unpublished report prepared for South Metro Connect, Perth, WA.

Appendix O

Wetland and migratory bird survey

Roe Highway Extension:

Wetland and Migratory Bird Study, 2009 - 2010

Yangebup Lake

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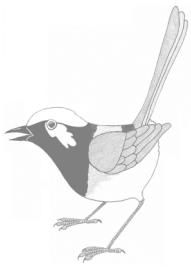

7th October 2010

EXECUTIVE SUMMARY

Introduction

Main Roads is proposing to extend Roe Highway from its current terminus at Kwinana Freeway to Stock Road in Coolbellup. The alignment falls between Bibra Lake and North Lake, two wetlands in the regionally significant Beeliar Wetland Chain. The Beeliar Wetland Chain is widely recognised as providing significant habitat for wetland birds on the Swan Coastal Plain.

This study was commissioned in order to assess the potential impacts that the proposed Roe Highway extension may have on the wetland and migratory birds of the wetlands in close proximity; Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp.

Methods

Bird surveys were carried out monthly from August 2009 to July 2010, with total counts of each wetland bird species obtained for 13 of the Beeliar Wetlands. The wetlands surveyed were Bibra Lake, Kogolup Lake, Horse Paddock Swamp, Lake Coogee, Fawcett Rd Wetland, Little Rush Lake, Manning Lake, Market Garden Swamp, North Lake, Lower Swamp (part of Roe Swamp and surrounding sumplands), South Lake, Thomsons Lake and Yangebup Lake.

To support the field study, a literature review was carried out. This included a review of relevant articles and 'grey literature', as well as extracts of bird records from three main databases; the Birds Australia Atlas Database, WetlandBase and the ScopeWest Database.

Three levels of conservation significance (CS) are used within this report to indicate the level of significance of wetland and migratory birds. Species of CS1 are those listed under the *Environment Protection and Biodiversity Conservation Act 1999* or the *Western Australian Wildlife Conservation Act 1950*. Species of CS2 are generally those listed as Priority species by the Department of Environment and Conservation (DEC). CS3 species are locally significant, and are generally those listed as declining on the Swan Coastal Plain in Bush Forever (Government of Western Australia 2000).

Results and discussion

There are 82 species of wetland bird likely to occur in the study area. Of these, 38 species have some level of conservation significance; 25 of CS1, three of CS2 and ten of CS3.

Small wetlands generally supported less species than larger wetlands, with the highest species richness at Thomsons Lake (71 species) and the lowest at Fawcett Rd Wetland (13 species). Overall, 30 species have been recorded breeding in the study area, with the highest number recorded from North Lake.

Bibra Lake, despite lacking formal recognition, is a highly significant wetland for waterbirds on the Swan Coastal Plain. Bibra Lake is a large wetland that is usually permanent, though in 2009 – 2010 it was mostly dry in February to May. Compared to other wetlands in the study area, Bibra Lake demonstrated high species richness, high maximum number of waterbirds (particularly in summer), high numbers of conservation significant species and a high number of breeding species. Bibra Lake only supports low counts of CS1 migratory shorebirds, but may support locally significant populations of two CS3 species; the Musk Duck and Dusky Moorhen. It has also supported high numbers of other CS3 duck species (the Australasian Shoveler, Pink-eared Duck and Hardhead) as it has large areas of open water.

North Lake is a moderately significant wetland on the Swan Coastal Plain, and it appears to have high significance as a breeding site. North Lake is a seasonal wetland that in 2009 – 2010 was mostly dry between January and May. Compared to other wetlands in the study area, North Lake demonstrated moderate species richness and maximum number of waterbirds, high numbers of conservation significant species and a high number of breeding species. North Lake also only supports a low number of CS1 migratory shorebirds.

Horse Paddock Swamp is of moderate significance to waterbirds on the Swan Coastal Plain. Horse Paddock Swamp is a small seasonal wetland that in 2009 – 2010 did not hold water, so this wetland was examined using historical data only. Compared to other wetlands in the study area, Horse Paddock Swamp demonstrated low species richness, a low total number of waterbirds, a low number of conservation significant species, a low number of CS1 migratory shorebirds and a low number of breeding species.

Lower Swamp is of moderate significance to waterbirds on the Swan Coastal Plain, at least as a breeding area. Lower Swamp is a small seasonal wetland that in 2009 – 2010 was mostly dry between December and July. It is the only open water within the Roe Swamp and surrounding sump-lands area. Compared to other wetlands in the study area, Lower Swamp demonstrated low species richness, a low total number of waterbirds, a low number of conservation significant species, a low number of CS1 migratory shorebirds and a moderate number of breeding species.

Potential impacts and mitigations

The potential impacts of the Roe Highway extension and possible mitigation strategies are summarised in Table 21. The main impacts considered were:

- Habitat loss
- The road as a barrier to movement
- Noise from road construction and traffic
- Artificial night lighting
- Road mortalities
- Traffic emissions and other pollution

Construction of the Roe Highway extension is likely to lead to the loss of some riparian woodlands and emergent rushes. Species most likely to be affected are those that roost and nest on wetland margins, including some conservation significant species.

A most waterbirds are highly mobile, the Roe Highway extension is generally not a barrier to waterbird movement. The only exceptions are ducks that walk their chicks from breeding sites (tree hollows in woodland) to the wetlands edge, and small passerines (perching birds) that inhabit emergent rushes. The provision of an underpass or bridge between the wetlands is likely to help mitigate any barrier effects.

Road noise may cause physiological stress to waterbirds, and may affect bird abundance, species richness and breeding within a zone that potentially encompasses the entirety of Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp, depending on the amount of traffic. The effects of traffic noise is likely to be mitigated to some extent by providing artificial barriers to noise along the highway extension, where it passes between wetlands.

Light spill from road lighting can have a range of effects on waterbirds, including distracting migratory birds, affecting prey abundance and influencing the timing of reproductive cycles. Although the impact of these effects on the status of bird populations is unclear, the precautionary approach suggests minimising light spill. Options range from dispensing with lighting altogether, placing lights at low heights and providing barriers between lights and the wetlands.

Although road mortalities may not influence the conservation status of waterbird species, they are still undesirable. Birds may be vulnerable to road mortalities if they walk or fly at low altitude across roads, or if they are attracted to foraging sites (e.g. damp grass) on road verges or median strips. Mitigation of road kills focuses on discouraging foraging along road edges and encouraging birds to fly over the height of the traffic by using a visual barrier.

Stormwater runoff into wetlands can potentially carry a range of pollutants into the water. This can have a negative effect on the plants and prey on which waterbirds feed, and on the waterbirds themselves from toxic effects. The best outcome is to prevent pollution from reaching the wetlands by treating any runoff before it drains into wetlands in the vicinity. This can be through the use of constructed treatment wetlands.

Conclusions

Bibra Lake is an important wetland for multiple reasons, and North Lake and Lower Swamp currently all have some value to waterbirds on the Swan Coastal Plain. Therefore, it is appropriate to minimise the impacts of the Roe Highway extension on these wetlands.

CS1 species (particularly migratory shorebirds) are generally uncommon in the wetlands adjacent to the Roe Highway extension. Although Bibra Lake supports a high number of migratory shorebird species, the number of individuals present is usually very low. Generally, the scale of impact on conservation significant species is thought to be negligible or low for a species if it only occurs as an occasional vagrant and the habitat present at the wetlands is not known to be important for that species.

Of more concern are species that have small population sizes, and that may use areas of shallow water and emergent rushes that may be impacted by the Roe Highway extension. This includes the Australasian Bittern (CS1) and Australian Little Bittern (CS2). Although neither species has been recorded in wetlands adjacent to the Roe Highway extension, they have been recorded in other wetlands in the study area and may occur in areas of suitable habitat (emergent rushes and shallow water).

Of the wetlands in close proximity to the highway extension, Bibra Lake in particular appears to have local significance to CS3 species. This is likely to be partly due to the large size of the wetland, the presence of breeding habitat (fringing vegetation and emergent rushes) and open water for duck species.

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1. INTRODUCTION

Currently, Roe Highway terminates at Kwinana Freeway in Jandakot. Main Roads is proposing to extend Roe Highway from its current terminus to Stock Road in Coolbellup. Although the majority of the proposed alignment will fall within the existing Primary Regional Road Reserve of the Metropolitan Regional Scheme, there is scope to move the alignment on to government-owned land in the section between The Kwinana Freeway and North Lake Road, if this is deemed more environmentally and socially acceptable.

The alignment falls between Bibra Lake and North Lake, two wetlands in the regionally significant Beeliar Wetland Chain. The Beeliar Wetland Chain is widely recognised as providing significant habitat for wetland birds on the Swan Coastal Plain.

1.1 Scope

This study was commissioned in order to assess the potential impacts that the proposed Roe Highway extension may have on the wetland and migratory birds of the wetlands in close proximity; Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp. Lower Swamp is part of Roe Swamp and its surrounding sumplands.

The study involved a literature review and a field study in order to collate existing data and collect current data on the status of wetland and migratory birds in the study area. The aim was to use the data gathered to inform a environmental impact assessment. Factors to be considered in the impact assessment included the potential effects that pollution, noise, light and road mortality may have on the wetland and migratory birds in proximity to the Roe Highway extension.

1.2 Definitions

1.2.1 Definition of 'wetland birds' and 'waterbirds'

For this report, wetland birds or waterbirds were deemed to be those that rely on wetlands for all or most of their needs. It generally excludes birds that are reliant on coastal ecosystems, and focuses on those species most likely to use the shallow near-coastal wetlands of the southern Swan Coastal Plain. Groups included are the following:

• Ducks and swans	(family Anatidae)
• Grebes	(family Podicipedidae)
• Darters	(family Anhingidae)
• Cormorants	(Family Phalacrocoracidae)
• Pelicans	(family Pelecanidae)
• Bitterns, egrets and herons	(Family Ardeidae)
• Ibis and spoonbils	(Family Threskiornithidae)
• Crakes, rails and allies	(Family Rallidae)
• Stilts and avocets	(Family Recurvirostridae)
• Plovers and dotterels	(Family Charadriidae)
• Godwits, sandpipers, stints and other shorebirds	(Family Scolopacidae)
• Gulls and terns	(Family Laridae)
• Eagles, harriers, kites and allies	(Family Accipiteridae)
• Acrocephalid warblers	(Family Acrocephalidae)
• Megalurid warblers	(Family Megaluridae)

Some members of these groups occur on the Swan Coastal Plain, but use coastal environments rather than freshwater wetlands, so have been excluded. In addition, unless recorded in the current study, vagrant species (for example, shorebirds that have been recorded only once on a wetland) have been excluded on the basis that the wetland is unlikely to be ecologically important for that species.

1.2.2 Definition of 'migratory birds'

For this report, migratory birds are those that are listed as 'Migratory' under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). Terrestrial migratory species have been excluded from this study.

1.2.3 Definition of 'shorebirds'

Shorebirds are generally considered to be the members of the families Charadriidae and Scolopacidae, so includes plovers, godwits, sandpipers, tattlers and stints. Shorebirds can be found on beaches, estuaries, saltwater and freshwater wetlands, with some species mainly preferring coastal environments, and others using a range of inland wetlands. Many shorebird species are international migrants, but some are sedentary or make movements within Australia.

1.2.4 Definition of 'migratory shorebirds'

In this report, the term 'migratory shorebirds' refers to shorebirds listed under the EPBC Act.

2. THE STUDY AREA – CONTEXT AND DESCRIPTION

As over 70% of wetlands have been lost or extensively modified in the past 150 years (Storey *et al*. 1993), all remaining wetlands have acquired an increased importance for conservation. The Beeliar Wetlands have important social and cultural values, as well as significant value for biodiversity conservation (CALM 2006). Of particular relevance to this study, the Beeliar Wetlands support a large diversity of wetland birds (CALM 2006).

The Beeliar Wetlands lie on the south-west Swan Coastal Plain. The Beeliar Wetlands stretch from Blue Gum Lake in the north to The Spectacles in the south, and are aligned in two chains parallel to the coast. The western chain of wetlands is situated in the Spearwood Dune System and lie in the depression between two limestone ridges. The eastern chain lies in a depression between the Spearwood Dune System and the Bassendean Dune System (CALM 2006).

The study area encompasses 13 wetlands of the Beeliar Wetland Chain (Table 1 and Figure 1). About half the wetlands are classified as lakes (permanently inundated basins) and half sumplands (seasonally inundated basins), though in dry years the lakes can have minimal or no water in late summer (pers. obs.).

Table 1. Description of the 13 wetlands surveyed in the study area.

Wetland	Type	Area (ha)	Salinity	Description
Bibra Lake	Lake	188.7	Fresh	Large, open wetland, usually with permanent open water. Fringing vegetation of rushes and woodlands. Open parkland on southern edge.
Horse Paddock Swamp	Lake	3.2	Fresh	Small, open wetland, usually with seasonal open water. Partly cleared.
Kogolup Lake	Sumpland	72.4	Fresh	Large, open wetland, usually with permanent open water. Fringing vegetation of rushes and woodlands.
Lake Coogee	Lake	62.9	Saline	Large, open wetland, usually with permanent open water. Fringing vegetation of samphire, rushes and woodlands.
Fawcett Rd Wetland	Sumpland	4.4	Fresh	Small, open wetland, usually with seasonal open water. Fringing vegetation of samphire, rushes and woodlands. Semi rural properties border the southwestern edge.
Little Rush Lake	Sumpland	11.2	Fresh	Medium, open wetland, usually with seasonal open water. Fringing vegetation of rushes and woodlands.
Manning Lake	Lake	14.9	Fresh	Medium, open wetland, usually with permanent open water. Fringing vegetation of rushes and woodlands.
Market Garden Swamp	Sumpland	4.8	Fresh	Small, densely vegetated wetland with some open water. Fringing vegetation of samphire, rushes and woodlands.
North Lake	Lake	24.6	Fresh	Medium, open wetland, usually with seasonal open water. Fringing vegetation of rushes and woodlands.
Lower Swamp	Sumpland	12.0	Fresh	Medium, densely vegetated wetland with little open water. Fringing vegetation of rushes and woodlands.
South Lake	Sumpland	31.5	Fresh	Medium, open wetland, usually with seasonal open water. Fringing vegetation of rushes and woodlands.
Thomsons Lake	Lake	244.3	Fresh to brackish	Large, open wetland, usually with seasonal open water. Fringing vegetation of rushes and woodlands.
Yangebup Lake	Lake	89.9	Fresh	Large, open wetland, usually with permanent open water. Fringing vegetation of rushes and woodlands.

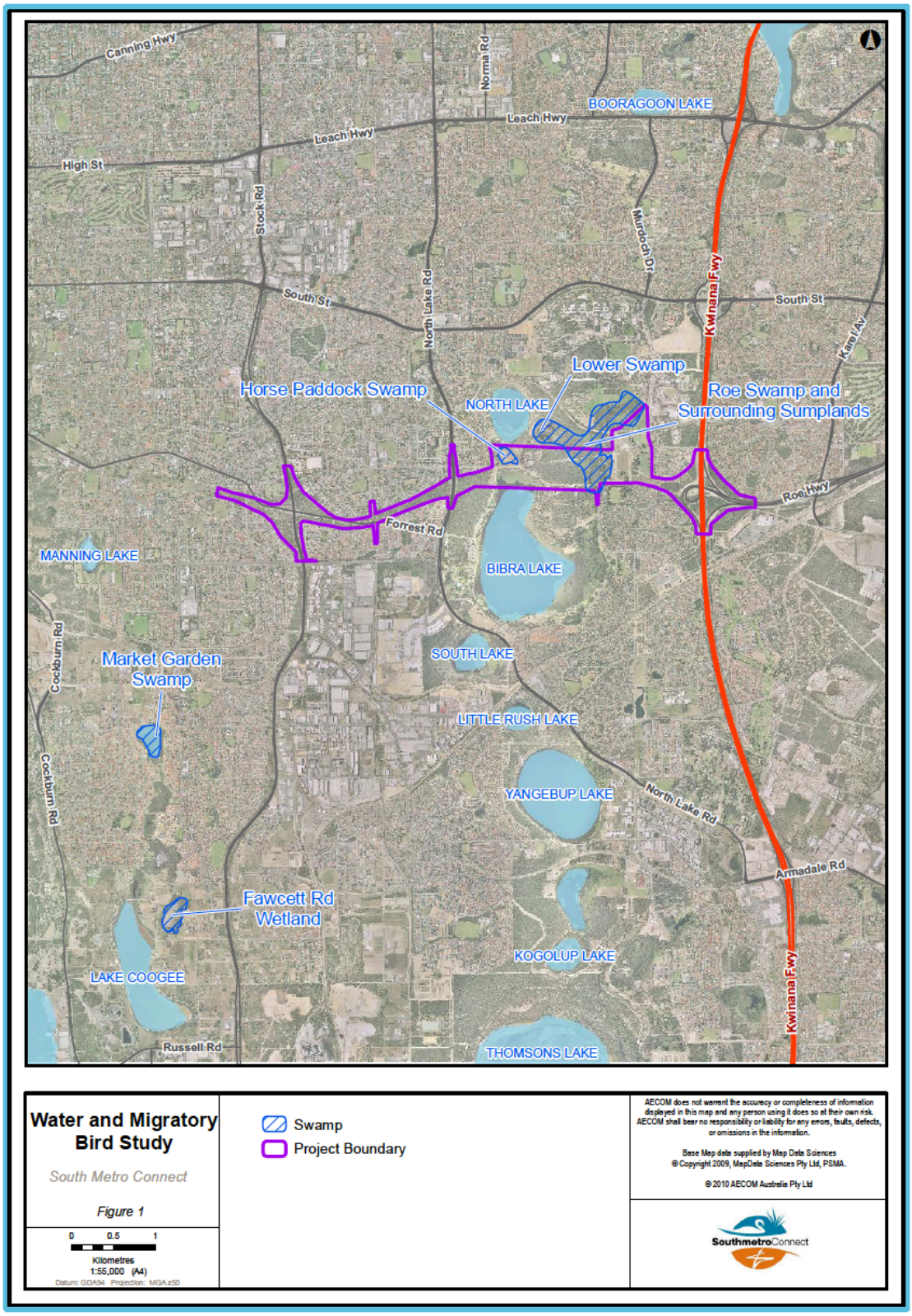

Figure 1. The wetlands in the study area.

3. METHODS

This study consisted of two main components, a field study of waterbirds in the study area, and a literature review in order to put the field study into context. A literature review is important, as wetland bird numbers can fluctuate both seasonally and from year to year.

3.1 Personnel

The personnel involved in the study, and their qualifications, were as follows:

- Ms Jenny Wilcox - *BSc. Biology and Environmental Science, Hons. Biology.*
- Dr Mike Craig - *BSc. Zoology, PhD. Zoology.*
- Mr Glenn Moore - *BSc. Zoology*.
- Mr Richard King - *BSc. Environmental Biology.*
- Ms Julie Raines – *BSc. Zoology, Hons. Zoology.*

J. Wilcox managed the project, co-ordinated the field surveys, and undertook the literature review. The field surveys were undertaken by J. Wilcox, M. Craig, G. Moore and R. King. Some data analysis was performed by J. Raines and G. Moore undertook some data gathering for the literature review.

3.2 Taxonomy and nomenclature

Taxonomy and nomenclature for bird species used in this report follow that given by Christidis and Boles (2008). Common names are used in the text, with the scientific names presented in Tables or in parentheses after the common name.

3.3 Waterbird surveys

Bird surveys were carried out at 13 of the Beeliar Wetlands. In order to obtain a 'snap-shot' of wetland and migratory bird abundance and species richness across a year, surveys were carried out monthly. The 12 surveys were undertaken from August 2009 to July 2010.

All 13 wetlands were surveyed on the same day, in order to reduce the error due to birds moving between wetlands between days. A total count of each species was recorded for each wetland, either by circumnavigating the wetland (in the case of densely vegetated wetlands where birds are hiding amongst vegetation) or by counting from several points around the wetland (open wetlands where birds are clearly visible). Where flocks of birds were very large, a count was obtained by counting a proportion of the flock, then estimating the total number of birds present.

3.4 Survey for road mortalities on Hope Rd

A survey was carried out on foot for the section of Hope Rd between Bibra Lake and North Lake. The aim of this survey was to identify the species of waterbirds that were subject to mortality on this road, identifying and counting any dead waterbirds encountered.

3.5 Literature review

An extensive literature review was carried out, and sources of information included published articles, books, government reports, database records and 'grey literature'.

The sources of bird records for each wetland are listed in Table 2. In order to develop a list of waterbird species likely to be present in the study area, the records collected in this study were supplemented by records from three main databases; the Birds Australia Atlas Database, WetlandBase and the ScopeWest Database held by Birds Australia Western Australia. The Birds Australia Atlas Database contains observational records and some counts of birds in Australia from 1998 to 2010, but these data do not contain systematic bird counts.

WetlandBase includes data from several sources, including the Department of Environment and Conservation (DEC) waterfowl counts from 1988 to 1992. These counts were of thirteen native and four introduced species of waterfowl and were undertaken in autumn and spring (Halse *et al*. 1995). WetlandBase also includes data from systematic waterbird counts carried out by the Royal Australasian Ornithologists Union (RAOU) in the 1980s.

The ScopeWest Database includes eight systematic waterbird counts from 1990 – 1992, and is reported on in Storey *et al*. (1993).

The literature review was focussed on the potential impacts that a highway development may have on wetland and migratory birds, and covered topics such as the impacts of light, noise, pollution and road mortality. Where possible, information used was restricted to the most relevant local or Australian sources, but international sources were also consulted.

3.6 Survey limitations

All fauna surveys have limitations. Factors that can affect the outcome of a field survey are indicated in Guidance Statement 56 (EPA 2004), and can include:

- Experience of fauna personnel
- Types of traps or other survey methods used
- Number of trapping sites
- Ability to survey all habitats present
- Availability of fauna information for the area in literature and on databases
- Effects of weather during the survey
- Seasonal effects
- Disturbance to site such as recent fires, cattle grazing.
- Ease of access to site

Birds may not be recorded because they are rare, they are difficult to observe due to their behaviour, or because they are only present on the site briefly. This study aimed to reduce these limitations by:

- Using zoologists that are experienced in bird identification
- Obtaining bird counts for entire wetlands
- Obtaining bird counts for numerous wetlands in the study area
- Surveying by circumnavigating wetlands where vegetation was dense, in order to count birds that may be hiding amongst vegetation
- Restricting surveys to clear days (not raining)
- Surveying monthly for a full year

The main limitation for this study is the amount of relevant information available in the literature. For example, while there are studies on the effects of road noise on birds, most of these studies are on passerines (rather than waterbirds) and are from international sources.

Table 2. Sources of bird records for each wetland.

Wetland	Source of records	Notes
Bibra Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	Bamford (2009)	From 29 surveys, June 1999 – Feb 2009.
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992.
Horse Paddock Swamp	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992. Wetland called 'Hope Rd Swamp'
Kogolup Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	Bamford (2009)	From 28 surveys, June 1999 – Feb 2009.
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992.
Lake Coogee	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	Ecoscape (2006)	From 42 surveys, Mar 1993 – Nov 1995.
	O'Brien Planning Consultants (1994)	Opportunistic presence/absence records.
Fawcett Rd Wetland	-	-
Little Rush Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
Manning Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
Market Garden Swamp	GHD (2009)	From 5 opportunistic surveys, Feb 2008 – Mar 2008.
	Ecoscape (2006)	From 4 surveys in 1994/1995.
North Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	Maddeford (2003)	Highest counts from surveys 1980 to 2002.
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992.
Lower Swamp	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992. Wetland called 'East Horse Paddock Swamp'
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
South Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
Thomson's Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	Bamford (2009)	From 28 surveys, June 1999 – Feb 2009.
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992.
Yangebup Lake	Birds Australia Atlas Database (2010)	Some presence/absence data and some count data, Aug 1998 – Mar 2010.
	Bamford (2009)	From 28 surveys, June 1999 – Feb 2009.
	WetlandBase	DEC waterfowl counts 1988 – 1992, & counts of waterbirds 1981 – 1988.
	Storey *et al*. (1993)	From 8 surveys, 1990 – 1992.

3.7 Assessing the conservation significance of bird species

Three levels of conservation significance are used within this report to indicate the level of significance of wetland and migratory birds.

3.7.1 Conservation Significance 1

Conservation Significance 1 (CS1) is the highest level of conservation significance, describing species that are protected under State or Commonwealth legislation. These species can be considered of national significance, and some species (e.g. migratory species) may be considered of international significance.

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Commonwealth Government's primary piece of environmental legislation. Listed under Part 3 of the EPBC Act are 'matters of National Environmental Significance'. These include threatened species, threatened ecological communities and migratory species. Proposed actions, such as mining or urban developments, that have the potential to significantly impact on a matter of National Environmental Significance must be referred to the Commonwealth Minister of Environment for assessment.

Fauna species are assessed against categories based on IUCN (International Union for Conservation of Nature) criteria, into:

- **Extinct**: Taxa not definitely located in the wild during the past 50 years.
- **Extinct in the Wild**: Taxa known to survive only in captivity.
- **Critically Endangered**: Taxa facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered**: Taxa facing a very high risk of extinction in the wild in the near future.
- **Vulnerable**: Taxa facing a very high risk of extinction in the wild in the medium-term future.
- **Conservation Dependent**: Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Only fauna classified as 'Extinct in the Wild' 'Critically Endangered', 'Endangered' or 'Vulnerable' are listed as matters of National Environmental Significance.

The migratory species listed under the EPBC Act are those recognised under the China-Australia Migratory Bird Agreement (CAMBA), the Japan-Australia Migratory Bird Agreement (JAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA), or species listed under the Bonn Convention for which Australia is a range state. Species listed in JAMBA are also protected under Schedule 3 of the *Western Australian Wildlife Conservation Act 1950*.

Reports on the conservation status of most vertebrate fauna species have been produced by the Department of the Environment, Water, Heritage and the Arts (DEHWA) in the form of Action Plans. An Action Plan is a review of the conservation status of taxonomic group against IUCN categories. An Action Plan was prepared for birds in 2000 (Garnett and Crowley 2000), so some information it contains may be out of date due to changes since publication.

The Western Australian Wildlife Conservation Act 1950 (WA Wildlife Conservation Act) is State legislation for fauna protection administered by the Department of Environment and Conservation (DEC). The WA Wildlife Conservation Act lists species under a set of Schedules:

- **Schedule 1:** Fauna that are rare or likely to become extinct.
- **Schedule 2:** Fauna presumed to be extinct.
- **Schedule 3:** Migratory birds that are listed under JAMBA.
- **Schedule 4:** Other specially protected fauna.

Schedule 1 species are further categorised by DEC into the categories 'Extinct', 'Extinct in the Wild', 'Critically Endangered', 'Endangered', 'Vulnerable' and 'Conservation Dependent' species.

3.7.2 Conservation Significance 2

Species of Conservation Significance 2 (CS2) are not listed under State or Commonwealth Acts, but are listed as Priority species by DEC. These species may be considered to be regionally significant. In Western Australia, DEC maintains a list of Priority Fauna made up of species that are not considered Threatened under *The Western Australian Wildlife Conservation Act 1950*, but for which DEC feels there is cause for concern. There are five levels of Priority as defined by DEC:

- **Priority 1:** Taxa with few, poorly known populations on threatened lands.
- **Priority 2:** Taxa with few, poorly known populations on conservation lands.
- **Priority 3:** Taxa with several, poorly known populations, some on conservation lands.
- **Priority 4:** Taxa in need of monitoring.
- **Priority 5:** Taxa in need of monitoring.

3.7.3 Conservation Significance 3

Conservation Significance 3 (CS3) species are not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DEC, but are considered of local significance. For example, a list of significant species on the Swan Coastal Plain is presented in Bush Forever (Government of Western Australia 2000). Also, birds may be of significance due to their patterns of distribution, as in the case of species that congregate or nest colonially in small areas.

3.8 Assessing the conservation significance of wetlands

A wetland may be important because it supports birds of conservation significance, it supports a large proportion of the global or national population of a bird species, it supports a large number of breeding birds or it supports a large total number of waterbirds. Important wetlands are often recognised in some way, such as listing as a Ramsar site, an Important Bird Area (IBA) or an Internationally important shorebird site. These are listed below.

3.8.1 Ramsar wetlands

The Ramsar Convention is an intergovernmental treaty that provides a framework for national action and international cooperation for the conservation and wise use of wetlands. Sites are selected that meet the 'criteria for identifying wetlands of international importance', and data is collected and presented on a Ramsar Information Sheet. Sites that meet the criteria are listed on a database held by Wetlands International, and in Australia, listed in the Australian Wetlands Database. Two of the criteria are directly related to waterbirds:

- Ramsar Criterion 5: "A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds."

- Ramsar Criterion 6: "A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird." Ramsar Convention Bureau 2000).

A wetland is deemed to regularly support a bird population of a given size if:

- the required number of birds are known to have occurred in two seasons out of three for which adequate data are available, or
- for the seasons in which the site is internationally important, the mean of the maximum count of the bird species, taken over at least five years, amounts to the required number.

3.8.2 Important Bird Areas

Birds Australia has been working with BirdLife International to identify Important Bird Areas (IBAs) across Australia, with 314 sites identified thus far. IBAs are sites of global conservation significance to birds. An IBA must meet four criteria as defined by BirdLife International. The IBA criterion of most pertinence to wetland and migratory birds is that for congregatory waterbirds:

- IBA Criterion 4i: "Site known or thought to hold, on a regular basis, more than 1% of a biogeographic population of a congregatory waterbird species"

The definition for 'regular' adopted by Wetlands International in Australia is similar to that of the Ramsar Convention above.

An IBA does not have any legislative protection, but the IBA process is a scientific method of identifying sites that are important for bird conservation. The IBA 1% global population criteria have been used in this report to determine whether any wetlands support a significant number of any shorebird species. These criteria are sourced from global waterbird numbers published in Delaney and Scott (2006), and are presented in Appendix 1.

3.8.3 Internationally important shorebird sites

In Australia, 118 sites have been recognised as being internationally important shorebird sites (Bamford *et al*. 2008). These are sites that meet Criterion 6 of the Ramsar Convention; (the 1% criteria are presented in Appendix 1). Bamford *et al*. (2008) also publish a 0.25% flyway population criterion for shorebirds on migration, though these are less relevant on the Swan Coastal Plain.

The migratory shorebirds that visit Australia are from the East Asian – Australasian (EAA) Flyway. The EAA Flyway includes Russia, Alaska, parts of south and east Asia, Australia and New Zealand. Some species occur only within this flyway, so the flyway and global population figures are the same. Other species occur in more than one flyway, so the population figures for the EAA Flyway are lower. Therefore, a species may not meet the 1% criterion for its global population, but it may meet or exceed the 1% criterion for the flyway population.

3.8.4 Nationally important shorebird sites

In 1993, a National Plan for Shorebird Conservation in Australia identified 201 sites of national importance to shorebirds, 90% of which also had international importance (Watkins 1993). The criteria used for identifying nationally important sites were that the site supported at least 1% of the Australian population of a shorebird (Watkins 1993).

3.9 Assessing potential impacts

The potential impact of the development is considered in terms of the importance of the project area to wetland and migratory birds, and the impacts on individual bird species of conservation significance. The severity of impacts depends on the nature of the impact, the characteristics of the project area and the characteristics of the bird species present.

The potential impact of the development on each conservation significant fauna species is categorised as:

- **Negligible:** no change in species population status.
- **Low:** population change/decline within project area but no change in population in the surrounding local area.
- **Moderate:** population change/decline/loss within the project area, some change/decline in population in the surrounding local area.
- **High:** population change/decline/loss in the project area, resulting in the change/decline/loss of population of the surrounding local area.
- **Extreme:** loss of species from the bioregion.

When estimating the potential impact on conservation significant fauna species, both the intrinsic characteristics of the species and the importance of the project area to the species are considered. Characteristics that make species more vulnerable to change include a small geographic distribution, a small total population, specialised habitat preferences and a poor ability to disperse. Species that are long-lived with few offspring, ground-dwelling, ground-nesting or are intolerant to human disturbance are also vulnerable.

Significant impacts on migratory shorebirds include the destruction, isolation or substantial modification of important areas of habitat, and/or the serious disruption of the lifecycle of an ecologically significant proportion of the population of a migratory species. Important habitat for a migratory species can include areas that are only used occasionally or periodically, but supports an ecologically significant proportion of the population. In the case of migratory shorebirds, this can include a site that is important during one or more of the breeding or non-breeding season, or as a staging area during northward or southward migration.

4. RESULTS AND DISCUSSION

4.1 Wetland and migratory birds of study area

Table 3 lists the 82 migratory and wetland birds likely to be present in the study area, and their conservation status. The list was compiled from a range of sources and includes records from 1981 to 2010. Some species appear on database lists for the Swan Coastal Plain, but have been excluded from Table 3 unless recorded at one of the wetlands sampled in this study (Appendix 2). The majority of these species rely almost entirely on coastal and estuarine environments such as beaches and intertidal mudflats, so are unlikely to occur on the Beeliar Wetlands, except as occasional vagrants.

Although most species in Table 3 are common on the Swan Coastal Plain, 38 species have some level of conservation significance. Of the conservation significant birds listed, there are 25 of CS1, three of CS2 and ten of CS3 (Table 3).

The species records for each of the 13 wetlands surveyed in this study are presented in Table 4. This Table includes not only the records from the surveys in 2009 – 2010, but also includes records from various sources spanning 1981 to 2010. Caution is required for interpreting Table 4, as some wetlands (notably Fawcett Rd Wetland) lacked historical data, so the total species count is likely to be low. Small wetlands such as Fawcett Rd Wetland and Lower Swamp generally supported less species than larger wetlands. The highest species richness was at Thomsons Lake (71 species) and the lowest at Fawcett Rd Wetland (13 species). Some vagrant species were included where the species was recorded during this study, or recorded in the sources in Table 2. Species that are in Table 4, but not included in Table 3 are the Radjah Shelduck (*Tadorna radjah*), Intermediate Egret (*Ardea intermedia*), Royal Spoonbill (*Platalea regia*) and Masked Lapwing (*Vanellus miles*). The distribution of these three species is in the north and east of Australia, and they do not normally occur on the Swan Coastal Plain.

The species recorded on each wetland in 2009 – 2010 and their mean counts are presented in Table 5. The mean count of all waterbirds on a survey is also given for each wetland. Bibra Lake had the highest mean monthly count, and Lower Swamp the lowest. In 2009 – 2010, the highest number of species was recorded at Bibra Lake (45 species) and the lowest at Horse Paddock Swamp (nil species).

Table 6 shows the highest single count of each bird species for each wetland. A sum of the maximum counts gives an indication of the minimum number of birds each wetland supported in the 12 month survey period, August 2009 – July 2010.

Breeding records are presented in Tables 7 and 8. Table 7 includes not only the records from the surveys in 2009 – 2010, but also includes records from various sources spanning 1981 to 2010. Again, care should be taken interpreting Table 7 due to the lack of data for some sites. Overall, 30 species have been recorded breeding in the study area, with the highest number recorded from North Lake. Table 8 shows the species recorded during the 2009 – 2010 surveys, and the maximum number of chicks observed on each wetland. Thirteen species were recorded breeding in 2009 – 2010, with the highest number recorded at Market Garden Swamp.

The ecology of each group of waterbirds in the study area have been discussed below, including notes on distribution, habitat preferences and extent of occurrence in the study area. Habitat preferences for each species are tabulated in Appendix 3. Within each group, the conservation significant species have been discussed in more detail.

Table 3. Wetland birds in the study area and their conservation significance.

Note: Note: VU = Vulnerable, NT = Near Threatened, LC = Least Concern, P4 = Priority 4, Int = Introduced species.

Species		Conservation Significance	Conservation Listings								
			EPBC ACT	JAMBA	CAMBA	ROKAMBA	Schedule 1	DEC Priority	IUCN Red List	Action Plan	Bush Forever
Anatidae (ducks and swans)											
Musk Duck	*Biziura lobata*	CS3									•
Freckled Duck	*Stictonetta naevosa*	CS3								LC	•
Black Swan	*Cygnus atratus*										
Australian Shelduck	*Tadorna tadornoides*										
Australian Wood Duck	*Chenonetta jubata*										
Pink-eared Duck	*Malacorhynchus membranaceus*	CS3									•
Australasian Shoveler	*Anas rhynchotis*	CS3									•
Grey Teal	*Anas gracilis*										
Chestnut Teal	*Anas castanea*										
Northern Mallard	*Anas platyrhynchos*	Int.									
Pacific Black Duck	*Anas superciliosa*										
Hardhead	*Aythya australis*	CS3									•
Blue-billed Duck	*Oxyura australis*	CS3							NT	LC	•
Muscovy Duck	*Cairina moschata*	Int.									
Domestic Goose	*Anser sp.*	Int.									
Podicipedidae (grebes)											
Australasian Grebe	*Tachybaptus novaehollandiae*										
Hoary-headed Grebe	*Poliocephalus poliocephalus*										
Great Crested Grebe	*Podiceps cristatus*										
Anhingidae (darter)											
Australasian Darter	*Anhinga novaehollandiae*										
Phalacrocoracidae (cormorants)											
Little Pied Cormorant	*Microcarbo melanoleucos*										
Great Cormorant	*Phalacrocorax carbo*										
Little Black Cormorant	*Phalacrocorax sulcirostris*										
Pied Cormorant	*Phalacrocorax varius*										
Pelecanidae (pelicans)											
Australian Pelican	*Pelecanus conspicillatus*										

Table 3. (cont.)

Species		Conservation Significance	Conservation Listings								
			EPBC ACT	JAMBA	CAMBA	ROKAMBA	Schedule 1	DEC Priority	IUCN Red List	Action Plan	Bush Forever
Ardeidae (bitterns, egrets and herons)											
Australasian Bittern	*Botaurus poiciloptilus*	CS1					VU		EN	VU	•
Australian Little Bittern	*Ixobrychus dubius*	CS2						P4		NT	•
White-necked Heron	*Ardea pacifica*										
Eastern Great Egret	*Ardea modesta*	CS1	•	•	•						
Cattle Egret	*Ardea ibis*	CS1	•	•	•						
White-faced Heron	*Egretta novaehollandiae*										
Little Egret	*Egretta garzetta*										
Nankeen Night-Heron	*Nycticorax caledonicus*	CS3									•
Threskiornithidae (ibis and spoonbills)											
Glossy Ibis	*Plegadis falcinellus*	CS1	•		•						
Australian White Ibis	*Threskiornis molucca*										
Straw-necked Ibis	*Threskiornis spinicollis*										
Yellow-billed Spoonbill	*Platalea flavipes*										
Accipitridae (eagles, harriers, kites and allies)											
Eastern Osprey	*Pandion cristatus*	CS1	•								
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	CS1	•		•						
Whistling Kite	*Haliastur sphenurus*	CS3									•
Swamp Harrier	*Circus approximans*										
Rallidae (crakes, rails and allies)											
Purple Swamphen	*Porphyrio porphyrio*										
Buff-banded Rail	*Gallirallus philippensis*										
Baillon's Crake	*Porzana pusilla*										
Australian Spotted Crake	*Porzana fluminea*										
Spotless Crake	*Porzana tabuensis*										
Black-tailed Native-hen	*Tribonyx ventralis*										
Dusky Moorhen	*Gallinula tenebrosa*	CS3									•
Eurasian Coot	*Fulica atra*										
Recurvirostridae (stilts and avocets)											
Black-winged Stilt	*Himantopus himantopus*										
Red-necked Avocet	*Recurvirostra novaehollandiae*										
Banded Stilt	*Cladorhynchus leucocephalus*										

Table 3. (cont.)

Species		Conservation Significance	Conservation Listings								
			EPBC ACT	JAMBA	CAMBA	ROKAMBA	Schedule 1	DEC Priority	IUCN Red List	Action Plan	Bush Forever
Charadriidae (plovers and dotterels)											
Pacific Golden Plover	*Pluvialis fulva*	CS1	•			•					•
Grey Plover	*Pluvialis squatarola*	CS1	•	•	•	•					
Little Ringed Plover	*Charadrius dubius*	CS1	•		•	•					•
Red-capped Plover	*Charadrius ruficapillus*										
Black-fronted Dotterel	*Elseyornis melanops*										
Hooded Plover	*Thinornis rubricollis*	CS2						P4	NT	NT	•
Red-kneed Dotterel	*Erythrogonys cinctus*	CS3									•
Masked Lapwing	*Vanellus miles*										
Scolopacidae (godwits, sandpipers, stints and allies)											
Black-tailed Godwit	*Limosa limosa*	CS1	•	•	•	•			NT		•
Bar-tailed Godwit	*Limosa lapponica*	CS1	•	•	•	•					•
Common Sandpiper	*Actitis hypoleucos*	CS1	•	•	•	•					•
Grey-tailed Tattler	*Tringa brevipes*	CS1	•	•	•	•					•
Common Greenshank	*Tringa nebularia*	CS1	•	•	•	•					•
Marsh Sandpiper	*Tringa stagnatilis*	CS1	•	•	•	•					•
Wood Sandpiper	*Tringa glareola*	CS1	•	•	•	•					•
Great Knot	*Calidris tenuirostris*	CS1	•	•	•	•					•
Red Knot	*Calidris canutus*	CS1	•	•	•	•					•
Red-necked Stint	*Calidris ruficollis*	CS1	•	•	•	•					•
Long-toed Stint	*Calidris subminuta*	CS1	•	•	•	•					•
Pectoral Sandpiper	*Calidris melanotos*	CS1	•	•		•					•
Sharp-tailed Sandpiper	*Calidris acuminata*	CS1	•	•	•	•					•
Curlew Sandpiper	*Calidris ferruginea*	CS1	•	•	•	•					•
Ruff (Reeve)	*Philomanchus pugnax*	CS1	•	•	•	•					•
Laridae (gulls and terns)											
Fairy Tern	*Sternula nereis*	CS2							VU	LC	
Gull-billed Tern	*Gelochelidon nilotica*										
Whiskered Tern	*Chlidonias hybrida*										
White-winged Black Tern	*Chlidonias leucopterus*	CS1	•	•	•	•					
Silver Gull	*Chroicocephalus novaehollandiae*										
Acrocephalidae											
Australian Reed-Warbler	*Acrocephalus australis*										
Megaluridae											
Little Grassbird	*Megalurus gramineus*										
Totals:	**82**	**38**	**25**	**20**	**22**	**20**	**1**	**2**	**5**	**6**	**30**

4.1.1 Ducks and swans

Family Anatidae is represented by 15 species in the study area, of which three are introduced and 12 native (Table 2). Ducks and the Black Swan are a numerically important and visually obvious component of waterbird communities on Swan Coastal Plain wetlands. In January 2010, over 9000 ducks and swans were counted on the wetlands in the study area (Figure 2). Although some species have declined in abundance on the Swan Coastal Plain (Government of Western Australia 2000), species such as the Pacific Black Duck and Grey Teal are very common, even on artificial ponds and compensation basins. For example, population estimates for Grey Teal on the Swan Coastal Plain were 70,700 in October 1990 and 54,200 in October 1991 (Storey *et al*. 1993). In the 2009 – 2010 study, as expected, the Grey Teal and Pacific Black Duck made up a large proportion of the sample (Figure 2)

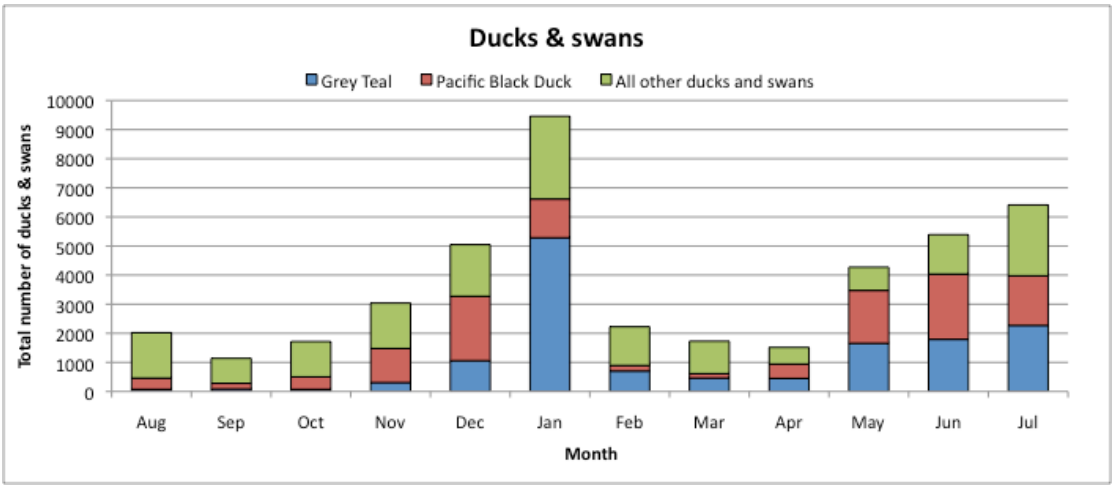

Figure 2. Total number of ducks and swans in the study area, Aug 2009 - Jul 2010.

Most ducks breed on the margins of well-vegetated wetlands building a nest amongst rushes or shrubs on the waters edge. Some species, (Australian Wood Duck, Australian Shelduck, Pacific Black Duck and Grey Teal) often breed in large tree hollows, then walk the ducklings to water. In the case of Grey Teal, these tree hollows can be up to 1km from the wetland (Johnstone and Storr 1998).

The **Musk Duck (CS3)** is a relatively common species, though it is thought to be declining on the Swan Coastal Plain (Government of Western Australia 2000). The Musk Duck was recorded in low numbers on most wetlands during the 2009 – 2010 study (Table 5), with the highest single count of 41 birds on Yangebup Lake (Table 6). The only breeding records in 2009 - 2010 for the Musk Duck were at Market Garden Swamp (Table 8), though it has also been recorded breeding at other wetlands (Table 7).

The **Freckled Duck (CS3)** is an uncommon visitor to Perth wetlands. It was represented by a single bird at South Lake during the 2009 – 2010 study, and has not been recorded from the other wetlands in the study area (Tables 4 and 5). None of the wetlands in the study area are likely to be important for the Freckled Duck.

The **Pink-eared Duck (CS3)** colonised the Swan Coastal Plain in the early 1950s (Johnstone and Storr (1998). It tends to favour larger fresh or saltwater wetlands (Johnstone and Storr 1998) and has been recorded from most wetlands in the study area (Table 4). In the 2009 – 2010 study, two wetlands had particularly high single counts of this species in summer; 730 birds at Bibra Lake and 985 birds at Yangebup Lake (Table 6). However, no counts approached 1% of the global population for this species according to the criterion in Appendix 1. The only breeding records for the Pink-eared Duck in 2009 – 2010 were at Market Garden Swamp (Table 8), but it has also been recorded breeding at Manning Lake (Table 7).

The **Australasian Shoveler (CS3)** favours larger, deeper freshwater wetlands (Johnstone and Storr 1998). The Australasian Shoveler has been recorded from most wetlands in the study area (Table 4). In the 2009 – 2010 study, the highest single counts were 320 birds on Thomsons Lake and 298 birds on Bibra Lake (Table 6). While Johnstone and Storr (1998) state that this species has been increasing since colonial times, it is listed as declining on the Swan Coastal Plain in Bush Forever (Government of Western Australia 2000). In the 1980s, the Australasian Shoveler appears to have been much more abundant, with counts on Thomsons Lake of between 600 and 2200 birds between 1982 and 1988 (WetlandBase 2010).

The **Hardhead (CS3)** occurs on freshwater and brackish wetlands, usually in small groups, but sometimes in large aggregations in summer (Johnstone and Storr 1998). It was recorded from most wetlands in the study area, but not Lake Coogee, which is saline. The highest single counts of this species were 577 birds at Bibra Lake and 384 birds at Yangebup Lake (Table 6). However, no counts approached 1% of the global population for this species according to the criterion in Appendix 1.

The **Blue-billed Duck (CS3)** favours the deeper freshwater wetlands (Johnstone and Storr 2004). Though this species is threatened by wetland drainage, wetland degradation and lowering groundwater tables, large populations in Victoria prevent it from being listed as a threatened species (Garnett and Crowley 2000). In the 2009 – 2010 study, the only wetland with significant numbers of Blue-billed Duck was Yangebup Lake, with the single highest count of 393 birds (Table 6). Thomsons Lake had a high count of 61 birds (Table 6), but does not support Blue-billed Ducks year-round. Blue-billed Duck counts on Yangebup Lake exceed the 1% of the global population of this species, according to the IBA criterion in Appendix 1.

The Radjah Shelduck was recorded at Bibra Lake, South Lake and Yangebup Lake during the 2009 – 2010 study. This species is listed under Schedule 4 of the *Western Australian Wildlife Conservation Act 1950*, so is a conservation significant species. However, the records in the study area are from vagrant birds that are either outside of their natural range (the north and east of Australia) or escapees from the Perth Zoo. Therefore, the study area is not important for the Radjah Shelduck and this species has not been listed as a significant species for the area in Table 3.

Many wetlands on the Swan Coastal Plain have small populations of introduced ducks and geese, usually supplemented by birds released by the general public. Although the Northern Mallard is of concern due to its ability to hybridise with the native Pacific Black Duck, this is probably not an important issue (Braithwaite and Miller 1975).

4.1.2 Grebes

Grebes (Family Podicipedidae) are represented by three species in the study area, all of which are relatively common. The least common species, the Great Crested Grebe is increasing in abundance on the Swan Coastal Plain (Johnstone and Storr 1998). Grebes build floating nests attached to aquatic plants or nest amongst vegetation on the waters edge (Johnstone and Storr 1998), so fringing vegetation in wetlands is important for these species.

In the study area grebes were most common in spring and early summer (Figure 3), probably corresponding to the period in which the wetlands were deep enough for them to forage. The most common grebe species was the Hoary-headed Grebe, which made up 95 to 99% of the total grebe count September to January in Figure 3.

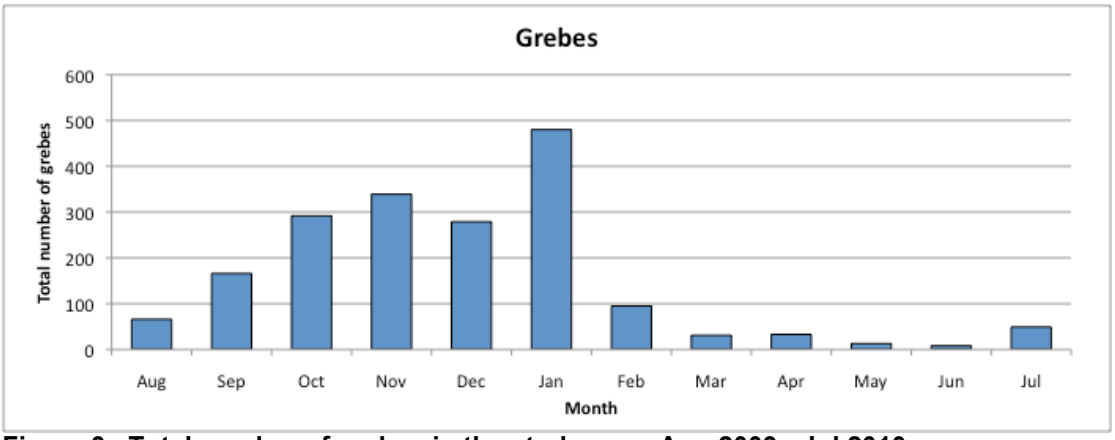

Figure 3. Total number of grebes in the study area, Aug 2009 - Jul 2010.

No grebes are of conservation significance in the study area. Bibra Lake is noted for a high count of 4900 Hoary-headed Grebes in 1988 (Environmental Protection Authority 1989), but these counts do not seem to have been maintained over the years, and the highest single count on Bibra Lake in the 2009 – 2010 study was seven (Table 6). The highest single count on any of the wetlands was 441 birds at Yangebup Lake.

4.1.5 Cormorants

Four cormorant species (Family Phalacrocoracidae) are present on the Swan Coastal Plain. All are common, though they usually occur in small numbers on lakes and swamps. Cormorants roost on trees and shrubs on the waters edge, so fringing vegetation is important for these species. Similarly to the grebes, cormorants were most common in the study area in spring and summer. As cormorants feed by diving for fish and crustaceans (Johnstone and Storr 1998), they are only likely to be common when wetlands are deep enough for foraging.

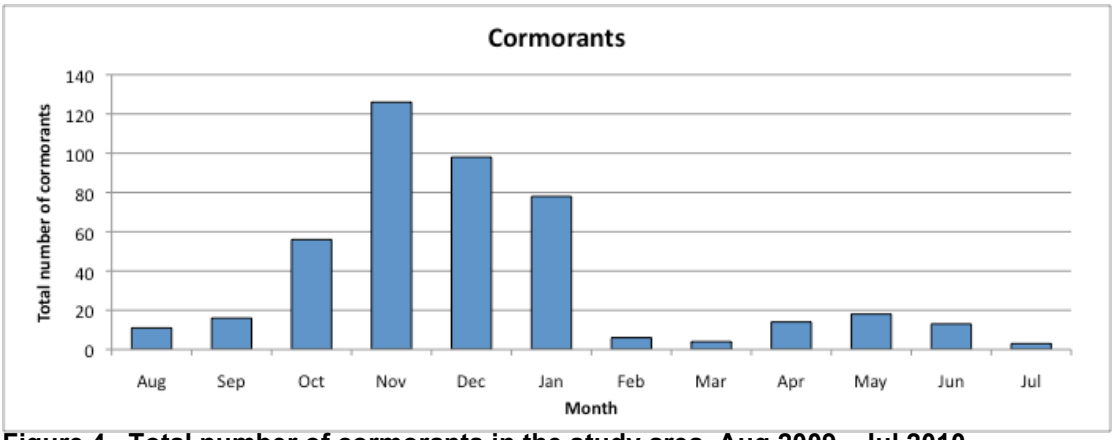

Figure 4. Total number of cormorants in the study area, Aug 2009 - Jul 2010.

The Pied Cormorant has only been recorded at five of the wetlands, and was not recorded during the 2009 – 2010 study. The Great Cormorant was recorded infrequently during the 2009 – 2010 study, usually as single birds (Tables 5 and 6). These species favour marine

and estuarine environments, and coastal habitats are likely to be more important than freshwater wetlands. The Little Black Cormorant and Little Pied Cormorant were recorded in low numbers at many wetlands, with the highest single counts for both species at Lake Coogee, a saline near-coastal wetland. Lake Coogee may be important locally as a roost site for small numbers of cormorants throughout the year.

No cormorant species are of conservation significance in the study area. Although congregatory waterbirds, none were recorded at levels approaching 1% of their global population (Appendix 1), and no breeding colonies are known from the wetlands surveyed.

4.1.6 The Australian Pelican

The Australian Pelican is the only member of the family Pelecanidae on the Swan Coastal Plain. This large fish-eating bird is common on the Swan Coastal Plain, but breeds on offshore islands (Johnstone and Storr 1998). The Australian Pelican was recorded at most wetlands in the study area (Table 4), with the highest counts in 2009 – 2010 on Bibra Lake (53 birds) and Yangebup Lake (21 birds) (Table 6). The Australian Pelican is not of conservation significance in the study area.

4.1.7 Bitterns, egrets and herons

Bitterns, egrets and herons (Family Ardeidae) are large wading birds, and eight species occur in the study area, of which half are conservation significant (Table 4). A ninth species, the Intermediate Egret, was recorded at Bibra Lake in 2009 – 2010 (Table 5), but this species is a vagrant from northern Australia.

Bitterns, egrets and herons usually inhabit shallow waters, where they forage for fish, frogs, reptiles and invertebrates (Johnstone and Storr 1998). The Nankeen Night-Heron usually feeds in shallow water at night, roosting and breeding in the trees near wetlands. Thus the margins of wetlands and fringing vegetation are important habitats for this group.

No bitterns were recorded in the 2009 – 2010 surveys (Table 5). The numbers of herons and egrets were highest in January 2010 (Figure 5), mainly due to high numbers of the White-faced Heron, a common species on the Swan Coastal Plain (Johnstone and Storr 1998).

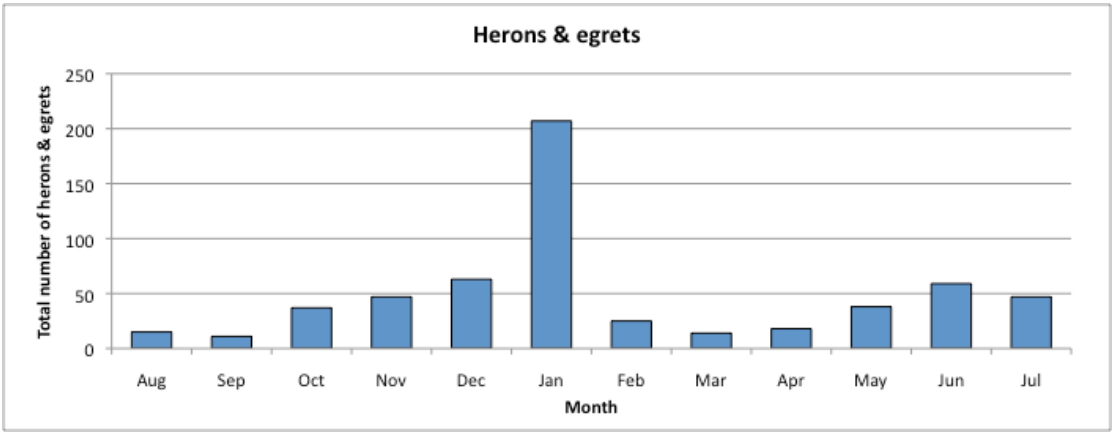

Figure 5. Total number of herons and egrets in the study area, Aug 2009 - Jul 2010.

The White-necked Heron is generally an uncommon winter/spring visitor to the Swan Coastal Plain, but is irruptive, so can occur in large numbers in some years. In the 2009 – 2010 survey period, it was only recorded at North Lake and Thomsons Lake (Table 5), though it has also been recorded at most other wetlands in the study area (Table 4).

The Little Egret is uncommon on the Swan Coastal Plain (Johnstone and Storr 1998). Though it has been recorded at most wetlands in the study area (Table 4), it is in low numbers both in the 2009 – 2010 surveys (Table 5) and in the 1980s (WetlandBase 2010).

Both bittern species are extremely uncommon, inhabiting and nesting in dense beds of rushes in freshwater wetlands (Johnstone and Storr 1998). Garnett and Crowley (2000) list wetland destruction as a key threat for both the Australasian Bittern and Australian Little Bittern.

The **Australasian Bittern (CS1)** inhabits shallow, densely vegetated wetlands that have a mixture of tall and short rushes (Johnstone and Storr 1998, Marchant and Higgins 1990). Wetlands in the study area that have dense beds of rushes such as *Typha* or *Baumea* species may be suitable, though this species is only known from Thomsons Lake (Table 4). There were no records of this species in the study area on the Birds Australia Atlas Database (2010), and though the EPA (1989) notes that Thomson's Lake may be an important breeding area for the species, no breeding records are known (WetlandBase 2010, Storey *et al*. 1993, Jaensch *et al*. 1988).

The **Australian Little Bittern (CS2)** may also inhabit and breed on any wetlands in the study area that have dense beds of rushes such as *Typha* or *Baumea* species. In 2006 there were two records of the Australian Little Bittern from Thomson's Lake (Birds Australia Atlas Database 2010) and in 1987 there were two records from Lake Kogolup, where it was also recorded breeding (WetlandBase 2010). This species may be resident on the Swan Coastal Plain or a spring/summer visitor (Johnstone and Storr 1998).

The **Eastern Great Egret (CS1)** is a common bird of shallow freshwater wetlands (Johnstone and Storr 1998). Although very rare before 1917, numbers of this species have increased since that time (Johnstone and Storr 1998). The Eastern Great Egret nests colonially in trees in wooded wetlands and along rivers (Johnstone and Storr 1998). This species usually only occurs in small groups, with high counts of 15 birds at Bibra Lake and 11 birds at Thomsons Lake in 2009 – 2010 (Table 6). All wetlands in the study area are likely to support this species, at least on occasion. Globally, the Eastern Great Egret has a large range and population size, though its possible there is a decreasing trend (IUCN 2010).

The **Cattle Egret (CS1)** is an occasional visitor to the Swan Coastal Plain, mainly occurring in autumn (Johnstone and Storr 1998). This species has been recorded at North Lake and South Lake (Table 4) and generally inhabits pastures and wetlands (Johnstone and Storr 1998). Although a migratory species, the Cattle Egret is listed as of Least Concern on the IUCN Red List, as it has an extremely large range and a large population that appears to be increasing (IUCN 2010). No wetlands in the study area are likely to be significant for this species.

4.1.8 Ibis and spoonbills

There are four members of the Family Threskiornithidae present in the study area, three ibis and a spoonbill. The Royal Spoonbill has also been recorded, but this species is a vagrant to the Swan Coastal Plain. All species are self-introduced to the Swan Coastal Plain, for example the Yellow-billed Spoonbill was not recorded until 1920 (Johnstone and Storr 1998). Ibis and spoonbills generally forage around wetland margins, and ibis also forage in damp pastures. Ibis and spoonbills generally nest colonially in wooded wetlands, constructing nests in trees. The Australian White Ibis and Straw-necked Ibis are nomadic species that are very common on the Swan Coastal Plain, while the Glossy Ibis is generally an uncommon visitor.

Ibis and spoonbills were relatively common through spring, summer and autumn, with the lowest numbers in winter (Figure 6). The most common species was the Australian White Ibis, making up between 67 and 100% of all ibis and spoonbills in the study area. The low counts in winter may be due to ibis dispersing to forage in winter-wet pastures and grasslands in the southwest.

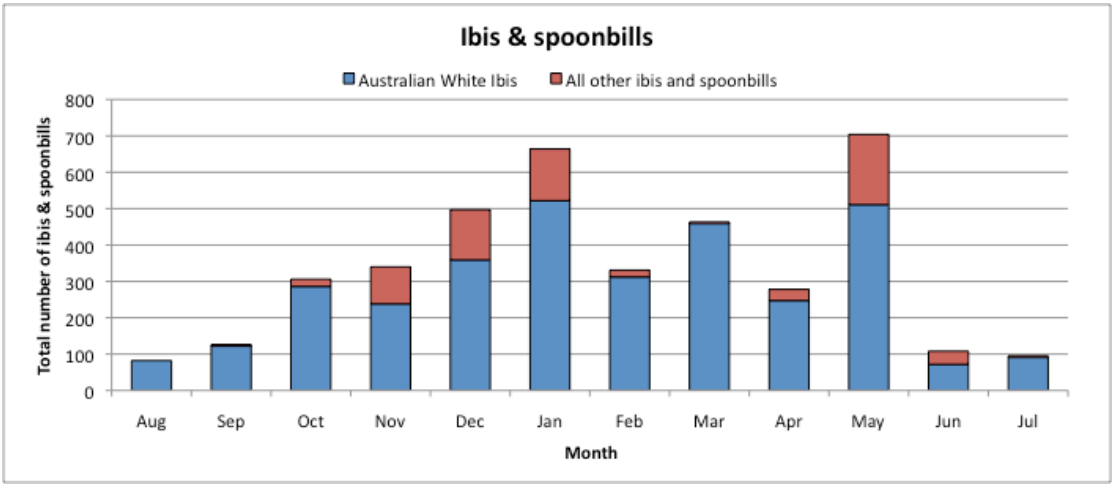

Figure 6. Total counts of ibis and spoonbills in the study area, Aug 2009 - Jul 2010.

The **Glossy Ibis (CS1)** is mainly a non-breeding visitor to the south-west of Western Australia, although breeding has been recorded (Johnstone and Storr 1998). This species was not recorded in the south-west until 1898, and has been increasing since that time (Johnstone and Storr 1998). This species had been recorded at several wetlands, namely Bibra Lake, Kogolup Lake, Little Rush Lake, North Lake and Thomson's Lake (Table 4). In the 2009 – 2010 surveys, the Glossy Ibis was recorded from three wetlands, with highest counts of 44 from Thomsons Lake, 28 from North Lake and 23 from Bibra Lake (Table 6). Although a migratory species, the Glossy Ibis is listed as of Least Concern on the IUCN Red List, as it has an extremely large range and although the population trend appears to be decreasing, it has an extremely large population (IUCN 2010). It is unlikely that any of the wetlands in the study area are of particular importance to this species.

The remaining ibis and spoonbill species are not of conservation significance in the study area. Although they are congregatory waterbirds, none approach 1% of their global population in the study area (Appendix 1), and no breeding colonies are known from the wetlands surveyed.

4.1.9 Birds of prey

Four birds of prey from the Family Accipitridae are present in the study area, two of which are conservation significant. The Eastern Osprey and White-bellied Sea-Eagle are mainly coastal species that breed on offshore islands. The Whistling Kite and Swamp Harrier often forage on wetlands. The Swamp Harrier nests amongst rushes in wetlands, so fringing vegetation is important for this species. The Swamp Harrier was recorded at most wetlands in this study (Table 4) with the highest single counts of two birds at both Kogolup Lake and Thomsons Lake (Table 6).

The **Eastern Osprey (CS1)** was not recorded during the 2009 – 2010 study, but was recorded from Bibra Lake in 2009 and North Lake in 2001 (Birds Australia Atlas Database 2010). This species is generally a bird of coasts, estuaries and islands, and it usually breeds on offshore islands (Johnstone and Storr 1998). The Eastern Osprey is only likely to be an occasional non-breeding visitor to the study area.

The **White-bellied Sea-Eagle (CS1)** is generally a bird of coasts, islands, estuaries and larger river systems (Johnstone and Storr 1998, Marchant and Higgins 1993). Although it often nests on offshore islands (Johnstone and Storr 1998), the White-bellied Sea-Eagle has also been recorded nesting in tall trees on the mainland (Marchant and Higgins 1993). In the 2009 - 2010 study the White-bellied Sea-Eagle was recorded at three wetlands; Bibra Lake, Kogolup Lake and Thomsons Lake (Table 5), and it has also been recorded from three other wetlands (Table 4). The White-bellied Sea-Eagle is likely to be an occasional visitor to the study area, and while this species may potentially nest in the study area, the likelihood is low.

The **Whistling Kite (CS3)** is listed as a species that is declining on the Swan Coastal Plain (Government of Western Australia 2000), though it is widespread and relatively common in Western Australia (Johnstone and Storr 1998). Although this species also uses terrestrial habitats, it is commonly found around wetlands where it forages on vertebrate prey. The fringing vegetation around wetlands is important for this species, as it breeds in large eucalypts (Johnstone and Storr 1998). The Whistling Kite has been recorded at most wetlands (Table 4) with the highest single counts in the 2009 – 2010 study 18 birds at Thomsons Lake and seven birds at Kogolup Lake (Table 6).

4.1.10 The Eurasian Coot, crakes and rails

There are seven species from Family Rallidae present in the study area, most of which inhabit the vegetated margins of wetlands. All species nest on the ground or at water level, building a nest of rushes, sedges or bark into vegetation. One species, the Dusky Moorhen is of conservation significance.

In surveys of wetlands on the Swan Coastal Plain carried out in 1990 – 1992, the Eurasian Coot was the most abundant waterbird on the Swan Coastal Plain (Storey *et al*. 1993). In this study it was recorded at almost every wetland, and was particularly common at Bibra Lake, Yangebup Lake and Manning Lake, with respective mean abundances of 382, 101 and 58 birds per survey (Table 5). In the 2009 – 2010 survey, the Eurasian Coot was most abundant in winter and spring (Figure 7), which coincides to the periods when most wetlands held water.

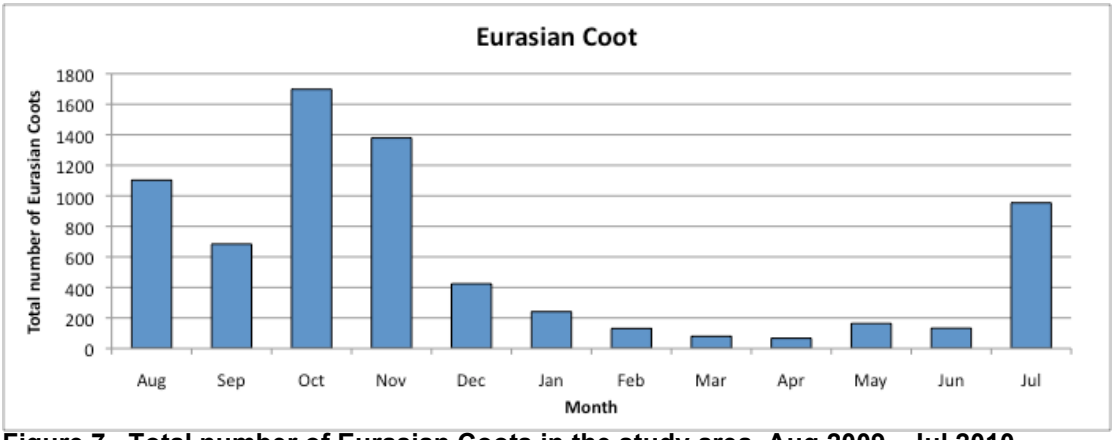

Figure 7. Total number of Eurasian Coots in the study area, Aug 2009 - Jul 2010.

The Buff-banded Rail, Ballion's Crake, Australian Spotted Crake and Spotless crake all inhabit densely vegetated wetland edges, and are often under-surveyed due to their cryptic behaviour. Of the four rail and crake species, three were recorded at Yangebup lake in 2009 – 2010 surveys (Table 5), and all four are known from Kogolup Lake, Thomsons Lake and Yangebup Lake (Table 4). The banks of emergent rushes at these wetlands are likely to be important for these species.

The Purple Swamphen was recorded at most wetlands, with particularly high counts of 82 birds at Kogolup Lake and 37 birds at Thomsons Lake (Table 6). The banks of emergent rushes at these wetlands are likely to be at least locally important for the Purple Swamphen.

The **Dusky Moorhen (CS3)** is listed as a species that is declining on the Swan Coastal Plain (Government of Western Australia 2000). The Dusky Moorhen occurs on the edges of wetlands, usually where there is cover such as emergent rushes. This species was recorded at almost all wetlands, though counts were usually low. The highest mean count was 2.1 birds/survey at Bibra Lake (Table 5) and eight birds at Kogolup Lake was the highest single count (Table 6). As the Dusky Moorhen is not a congregatory waterbird, sites may be locally important for this species if they regularly support this species, even if they only support low numbers.

4.1.11 Stilts and avocets

The stilts and avocets (Family Recurvirostridae) are widespread in Western Australia, and all three species are common visitors to the Swan Coastal Plain, particularly in summer (Johnstone and Storr 1998). This is reflected in the total counts of this group in the study area (Figure 8). Stilts and avocets breed on inland salt lakes, and are non-breeding visitors to shallow wetlands in the study area. Stilts and avocets have been recorded at almost all wetlands, at least in low numbers (Table 5).

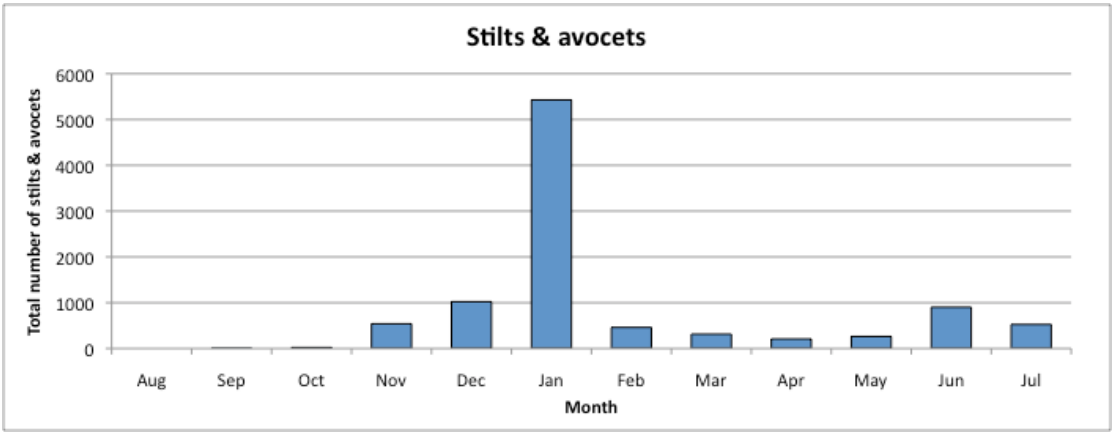

Figure 8. Total number of stilts and avocets in the study area, Aug 2009 - Jul 2010.

The Banded Stilt was uncommon in the 2009 – 2010 surveys (Table 5). In some years this species may be more common, with high single counts of 360 birds at Thomsons Lake in 1982 and 310 birds at Yangebup Lake in 1988 (WetlandBase 2010).

The Black-winged Stilt was common, making up 75% of the high count of stilts and avocets in January 2010. The highest single counts for this species were of 1553 birds on Bibra Lake and 1500 birds on Thomsons Lake in January 2010 (Table 6). Although no counts in the 2009 – 2010 surveys exceeded the 1% IBA criterion for this species, 3000 birds were recorded at Thomsons Lake in 1986 (WetlandBase 2010).

The Red-necked Avocet has been recorded from most wetlands (Table 4) and during the 2009 – 2010 study was particularly common at Bibra Lake, with a high count of 1329 (Table 6). This count exceeds the IBA criterion for 1% of the global population of this species (Appendix 1), though it is uncertain whether Bibra Lake regularly supports high numbers of the Red-necked Avocet, as there are no other data to substantiate this on the Birds Australia Atlas Database (2010) or WetlandBase (2010). No Red-necked Avocets were recorded on Thomsons Lake during the 2009 – 2010 study, but counts in 1982 (1300 birds) and 1983 (2000 birds) were also greater than 1% of the global population.

4.1.12 Shorebirds

There are 23 species of shorebird in the study area (Families Charadriidae and Scolopacadiae), of which 18 are international migrants and listed under the EPBC Act. These internationally migrant shorebirds breed in the northern hemisphere, migrating to Australia in summer for the non-breeding season (Geering *et al*. 2007). The remaining five species are not international migrants, although they may make nomadic movements within Australia.

As expected, shorebirds were most abundant in summer (Figure 9), though this peak was primarily due to a large count of 1272 Red-capped Plovers on Bibra Lake (Table 6, Appendix 4). The Red-capped Plover is not an international migrant and often occurs on the shores of drying wetlands, although it also uses coastal and estuarine habitats (Johnstone and Storr 1998).

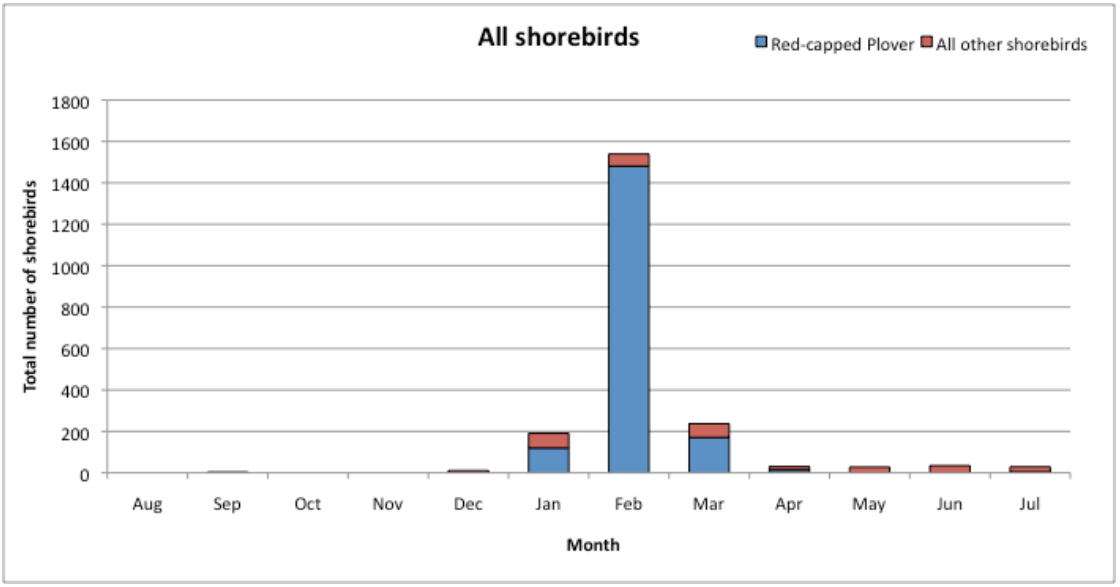

Figure 9. Total number of all shorebirds in the study area, Aug 2009 - Jul 2010.

All migratory shorebirds are of CS1, though many appear to have stable populations, some appear to be declining (Bamford *et al*. 2008). The total number of migratory shorebirds in the study area was highest in the summer months (Figure 10), but even the January count was of less than 70 birds across all wetlands sampled. The number of migratory shorebird species at individual wetlands in the 2009 – 2010 study was the highest at Thomsons Lake (seven species) followed by Kogolup Lake (five species), with the remaining wetlands having between zero and three species. While no wetlands had significant numbers of migratory shorebirds during the 2009 – 2010 survey period, high counts are known from Thomsons Lake in the 1980s (WetlandBase 2010).

The **Pacific Golden Plover (CS1)** is a bird of the coast, inhabiting intertidal mudflats, rocky shores and coastal salt-marshes (Geering *et al*. 2007). As such it is likely only to be an occasional vagrant to the wetlands in the study area. It has only been recorded from Yangebup Lake (Table 4).

The **Grey Plover (CS1)** usually occurs on intertidal beaches and mudflats (Geering *et al*. 2007), though it occasionally uses drying freshwater wetlands (Johnstone and Storr 1998). This species has been recorded from Yangebup Lake in 1998 and 1999, and nine birds were recorded on North Lake in 1999 (Birds Australia Atlas Database 2010). The Grey Plover is likely to be a very uncommon summer visitor to the study area, and the wetlands are unlikely to support 1% of the flyway population of this species.

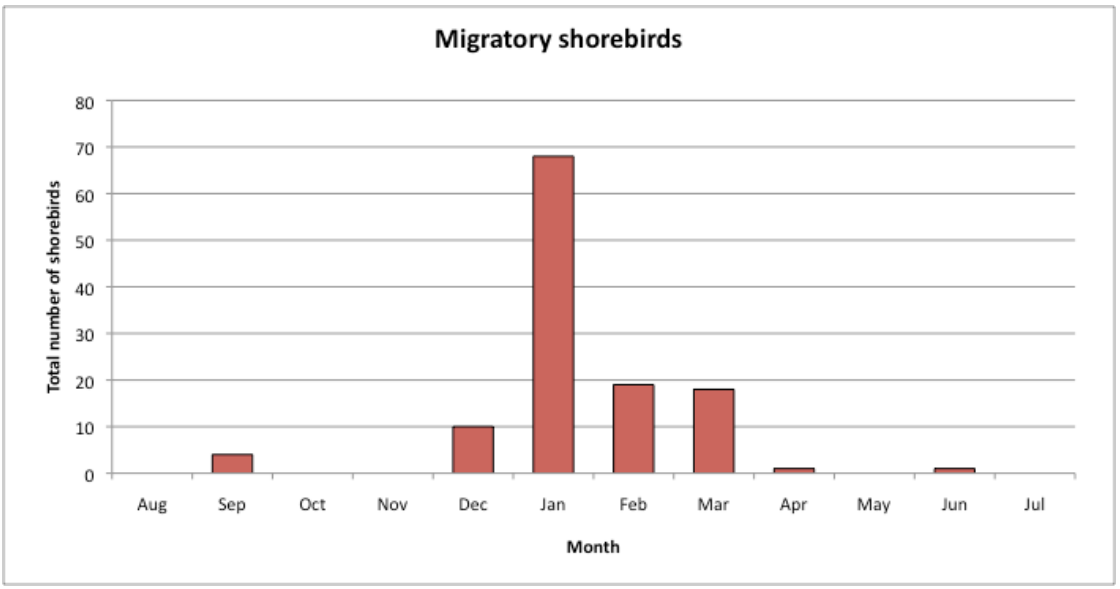

Figure 10. Total number of migratory shorebirds in the study area, Aug 2009 – Jul 2010.

The **Little Ringed Plover (CS1)** inhabits the muddy edges of freshwater wetlands (Geering *et al*. 2007). This species is an extremely uncommon bird in Western Australia, represented by a handful of records. The majority of birds migrate to Africa and Asia, with only a few individuals flying as far as Australia (Johnstone and Storr 1998). It has only been recorded from Bibra Lake and Yangebup Lake (Table 4). The wetlands in the study area are not likely to be ecologically significant for the Little Ringed Plover.

The **Hooded Plover (CS2)** is usually a bird of beaches, salt lakes and estuaries (Johnstone and Storr 1998), although there is one record from 2007 for this species on Thomson's Lake on the Birds Australia Atlas Database. Overall, the wetlands of the study area are unlikely to be important for the Hooded Plover.

The **Black-tailed Godwit (CS1)** inhabits freshwater and brackish wetlands, as well as intertidal mudflats (Geering *et al*. 2007). This species has been recorded from Bibra Lake, North Lake, South Lake and Thomsons Lake (Table 4), with Thomsons Lake having the only record in the 2009 – 2010 survey (Table 5). The wetlands are unlikely to support 1% of the flyway population of this species, with records being of between one and 15 birds (WetlandBase 2010, Birds Australia Atlas Database 2010, Maddeford 2003).

The **Bar-tailed Godwit (CS1)** is rarely found far from the coast and favours intertidal mudflats (Geering *et al*. 2007). It has only been recorded on two wetlands, Lake Coogee (a saline lake near the coast) and a single bird at Thomsons Lake in 1982 (WetlandBase 1982). The wetlands in the study area are unlikely to be important for this species, compared to coastal habitats.

The **Common Sandpiper (CS1)** is usually solitary or in small flocks (Geering *et al*. 2007). It occurs in a range of habitats including estuaries, mangrove creeks, coastal salt lakes, river pools, dams and drying wetlands (Johnstone and Storr 1998). The Common Sandpiper has been recorded on six of the wetlands (Table 4), with records of single birds from Kogolup Lake and Yangebup Lake in the 2009 – 2010 study (Table 6).

The **Common Greenshank (CS1)** occurs on freshwater and saltwater wetlands, as well as on intertidal mudflats (Geering *et al*. 2007). This species has been recorded from most wetlands in the study area (Table 4). Generally the numbers recorded in 2009 – 2010 were low, with the highest being 40 at Thomson's Lake in 1982 (WetlandBase 2010).

The **Marsh Sandpiper (CS1)** inhabits freshwater and saltwater wetlands, both near the coast and inland (Geering *et al*. 2007). This species has been recorded from Bibra Lake, Kogolup Lake, Lake Coogee, Little Rush Lake and Thomsons Lake in small numbers (Birds Australia Atlas Database 2010, WetlandBase 2010). In the 1980s, up to 30 birds were recorded on Thomsons Lake (WetlandBase 2010), but a maximum of four were recorded there during the 2009 – 2010 study (Table 6).

The **Wood Sandpiper (CS1)** usually inhabits freshwater wetlands, though it also occasionally occurs on intertidal mudflats (Geering *et al*. 2007). This species has been recorded from six of the wetlands in small numbers, Bibra Lake, Kogolup Lake, Horse Paddock Swamp, Little Rush Lake, Thomsons Lake and Yangebup Lake (Table 4). High counts are of 60 at Kogolup Lake and 45 at Thomsons Lake (Jaensch *et al*. 1993 and Storey *et al*. 1993).

The **Red-necked Stint (CS1)** occurs across a wide range of fresh and saltwater habitats, including freshwater wetlands (Geering *et al*. 2007). It is a non-breeding visitor to the study area, between October and March (Johnstone and Storr 1998). This species has been recorded from Bibra Lake, Kogolup Lake, Lake Coogee, North Lake, Thomson's Lake and Yangebup Lake (Table 4). High counts are of 2500 birds at Thomsons Lake in 1983 and 1500 birds at Yangebup Lake in 1983 (WetlandBase 2010), and no wetland supports numbers approaching 1% of the global population of this species.

The **Long-toed Stint (CS1)** usually inhabits freshwater wetlands and river pools, though it can occur in other habitats (Johnstone and Storr 1998). This species is a non-breeding visitor to the study area, between December and March (Johnstone and Storr 1998), and has been recorded from Kogolup Lake, Thomsons Lake and Yangebup Lake (Table 4). In general the counts are low, with the highest counts of 45 from Kogolup Lake, 25 from Thomsons Lake and 15 from Lake Yangebup (Jaensch *et al*. 1993). These counts are less than the 1% of the global population of this species, but may be locally significant on the Swan Coastal Plain (Raines 2010).

The **Pectoral Sandpiper (CS1)** usually occurs as single birds or small flocks on freshwater wetlands (Geering *et al*. 2007). It was not recorded in the 2009 – 2010 surveys. This species has only been recorded from Kogolup Lake (in 1991 and 2002), Yangebup Lake (in 1992) and Thomsons Lake in 1982 (1 bird), 1983 (2 birds) and 1986 (3 birds) (Birds Australia Atlas Database 2010, Storey *et al*. 1993, WetlandBase 2010).

The **Sharp-tailed Sandpiper (CS1)** favours non-tidal freshwater or brackish wetlands, though it also occurs in other habitats (Geering *et al*. 2007). This species has been recorded from Bibra Lake, Kogolup Lake, North Lake, Thomsons Lake and Yangebup Lake (Table 4). Numbers are highest on Thomsons Lake with, for example, 1000 birds recorded in January 1986 and 100 birds in December 2004 (Birds Australia Atlas Database 2010, WetlandBase 2010). Counts on other wetlands were low, ranging from 80 at Yangebup Lake in January 1982 to a single bird on North Lake in April 1982 (WetlandBase 2010, Maddeford 2003).

The **Curlew Sandpiper (CS1)** usually occurs on intertidal mudflats, but also uses freshwater wetlands (Geering *et al*. 2007). This species has been recorded on Bibra Lake, Kogolup Lake, Lake Coogee, South Lake, Thomson's Lake and Yangebup Lake (Table 4). Despite high counts of this species in the past, the Curlew Sandpiper was not recorded during the 2009 – 2010 surveys. High counts of up to 2500 Curlew Sandpipers at Thomsons Lake in 1983 led to this site being recognised as an internationally important shorebird site (Bamford *et al*. 2008), though the only recent record on the Birds Australia Atlas Database (2010) is of 150 birds in 2007.

The **Ruff (CS1)** is a rare non-breeding visitor to Australia, where it inhabits the margins of freshwater and brackish wetlands (Geering *et al*. 2007). There were no recent records of this species in the study area on the Birds Australia Atlas Database, although single birds were recorded on Yangebup Lake in 1983 and Thomson's Lake in 1985 (WetlandBase 2010). No wetlands in the study area are likely to be important for this species.

4.1.13 Gulls and terns

There are five species of gulls and terns (Family **Laridae**) present in the study area, of which two are conservation significant in the study area. Although more species are known from the region, they are coastal species. The Silver Gull is the most abundant member of this group, and although it breeds on offshore islands, it is common on near-coastal wetlands on the Swan Coastal Plain.

The Gull-billed Tern is a scarce visitor to the Swan Coastal Plain, unrecorded before 1953 (Johnstone and Storr 1998). It was not recorded in the 2009 – 2010 surveys, and is only known from Yangebup Lake (Table 4). The Whiskered Tern is usually an uncommon visitor to the south-west, though it can be common in some years. In the 2009 – 2010 surveys it was only recorded in low numbers at Bibra Lake (Table 5), though 50 birds were recorded at Thomsons Lake in 1983 and 1985 (WetlandBase 2010).

The **Fairy Tern (CS2)** is listed as of Least Concern in the Action Plan for Australian Birds (Garnett and Crowley 2000) as although there have been local declines in breeding populations, it has been offset by an increase in the species' range. However, the species is listed as Vulnerable on the IUCN Red List due to a declining population (IUCN 2010). Breeding populations are threatened by human disturbance and exotic predators, though Western Australian populations remain secure on offshore islands (Garnett and Crowley 2000). The Fairy Tern is usually uncommon in the south-west, and although generally a coastal species, it also occurs on near-coastal wetlands. This species has been recorded at Bibra Lake in 2005 and 2010 (Birds Australia Atlas Database 2010) and is likely to be an uncommon non-breeding visitor to near-coastal wetlands.

In the southwest, the **White-winged Black Tern (CS1)** mainly inhabits freshwater wetlands, where it is an irregular visitor from September to May (Johnstone and Storr 1998). The only wetlands with records of this species are Thomsons Lake with a high count of 150, and Yangebup Lake with a high count of 110 (Jaensch *et al*. 1993). Although a migratory species, the White-winged Black Tern is listed as of Least Concern on the IUCN Red List, as it has an extremely large range and a large, stable population (IUCN 2010).

4.1.14 The Australian Reed-warbler and Little Grassbird

Families Acrocephalidae and Megaluridae are represented by one species each in the study area, the Australian Reed-Warbler and the Little Grassbird. These small passerines are common in the fringing vegetation around wetlands in the study area, particularly amongst rushes. They nest in fringing vegetation, building a cup-shaped nest amongst rushes (Johnstone and Storr 2004). Neither species is of conservation significance in the study area.

Table 4. Records of waterbirds at each wetland in the study area.

● = recorded during 2009/2010 study, or from sources in Table 1.

● = recorded during 2009/2010 study only.

Note: Int. = introduced species, V = vagrant species to wetlands on the Swan Coastal Plain.

Species	Conservation Significance	Records at each wetland												
		Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Anatidae (ducks and swans)														
Musk Duck	3	●	●	●	●	●	●	●	●	●	●	●	●	●
Freckled Duck	3	●										●		
Black Swan		●	●	●	●	●	●	●	●	●	●	●	●	●
Australian Shelduck		●	●	●	●	●	●	●	●	●	●	●	●	●
Radjah Shelduck (V)		●										●		●
Australian Wood Duck		●	●	●	●		●			●	●	●	●	●
Pink-eared Duck	3	●	●	●			●	●	●	●		●	●	●
Australasian Shoveler	3	●	●	●	●		●	●	●	●	●	●	●	●
Grey Teal		●	●	●	●	●	●	●	●	●	●	●	●	●
Chestnut Teal		●	●										●	●
Northern Mallard (Int.)		●			●		●	●	●				●	●
Pacific Black Duck		●	●	●	●	●	●	●	●	●	●	●	●	●
Hardhead	3	●	●	●	●		●	●	●	●	●	●	●	●
Blue-billed Duck	3	●	●	●			●	●	●	●		●	●	●
Muscovy Duck (Int.)		●								●				
Domestic Goose (Int.)		●					●	●		●				●
Podicipedidae (grebes)														
Australasian Grebe		●	●	●	●		●	●	●	●	●	●	●	●
Hoary-headed Grebe		●	●		●		●	●	●	●		●	●	●
Great Crested Grebe		●		●	●					●			●	●
Anhingidae (darter)														
Australasian Darter		●	●		●		●		●	●		●	●	●
Phalacrocoracidae (cormorants)														
Little Pied Cormorant		●	●	●	●		●	●	●	●	●	●	●	●
Great Cormorant		●			●		●			●			●	●
Little Black Cormorant		●	●		●		●	●	●	●	●	●	●	●
Pied Cormorant		●			●							●	●	●
Pelecanidae (pelicans)														
Australian Pelican		●	●		●		●	●	●	●		●	●	●

Table 4. (cont.)

Species	Conservation Significance	Records at each wetland												
		Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Ardeidae (bitterns, egrets and herons)														
Australasian Bittern	1												•	
Australian Little Bittern	2		•										•	
White-necked Heron		•	•				•		•	•	•	•	•	
Eastern Great Egret	1	•	•	•	•		•	•	•	•	•	•	•	•
Intermediate Egret (V)		•												
Cattle Egret	1									•		•		
White-faced Heron		•	•	•	•	•	•	•	•	•	•	•	•	•
Little Egret		•	•		•		•		•	•			•	•
Nankeen Night-Heron	3	•	•		•	•	•	•		•	•	•	•	•
Threskiornithidae (ibis and spoonbills)														
Glossy Ibis	1	•	•				•			•			•	
Australian White Ibis		•	•	•	•	•	•	•	•	•	•	•	•	•
Straw-necked Ibis		•	•	•	•	•	•	•	•	•	•	•	•	•
Yellow-billed Spoonbill		•	•	•	•	•	•	•	•	•	•	•	•	•
Royal Spoonbill (V)													•	
Accipitridae (eagles, harriers, kites and allies)														
Eastern Osprey	1	•			•					•			•	
White-bellied Sea-Eagle	1	•	•		•					•			•	•
Whistling Kite	3	•	•		•		•	•	•	•		•	•	•
Swamp Harrier		•	•		•		•		•	•		•	•	•
Rallidae (crakes, rails and allies)														
Purple Swamphen		•	•		•		•	•	•	•	•	•	•	•
Buff-banded Rail		•	•		•		•			•			•	•
Baillon's Crake		•	•										•	•
Australian Spotted Crake			•							•			•	•
Spotless Crake		•	•		•					•			•	•
Black-tailed Native-hen		•						•		•			•	
Dusky Moorhen	3	•	•		•	•	•	•	•	•	•	•	•	•
Eurasian Coot		•	•	•	•	•	•	•	•	•	•	•	•	•
Recurvirostridae (stilts and avocets)														
Black-winged Stilt		•	•	•	•	•	•	•	•	•	•	•	•	•
Red-necked Avocet		•	•		•	•	•			•		•	•	•
Banded Stilt		•	•		•	•	•	•		•		•	•	•

Table 4. (cont.)

Species	Conservation Significance	Records at each wetland												
		Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Charadriidae (plovers and dotterels)														
Pacific Golden Plover (V)	1													•
Grey Plover	1									•				•
Little Ringed Plover (V)	1	•												•
Red-capped Plover		•	•		•	•			•				•	•
Black-fronted Dotterel		•	•	•	•	•	•	•	•	•	•	•	•	•
Hooded Plover	2												•	
Red-kneed Dotterel	3	•	•		•					•		•	•	•
Masked Lapwing (V)			•							•				•
Scolopacidae (godwits, sandpipers, stints and allies)														
Black-tailed Godwit	1	•								•		•	•	
Bar-tailed Godwit	1				•								•	
Common Sandpiper	1	•	•		•					•			•	•
Grey-tailed Tattler (V)	1				•									
Common Greenshank	1	•	•		•		•	•	•	•		•	•	•
Marsh Sandpiper	1	•	•		•		•						•	
Wood Sandpiper	1	•	•	•			•						•	•
Great Knot (V)	1				•								•	
Red Knot (V)	1												•	
Red-necked Stint	1	•	•		•					•			•	•
Long-toed Stint	1		•										•	•
Pectoral Sandpiper	1		•										•	•
Sharp-tailed Sandpiper	1	•	•							•			•	•
Curlew Sandpiper	1	•	•		•							•	•	•
Ruff (Reeve)	1												•	•
Laridae (gulls and terns)														
Fairy Tern	2	•												
Gull-billed Tern														•
Whiskered Tern		•								•			•	•
White-winged Black Tern	1												•	•
Silver Gull		•	•	•	•	•	•	•	•	•		•	•	•
Acrocephalidae														
Australian Reed-Warbler		•	•		•		•			•			•	•
Megaluridae														
Little Grassbird		•	•							•			•	•
Total species:		**66**	**56**	**23**	**50**	**13**	**43**	**32**	**33**	**57**	**23**	**41**	**71**	**65**

Table 5. Mean number of each bird on each wetland, Aug 2009 - Jul 2010.

Note: Int. = introduced species, V = vagrant species to wetlands on the Swan Coastal Plain.

Species	Conservation Significance	Wetland											
		Bibra Lake	Kogolup Lake	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Musk Duck	3	10.6	2.8	4.1	0.3	2.3	0.3	0.8	0.1		1.9	3.1	18.0
Freckled Duck	3										0.1		
Black Swan		57.3	36.7	2.4	0.8	0.9	1.1	0.6	31.0		20.7	97.5	16.3
Radjah Shelduck (V)		0.3									0.1		0.1
Australian Shelduck		29.2	1.1	2.7	4.2	3.7	2.3	4.0	18.5	1.0	5.2	54.8	125.5
Australian Wood Duck		3.0	0.1									0.1	1.1
Pink-eared Duck	3	64.7	1.3			0.3	1.1	3.9	0.3		13.1		252.1
Australasian Shoveler	3	70.3	18.0	0.8		1.2	3.2	1.1	6.1		0.8	46.0	23.0
Grey Teal		795.7	53.3	5.7	1.6	36.8	17.2	23.0	51.8		30.8	84.4	85.4
Chestnut Teal		0.1	0.1										
Northern Mallard (Int.)		3.5					0.6	0.1					0.1
Pacific Black Duck		616.6	71.0	5.5	1.1	8.2	7.5	10.3	78.5	2.7	12.3	138.2	75.2
Hardhead	3	72.6	5.3			0.8	0.2	2.3			8.3	0.3	53.3
Blue-billed Duck	3	3.4	4.6	0.1			0.1				0.1	10.2	211.8
Domestic Goose (Int.)		0.6	0.0	0.0									1.8
Australasian Grebe		0.8	4.1	0.0			0.2	0.3	0.5	0.2	1.0	0.3	0.7
Hoary-headed Grebe		1.3	15.1	4.3		6.6		3.3			11.7	18.2	85.8
Great Crested Grebe		0.1											
Darter		0.3		0.1		0.2					0.1		
Little Pied Cormorant		0.9	1.3	13.7		0.1		0.8	0.6	0.2	0.8	3.3	0.3
Great Cormorant		0.2		0.1							0.1	0.1	0.8
Little Black Cormorant		1.8	0.2	7.8		1.2		0.7			1.4		1.0
Australian Pelican		5.9	0.6	0.5		0.1		0.1				3.3	5.9
White-necked Heron									0.2			2.4	
Eastern Great Egret	1	1.8	0.2	0.5		0.1		0.2	0.2	0.1		2.2	0.6
Intermediate Egret (V)						0.1							
Cattle Egret	1								0.1				
White-faced Heron		5.4	2.1	2.2	0.2	0.3	0.2	0.8	4.3	0.2	1.1	20.5	1.5
Little Egret			0.2	0.3		0.1		0.1				0.2	
Nankeen Night Heron	3				0.1					0.3		0.1	
Glossy Ibis	1	1.9							4.0			8.2	
Australian White Ibis		49.5	9.3	86.9	0.3	5.6	0.3	4.8	12.3	1.3	53.2	47.3	4.6
Straw-necked Ibis		19.6	0.8	1.3	0.6		1.5	0.6	0.6	0.2		7.1	3.1
Yellow-billed Spoonbill		1.1	1.0	0.7	0.1	1.0		0.6	0.1			2.8	0.8

Table 5. (cont.)

Species	Conservation Significance	Wetland											
		Bibra Lake	Kogolup Lake	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
White-bellied Sea-Eagle	1	0.1	0.1									0.1	
Whistling Kite	3		1.8	0.1								3.2	0.5
Swamp Harrier		0.5	1.0			0.3		0.2	0.1		0.3	1.2	0.2
Purple Swamphen		4.4	42.5			1.6	0.8	0.8	1.8			9.2	2.4
Buff-banded Rail													0.1
Baillon's Crake												0.1	
Australian Spotted Crake													0.1
Spotless Crake		0.1	0.5	0.2								2.2	0.1
Dusky Moorhen	3	2.1	1.3	0.2	0.1	0.4	0.2	0.5	0.3	0.3	0.2		0.2
Eurasian Coot		382.0	18.1	3.2	3.3	4.5	57.6	10.6	3.5	0.9	3.2	0.3	101.1
Black-winged Stilt		342.0	10.6	26.0	8.6	8.0	13.3	4.8	32.1		8.3	207.6	2.3
Banded Stilt		0.5	0.3	1.7	0.1	0.3	0.1				0.3		0.4
Red-necked Avocet		125.0	0.8	6.8	0.8	4.5			1.7		0.5		0.3
Red-capped Plover		106.0	1.8		0.2							41.0	0.3
Black-fronted Dotterel				1.0	0.1	0.1		0.3			1.7	0.1	11.2
Red-kneed Dotterel	3										0.1		
Masked Lapwing (V)													0.1
Black-tailed Godwit	1											0.1	
Common Sandpiper	1		0.1										0.3
Common Greenshank	1	3.5	0.4			0.3			0.2		0.2	0.8	0.1
Marsh Sandpiper	1	0.1	0.1	0.1		0.1						0.5	
Wood Sandpiper	1		0.1			0.7						0.8	
Red-necked Stint	1			0.1								0.3	
Long-toed Stint	1											0.1	
Sharp-tailed Sandpiper	1	0.2	0.6									0.8	
Whiskered Tern		0.3											
Silver Gull		103.7		100.3	4.7		50.5	0.8	0.1			25.0	0.8
Australian Reed-Warbler		0.8	3.5						0.4			4.1	0.8
Little Grassbird		0.1	0.8	0.1								2.1	0.5
Total species:		**45**	**40**	**31**	**18**	**30**	**20**	**27**	**26**	**11**	**28**	**43**	**43**
Mean monthly count:		**2,889.6**	**313.1**	**279.1**	**27.0**	**89.8**	**158.1**	**76.3**	**249.3**	**7.3**	**177.1**	**850.7**	**1,090.0**

Table 6. The highest single count of each bird on each wetland, Aug 2009 - Jul 2010.

Note: Int. = introduced species, V = vagrant species to wetlands on the Swan Coastal Plain.

Species	Conservation Significance	Wetland											
		Bibra Lake	Kogolup Lake	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Musk Duck	3	28	7	10	2	6	3	4	1		6	14	41
Freckled Duck	3										1		
Black Swan		255	157	11	2	2	4	2	155		131	282	67
Radjah Shelduck (V)		1									1		1
Australian Shelduck		99	8	10	33	36	11	18	160	8	33	236	656
Australian Wood Duck		19	1									1	8
Pink-eared Duck	3	730	10			4	9	17	2		106		985
Australasian Shoveler	3	298	48	7		10	20	5	35		6	320	69
Grey Teal		3467	289	47	10	213	53	101	444		305	850	368
Chestnut Teal		1	1										
Northern Mallard (Int.)		5					2	1					1
Pacific Black Duck		1587	326	27	4	35	17	24	392	22	86	810	318
Hardhead	3	577	24			7	2	23			46	4	384
Blue-billed Duck	3	16	12	1			1				1	61	393
Domestic Goose (Int.)		1											3
Australasian Grebe		3	16				1	3	2	2	4	2	4
Hoary-headed Grebe		7	43	26		43		16			56	129	441
Great Crested Grebe		1											
Darter		2		1		1					1		
Little Pied Cormorant		5	3	44		1		4	4	2	3	19	2
Great Cormorant		1		1							1	1	4
Little Black Cormorant		15	1	27		11		7			17		5
Australian Pelican		53	5	2		1		1				17	21
White-necked Heron									1			19	
Eastern Great Egret	1	15	1	2		1		1	1	1		11	1
Intermediate Egret (V)						1							
Cattle Egret	1								1				
White-faced Heron		29	8	5	1	1	1	3	26	2	4	152	3
Little Egret			1	2		1		1				2	
Nankeen Night Heron	3				1					4		1	
Glossy Ibis	1	23							28			44	
Australian White Ibis		490	33	458	4	44	2	18	51	13	196	294	14
Straw-necked Ibis		179	6	11	5		18	3	3	2		54	19
Yellow-billed Spoonbill		10	9	5	1	12		6	1			10	3

Table 6. (cont.)

Species	Conservation Significance	Wetland											
		Bibra Lake	Kogolup Lake	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
White-bellied Sea-Eagle	1	1	1									1	
Whistling Kite	3		7	1								18	2
Swamp Harrier		1	2			1		1	1		1	2	1
Purple Swamphen		10	82			7	4	3	6			37	7
Buff-banded Rail													1
Baillon's Crake												1	
Australian Spotted Crake													1
Spotless Crake		1	3	2								10	1
Dusky Moorhen	3	4	8	2	1	3	1	2	3	2	2		1
Eurasian Coot		1368	48	22	23	17	334	37	29	10	14	3	413
Black-winged Stilt		1553	73	74	82	40	87	26	227		98	1500	10
Banded Stilt		4	4	10	1	2	1				3		5
Red-necked Avocet		1329	9	49	10	35			20		6		2
Red-capped Plover		1272	21		2							209	4
Black-fronted Dotterel				11	1	1		4			19	1	46
Red-kneed Dotterel	3										1		
Masked Lapwing (V)													1
Black-tailed Godwit	1											1	
Common Sandpiper	1		1										1
Common Greenshank	1	22	3			2			2		2	6	1
Marsh Sandpiper	1	1	1	1		1						4	
Wood Sandpiper	1		1			8						8	
Red-necked Stint	1			1								2	
Long-toed Stint	1											1	
Sharp-tailed Sandpiper	1	2	5									6	
Whiskered Tern		4											
Silver Gull		491		382	18		165	6	1			300	8
Australian Reed-Warbler		3	7						2			9	1
Little Grassbird		1	3	1								9	1
Total species:		**45**	**40**	**31**	**18**	**30**	**20**	**27**	**26**	**11**	**28**	**43**	**43**
Total maximum counts:		**13,984**	**1,288**	**1,253**	**201**	**547**	**736**	**337**	**1,598**	**68**	**1,150**	**5,461**	**4,318**

Table 7. Breeding records from each wetland in the study area.

● = recorded during 2009/2010 study, or from sources in Table 1.

● = recorded during 2009/2010 study only.

Species	Conservation Significance	Records on each wetland												
		Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Musk Duck	3	●	●					●	●	●			●	
Black Swan		●	●			●	●	●	●	●	●	●	●	●
Australian Shelduck		●	●						●	●		●	●	●
Pink-eared Duck	3							●	●					
Australasian Shoveler	3							●		●	●			
Grey Teal		●			●			●	●	●	●			●
Pacific Black Duck		●	●	●	●		●	●	●	●	●	●	●	●
Hardhead	3	●								●	●		●	
Blue-billed Duck	3	●	●							●			●	●
Australasian Grebe		●		●				●		●	●		●	
Hoary-headed Grebe		●											●	●
Great Crested Grebe		●								●				
Great Cormorant		●												
Little Pied Cormorant			●						●					
Australian Little Bittern	2		●											
White-faced Heron										●				●
Australian White Ibis												●		
Swamp Harrier													●	
Purple Swamphen		●	●				●	●	●	●		●	●	●
Buff-banded Rail										●				
Ballion's Crake													●	
Spotless Crake													●	
Dusky Moorhen	3	●						●		●				●
Eurasian Coot		●	●	●	●	●	●	●	●	●	●	●	●	●
Black-winged Stilt										●				
Red-capped Plover													●	
Black-fronted Dotterel														●
Red-kneed Dotterel	3													●
Australian Reed-Warbler			●							●			●	
Little Grassbird													●	
Total breeding species:		**14**	**10**	**3**	**3**	**2**	**4**	**10**	**9**	**17**	**7**	**6**	**16**	**12**

Table 8. Breeding species recorded at each wetland, Aug 2009 - Jul 2010.

Note: N = nest recorded only, no chicks.

Species	Conservation Significance	Maximum count of chicks on each wetland											
		Bibra Lake	Kogolup Lake	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Musk Duck	3							1					
Black Swan		N	5		6	4		5	1			198	
Australian Shelduck		1						7				4	
Pink-eared Duck	3							16					
Grey Teal								8					
Pacific Black Duck		8		3			5	15	1		2		11
Blue-billed Duck	3		7										
Australasian Grebe												3	
Hoary-headed Grebe												3	
Little Pied Cormorant								4					
Australian White Ibis											N		
Purple Swamphen			2					1					
Eurasian Coot			2	2	3			1					3
Total breeding species:		**3**	**4**	**2**	**2**	**1**	**1**	**9**	**2**	**0**	**2**	**4**	**2**

4.2 The waterbirds of each of the 13 wetlands in the study area

4.2.1 Bibra Lake

Bibra Lake (Plate 1) is a large wetland of 188.7ha that is bordered to the north by Hope Rd and to the west by Progress Dr. The lake usually has permanent water, though levels can be very low in autumn, such as in the 2009 – 2010 study. The lake is surrounded by a fringe of emergent rushes and paperbark woodland, except on the western edge, where it is bordered by recreational parkland.

A total of 66 wetland bird species are known from Bibra Lake and 45 species were recorded there during the 2009 - 2010 surveys (Tables 4 and 5). The total number of wetland birds present ranged from 9,947 in January down to 515 in March (Figure 11). The graph below shows an obvious summer maximum in overall waterbird numbers, suggesting that Bibra Lake acts as a summer refuge for waterbirds, at least before it dries out. The peak January count is due mainly to waterfowl (9947 birds, of which over a third were Grey Teal) and stilts and avocets (3846 birds). In February, when the lake was mostly dry, over half of the total bird count was made up of Red-capped Plovers, a species that forages on drying lakebeds.

Plate 1. Bibra Lake.

The most abundant waterbirds on Bibra Lake in 2009 – 2010 were the Grey Teal (795.7 birds/survey), Pacific Black Duck (616.6 birds/survey) and Eurasian Coot (382.0 birds/survey) (Table 5). These were the highest mean numbers for these species on any of the 14 wetlands surveyed, indicating that in at least 2009 – 2010, Bibra Lake was an important lake for supporting ducks.

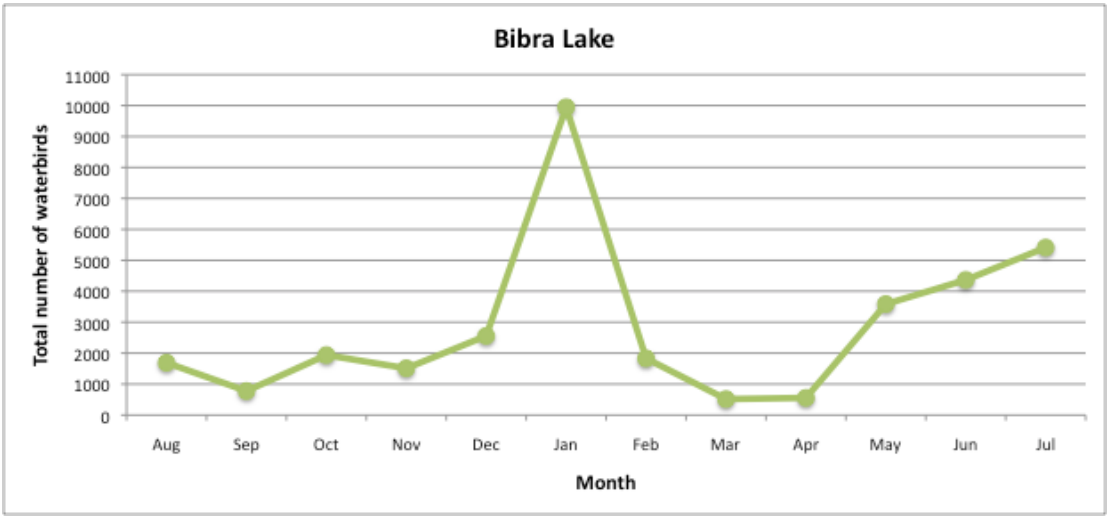

Figure 11. Total number of waterbirds on Bibra Lake, Aug 2009 - Jul 2010.

Overall, 23 conservation significant species are known from Bibra Lake, 13 of CS1, one of CS2 and 10 of CS3. Of the CS1 species, nine are migratory shorebirds of which three species were recorded from Bibra Lake in 2009 – 2010 (Table 5). The low counts and the lack of occurrence between survey periods indicates Bibra Lake is not a significant site for migratory shorebirds. Instead, it is likely that small numbers of migratory shorebirds opportunistically use the lake when water levels are low.

Table 9. Counts of CS1 migratory shorebirds on Bibra Lake.

Note: A = current study, B = Birds Australia Atlas Database (2010), C = Bamford (2009), D = Storey *et al*. (1993), E = WetlandBase (2010).

Species	Maximum count of species within survey period				
	2009 – 2010[A]	1998 – 2010[B]	1999 - 2009[C]	1990 - 1992[D]	1981 - 1988[E]
Little Ringed Plover		present			
Black-tailed Godwit					4
Common Sandpiper		present			1
Common Greenshank	22	1			
Marsh Sandpiper	1	present			
Wood Sandpiper			40		1
Red-necked Stint			30		1
Sharp-tailed Sandpiper	2		20		
Curlew Sandpiper		present			6
Number of species:	**3**	**5**	**3**	**0**	**5**

The remaining CS1 species known from Bibra Lake are the Eastern Great Egret, Glossy Ibis, Eastern Osprey and White-bellied Sea-Eagle. The Eastern Great Egret was relatively common on Bibra Lake, with a maximum count of 15 birds (Table 6). The Glossy Ibis was only recorded in summer (Appendix 4) and is likely to be a regular summer visitor to Bibra Lake, foraging in the shallows when water levels are low.

The only CS2 species recorded on Bibra Lake was the Fairy Tern (Table 4). Although the Fairy Tern occurs on near-coastal wetlands, it favours coastal habitats (Johnstone and Storr 1998). So, although Bibra Lake was the only wetland in the study area at which this species was recorded, Bibra Lake is unlikely to be important habitat for the Fairy Tern.

Ten CS3 species have been recorded on Bibra Lake. Of particular significance is the Dusky Moorhen, which in 2009 – 2010 had the highest mean abundance (2.1 birds/survey) and second highest maximum count (4 birds) of the 13 wetlands sampled. The Dusky Moorhen is not a congregatory waterbird, so wetlands that regularly support small numbers of this species may have local significance. The Dusky Moorhen was also recorded breeding at Bibra Lake (Table 7). In addition, although not recorded in numbers approaching 1% of their global population, the Australasian Shoveler and Hardhead were most abundant on Bibra Lake compared to the other 12 wetlands (Table 5).

In 1989, the EPA reported on discussions with the Royal Australasian Ornithological Union (RAOU, now Birds Australia) about the significance of some of the Beeliar wetlands to waterbirds (Environmental Protection Authority 1989). Notes from these discussions pointed out the importance of Bibra Lake for high waterbird diversity and high numbers of Hoary-headed Grebes. Specifically, this is due to a high count of 4,900 Hoary-headed Grebes in the 1980s (Jaensch et al. 1988). While waterbird diversity appears to remain high, the lake has supported only low numbers of Hoary-headed Grebe; a maximum count of seven in the 2009 – 2010 study, and from the records from Bamford (2009), a maximum of 211 birds in September 2002.

Two species were present in numbers greater than 1% of their global population according to the IBA criteria in Appendix 1. These were the Red-necked Avocet with a maximum count of 1329 birds in January 2010 and the Red-capped Plover with a maximum count of 1272 birds in February 2010 (Table 6). However, in 29 surveys at Bibra Lake between 1999 and 2009, the highest single count of Red-necked Avocets was 20 birds in December 2007, and the highest single count of Red-capped Plover was 35 in November 2007 (Bamford 2009). Other high counts for Red-necked Avocets are 500 birds in August 1983 (WetlandBase 2010), 151 in February 2003 and 201 in January 2008 (Birds Australia Atlas Database 2010), also all lower than the 1% criterion. On the Birds Australia Atlas Database, the highest count for Red-capped Plover on Bibra Lake is 250 birds in April 2005, also below the 1% criterion. Therefore, despite the high numbers of these species in 2010, it seems unlikely that Bibra Lake regularly supports over 1% of the global population of Red-necked Avocet or Red-capped Plover.

4.2.2 Kogolup Lake

Kogolup Lake (Plate 2) is a large wetland that usually retains water all year round, though levels may be low in autumn, as they were in this study. The lake is bordered by the Beeliar Regional Park, with Beeliar Dr in close proximity to the northern boundary. The lake is fringed with emergent rushes, some woodland, and has significant amounts of open water.

Plate 2. Kogolup Lake.

A total of 56 wetland bird species are known from Kogolup Lake (Table 4), and 40 species were recorded there during the 2009 - 2010 surveys. The total number of wetland birds present ranged from 133 in December up to 670 in February (Figure 12), suggesting that Kogolup Lake acts as a late summer refuge for waterbirds while it holds water. As water levels dropped in autumn, the number of waterbirds fell. The increase in numbers in May and June 2010 corresponds to an increase of Black Swans and Pacific Black Ducks on the lake.

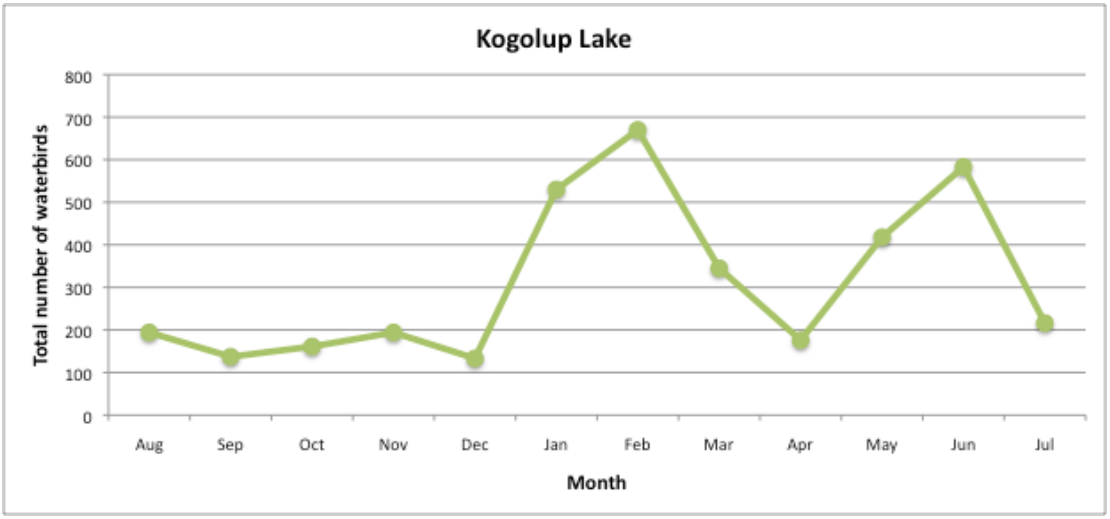

Figure 12. Total number of waterbirds on Kogolup Lake, Aug 2009 - Jul 2010.

The most abundant waterbirds on Kogolup Lake were the Pacific Black Duck (71.0 birds/survey), Grey Teal (53.3 birds/survey) and Purple Swamphen (42.5 birds/survey). Of the 13 wetlands sampled, Lake Kogolup had the highest numbers of the Purple Swamphen, suggesting that the lake may be at least locally significant for this species.

A total of 22 conservation significant species have been recorded from Kogolup Lake, 12 of CS1, one of CS2 and nine of CS3 (Table 4).

Of the 12 CS1 species, nine are migratory shorebirds. Five species of migratory shorebird were recorded from Kogolup Lake in the 2009 – 2010 surveys and the maximum counts obtained for these species in four waterbird studies are given in Table 10. The low counts and the lack of occurrence between survey periods indicates Kogolup Lake is not an internationally significant site for migratory shorebirds. However, Kogolup Lake is recognised as a nationally significant site for Wood Sandpiper on the basis of a count of 60 birds (Watkins 1993).

Table 10. Counts of CS1 migratory shorebirds on Kogolup Lake.

Note: A = current study, B = Bamford (2009), C = Storey *et al*. (1993), D = WetlandBase (2010).

Species	Maximum count of species within survey period			
	2009 – 2010[A]	1999 - 2009[B]	1990 - 1992[C]	1981 - 1988[D]
Common Sandpiper	1	1		
Common Greenshank	3	2	2	7
Marsh Sandpiper	1			3
Wood Sandpiper	1		2	3
Red-necked Stint			63	
Long-toed Stint			13	1
Pectoral Sandpiper			1	
Sharp-tailed Sandpiper	5	2	1	8
Curlew Sandpiper				2
Number of species:	**5**	**3**	**6**	**6**

The remaining CS1 species recorded on Kogolup Lake are the Eastern Great Egret, Glossy Ibis and White-bellied Sea-Eagle. The Eastern Great Egret was recorded only twice in 2009 - 2010 (Appendix 4) and is likely to be a regular visitor to Kogolup Lake in low numbers. The Glossy Ibis is likely to be a regular summer visitor to the lake. The White-bellied Sea-Eagle was recorded once in February 2010, and may forage or roost around the lake on occasion.

Of the nine CS3 species recorded at Kogolup Lake, the Whistling Kite and Dusky Moorhen may be significant (Table 6). The maximum count for Whistling Kite was seven, the second highest obtained in this study. The maximum count of eight Dusky Moorhens was the highest of any wetland in the study, suggesting that Kogolup Lake may be locally important for this species.

4.2.3 Horse Paddock Swamp

Horse Paddock Swamp (Plate 3) is a small, open seasonal wetland of 3.2ha. It is fringed with sparse rushes and trees, and is bordered to the south by Hope Rd and to the north by North Lake.

No birds were recorded at Horse Paddock Swamp during the 2009 – 2010 bird surveys, and the wetland was dry for the entire survey period. In years when water is present in winter and spring, the wetland is likely to support a suite of wetland species, particularly those that use shallow freshwater habitats, and 23 species were recorded in the 1980s and early 1990s (Storey *et al*., 1993, WetlandBase 2010).

Plate 3. Horse Paddock Swamp.

Five conservation significant species are known from Horse Paddock Swamp, one of CS1 and four of CS3 (Table 4). The only CS1 species was the Eastern Great Egret, a species that is likely to opportunistically use the shallow margins of this wetland when water is present. The four CS3 species are ducks, all present in low numbers.

Although no breeding records were obtained for this wetland in 2009 – 2010, three breeding species, the Pacific Black Duck, Eurasian Coot and Australasian Grebe have been recorded (Table 7).

4.2.4 Lake Coogee

Lake Coogee (Plate 4) is a relatively large, saline wetland of 62.9ha, that is bordered on the east by Fawcett Rd, a relatively quiet suburban road. The lake is fringed with a narrow strip of samphire, emergent rushes and paperbark woodland. Lake Coogee has extensive open water that is present year-round.

A total of 50 wetland bird species are known from Lake Coogee (Table 4), and 31 species were recorded there during the 2009 - 2010 surveys (Table 5). The total number of wetland birds present ranged from 40 in September up to 792 in March (Figure 13). The peak in March was due mainly to Australian White Ibis and Silver Gulls (Appendix 4).

Plate 4. Lake Coogee.

The most abundant birds on Lake Coogee were the Silver Gull (100.3 birds/survey), Australian White Ibis (86.9 birds/survey) and Black-winged Stilt (26.0 birds/survey) (Table 5). In general, Lake Coogee appears less important for ducks than other wetlands, instead having a higher proportion of cormorants (mainly Little Pied Cormorant and Little Black Cormorant) and Silver Gulls. This is likely to be a reflection of the proximity of Lake Coogee to the coast, as well as the salinity of the lake.

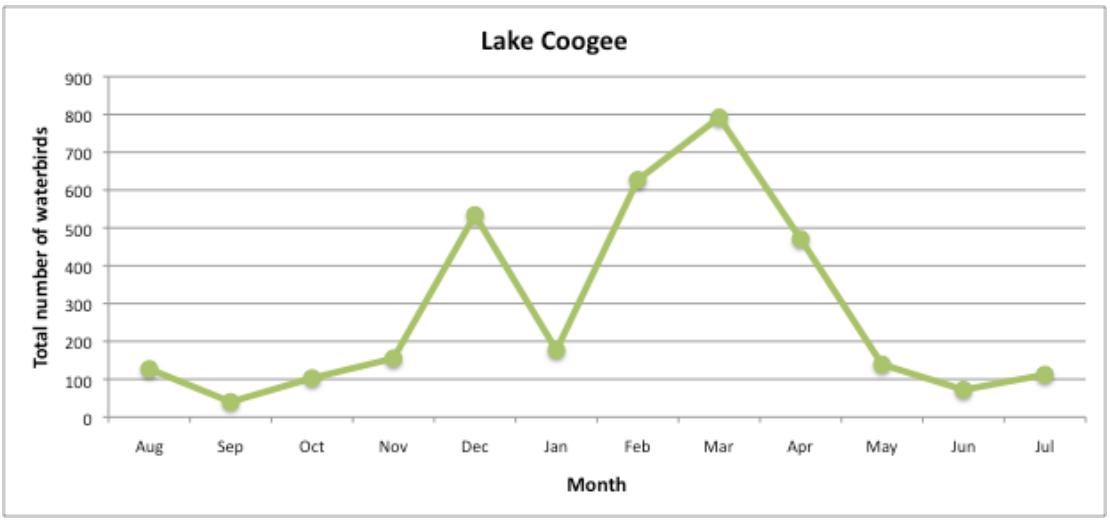

Figure 13. Total number of waterbirds on Lake Coogee, Aug 2009 - Jul 2010.

A total of eighteen conservation significant species have been recorded from Lake Coogee, 11 of CS1 and seven of CS3. Eight of the CS1 species are migratory shorebirds, of which two were recorded in 2009 – 2010 (Table 11). Very low counts were obtained in the studies indicated in Table 11. Ecoscape (2006) provide data indicating that Lake Coogee supported up to six migratory shorebirds, and although those data do not include counts of each species, it is unlikely the lake has supported significant numbers of shorebirds in the past. Two of the species listed, the Great Knot and Grey-tailed Tattler, generally prefer coastal or estuarine environments, and are not likely to be regular visitors to the lake. The low counts and the lack of regular occurrence from year to year indicate Lake Coogee is not a significant site for migratory shorebirds.

Table 11. Counts of CS1 migratory shorebirds on Lake Coogee.

Note: A = current study, B = Ecoscape (2006), C = WetlandBase (2010).

Species	Maximum count of species within survey period		
	2009 – 2010[C]	1993 – 1995[B]	1981 - 1988 [C]
Bar-tailed Godwit		present	
Common Sandpiper		present	
Grey-tailed Tattler			1
Common Greenshank		present	5
Marsh Sandpiper	1		
Great Knot			
Red-necked Stint	1	present	3
Curlew Sandpiper		present	1
Number of species:	**2**	**5**	**4**

The Eastern Great Egret was recorded in four of the 12 surveys (Appendix 4), and is likely to be a regular visitor to Lake Coogee. The Eastern Osprey and White-bellied Sea-Eagle have both been recorded at Lake Coogee, though given the proximity of the lake to the coast, these species may have simply been overflying the lake.

None of the seven CS3 species, mainly ducks, are known to occur in significant numbers on Lake Coogee, although it is one of the few wetlands in the study area at which the Red-kneed Dotterel has been recorded. Only three species are known to breed on the lake (Table 7), though this low total may be due to the lack of survey effort.

4.2.5 Fawcett Rd Wetland

Fawcett Rd Wetland (Plate 5) is a small wetland of 4.4ha. The wetland is seasonal, and has a narrow fringe of samphire, rushes and paperbark woodland. On the western border, semi-rural properties run to the waters edge.

Plate 5. Fawcett Rd Wetland.

A total of 18 wetland bird species are known from Fawcett Rd Wetland (Table 4), and these are the 18 species were recorded there during the 2009 - 2010 surveys. No other waterbird data have been found for this wetland. The total number of wetland birds present ranged from 0 in April when the wetland was dry, up to 99 in May, mostly due to a flock of Black-winged Stilts (Figure 14).

The most abundant birds on the Fawcett Rd Wetland were the Black-winged Stilt (8.6 birds/survey), Silver Gull (4.7 birds per survey) and Australian Shelduck (4.2 birds/survey) (Table 5). As a small wetland, Fawcett Rd Wetland is not likely to support significant numbers of any wetland bird species. However, it does support some breeding by Eurasian Coots and Black Swans (Table 7).

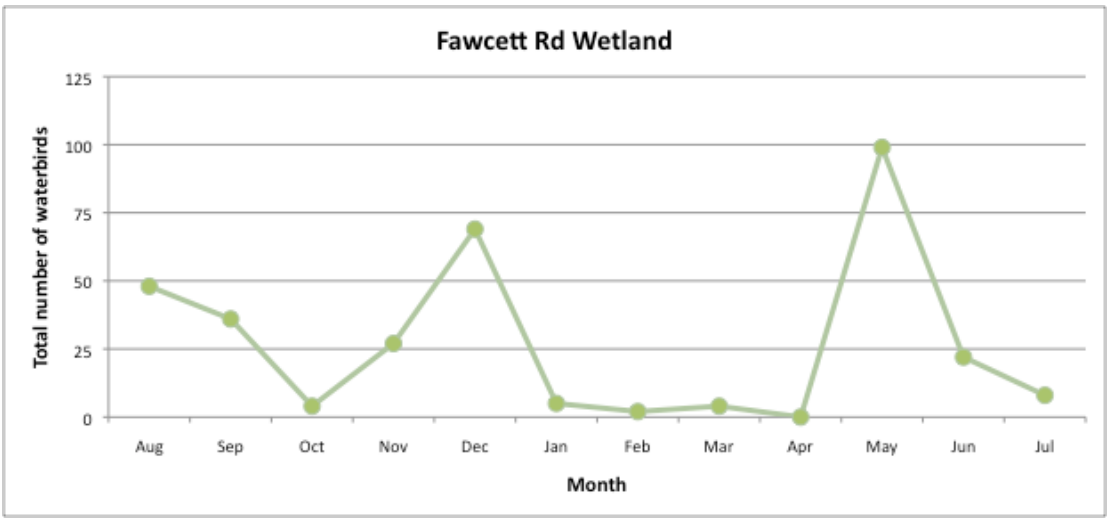

Figure 14. Total number of waterbirds on Fawcett Rd Wetland, Aug 2009 - Jul 2010.

Only three conservation significant birds were recorded, all of CS3. The Musk Duck, Nankeen Night-Heron and Dusky Moorhen were all recorded in low numbers. Only two species, the Eurasian Coot and Black Swan, were recorded breeding on Fawcett Rd wetland, but given the lack of any other survey data, this may be an underestimate.

4.2.6 Little Rush Lake

Little Rush Lake (Plate 6) is a moderate-sized wetland of 11.2ha. The wetland is usually permanent, and has a fringe of rushes and woodland.

A total of 43 wetland bird species are known from Little Rush Lake (Table 4), and 30 species were recorded there during the 2009 - 2010 surveys (Table 5). The total number of wetland birds present ranged from 300 in February down to 7 in July (Figure 15). The graph below shows an obvious summer maximum in overall waterbird numbers, suggesting that Little Rush Lake acts as a summer/autumn refuge for waterbirds, as other wetlands in the vicinity dry out. A large proportion of the birds in January – March 2010 were Grey Teal, as well as Black-winged Stilt and Red-necked Avocet that made use of the shoreline exposed as the water level dropped.

The most abundant species on Little Rush Lake were the Grey Teal (36.8 birds/survey), Pacific Black Duck (8.2 birds/survey) and Black-winged Stilt (8.0 birds/survey) (Table 5). Overall however, both the total counts of birds and the counts of individual species were low. Although four species have been recorded breeding at the wetland (Table 7), only the Black Swan was recorded as a breeding bird in 2009 – 2010.

Plate 6. Little Rush Lake.

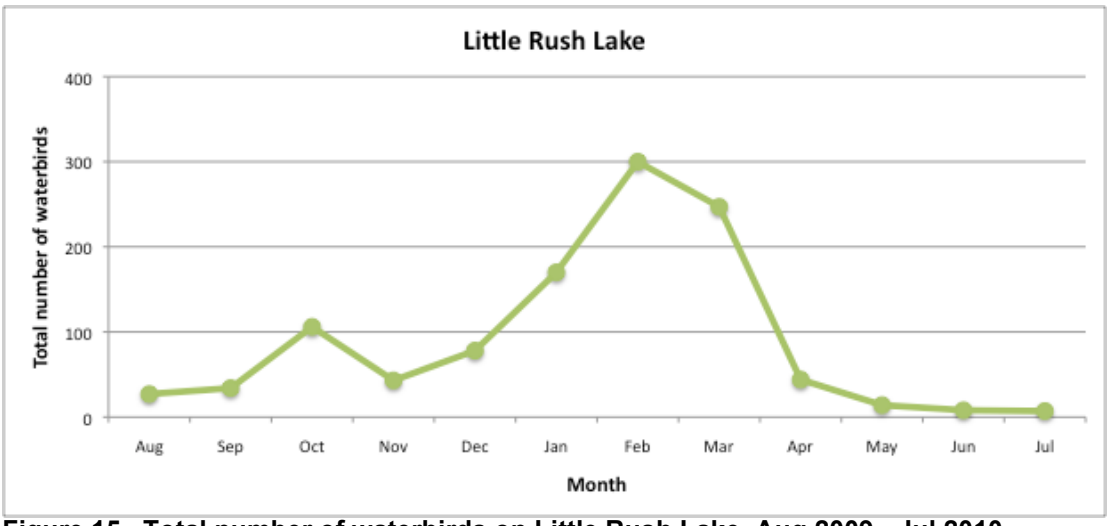

Figure 15. Total number of waterbirds on Little Rush Lake, Aug 2009 - Jul 2010.

Twelve conservation significant species have been recorded from Little Rush Lake. The five CS1 species include the Glossy Ibis, Eastern Great Egret and three migratory shorebirds. The Eastern Great Egret was recorded once in 2009 – 2010 (Appendix 4) and is likely to be a regular visitor to the wetland in low numbers. The Glossy Ibis was not recorded in 2009 – 2010, but was recorded in December 2006 and January 2007 (Birds Australia Atlas Database 2010). Small numbers of Glossy Ibis may occasionally visit Little Rush Lake in summer, when the water levels are low.

The three CS1 migratory shorebirds recorded were the Common Greenshank, Marsh Sandpiper and Wood Sandpiper (Table 5). All three had maximum counts of eight or less

birds in 2009 – 2010 (Table 6) and no migratory shorebirds were recorded on this wetland on WetlandBase (2010). Little Rush Lake is not likely to be an important site for migratory shorebirds.

Seven CS3 species have been recorded from Little Rush Lake, all in low numbers. Three CS3 species have been recorded breeding on the wetland, the Musk Duck, Pink-eared Duck, Australasian Shoveler and Dusky Moorhen (Table 7).

4.2.7 Manning Lake

Manning Lake (Plate 7) is a moderate-sized wetland of 14.9ha, and is bordered by Manning Park Bushland to the west and suburban development to the east. The lake is surrounded by a fringe of emergent rushes, samphire and paperbark woodland, which in turn is surrounded by recreational parkland.

A total of 32 wetland bird species are known from Manning Lake (Table 4), and 20 species were recorded there during the 2009 - 2010 surveys. The total number of wetland birds present ranged from 379 in July down to 1 in January, when the wetland was mostly dry (Figure 16). The high count in January was due in part to a count of 165 Silver Gulls and 87 Black-winged Stilts (Appendix 4).

The most abundant waterbirds on Manning Lake were the Eurasian Coot (57.6 birds/survey), Silver Gull (50.5 birds/survey) and Grey Teal (17.2 birds/survey) (Table 5). Overall, total waterbird numbers and numbers of individual species were low. Manning Lake is unlikely to support significant numbers of any waterbird species.

Plate 7. Manning Lake.

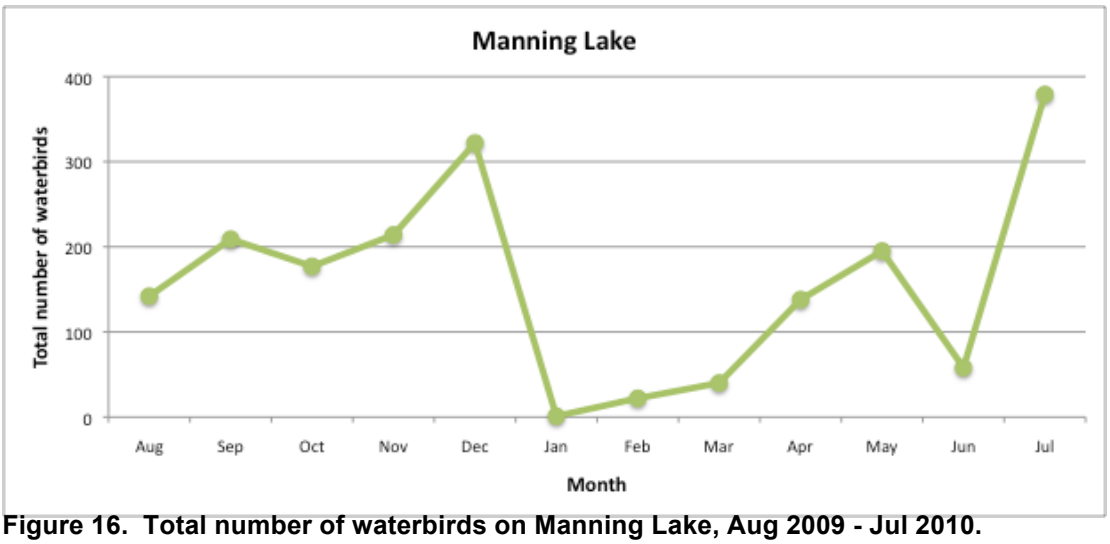

Figure 16. Total number of waterbirds on Manning Lake, Aug 2009 - Jul 2010.

Overall, ten conservation significant species have been recorded from Manning Lake, two of CS1 and eight of CS3 (Table 4). The CS1 species were the Eastern Great Egret and Common Greenshank, neither of which were recorded in 2009 – 2010 (Table 5). The Eastern Great Egret is likely to be a regular visitor but the Common Greenshank is only likely to occur on occasion.

Six CS3 species were recorded on Manning Lake in 2009 – 2010, all with low maximum counts of 20 birds or less (Table 6). Although only one species was recorded breeding in 2009 – 2010, previous records include breeding by four CS3 species, the Musk Duck, Pink-eared Duck, Australasian Shoveler and Dusky Moorhen (Tables 7 and 8).

4.2.8 Market Garden Swamp

Market Garden Swamp (Plate 8) is a small wetland that is virtually surrounded by suburban development. The swamp is surrounded by a narrow fringe of emergent rushes, samphire and paperbark woodland. There is a low samphire-covered island in the centre of the open water, dead trees scattered around the perimeter and sump areas that have been created for stormwater management and wildlife habitat.

A total of 33 wetland bird species are known from Market Garden Swamp (Table 4), and 27 species were recorded there during the 2009 - 2010 surveys. The total number of wetland birds present ranged from 163 in December down to 0 in February, when the wetland was dry (Figure 17). The high count in December was mainly due to 101 Grey Teal congregating on the swamp, while peak in autumn was due mainly to 40 Grey Teal and 26 Black-winged Stilt (Appendix 4).

The most abundant birds on Market Garden Swamp were the Grey Teal (23.0 birds/survey), Eurasian Coot (10.6 birds/survey) and Pacific Black Duck (10.3 birds/survey) (Table 5). No birds were present in particularly high counts (Table 6), but Market Garden Swamp had the highest number of breeding species, with nine recorded during the 2009 – 2010 survey period (Table 8).

Plate 8. Market Garden Swamp.

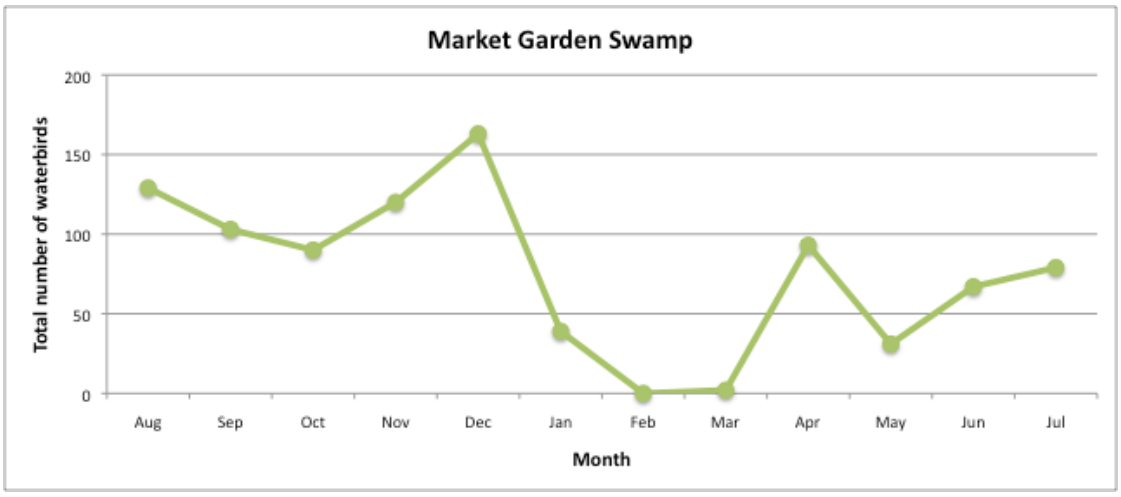

Figure 17. Total number of waterbirds on Market Garden Swamp, Aug 2009 - Jul 2010.

Nine conservation significant species are known from Market Garden Swamp, two of CS1 and seven of CS3 (Table 4). Of the two CS1 species, only the Eastern Great Egret was recorded in 2009 – 2010, with single birds present on two occasions (Table 6, Appendix 4). The Eastern Great Egret was also recorded by Ecoscape (1996), and is likely to be a regular visitor to Market Garden Swamp.

The other CS1 species was the Common Greenshank, the only migratory shorebird species recorded at Market Garden Swamp was the Common Greenshank, and it was not recorded in 2009 – 2010 (Table 5). While occasional migratory shorebirds may visit this wetland, Market Garden Swamp is not likely to be an important shorebird site.

The seven CS3 species were present in low numbers (Table 6, Appendix 1). However, two CS3 species, the Musk Duck and the Pink-eared Duck, were recorded breeding in 2009 – 2010 (Table 8).

4.2.9 North Lake

North Lake (Plate 8) is a moderately sized wetland of 24.6ha. The lake is seasonal, and the open water is extensive when present.

A total of 57 wetland bird species are known from North Lake (Table 4), and 26 species were recorded there during the 2009 - 2010 surveys. The total number of wetland birds present ranged from 1357 in December down to 0 in February and March, when the wetland was dry (Figure 18). The peak counts in November and December were mainly due to ducks (Grey Teal, Pacific Black Duck and Australian Shelduck) congregating on the remaining water, and Black-winged Stilts making use of the shallows.

The most abundant waterbirds on North Lake were the Pacific Black Duck (78.5 birds/survey), Grey Teal (51.8 birds/survey) and Black-winged Stilt (32.1 birds/survey) (Table 5).

Plate 9. North Lake.

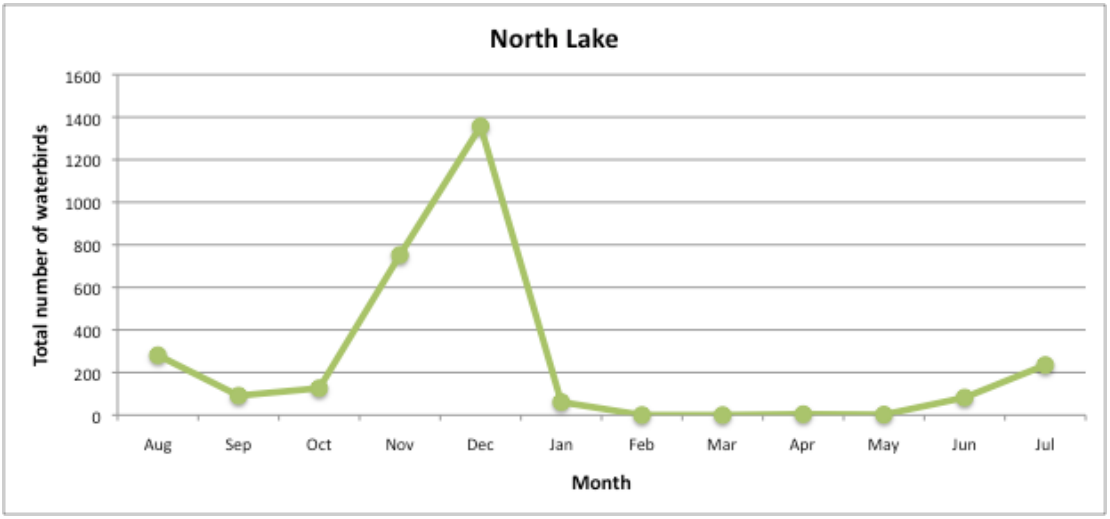

Figure 18. Total number of waterbirds on North Lake, Aug 2009 - Jul 2010.

A total of 16 conservation significant species have been recorded from North Lake, eight of CS1 and eight of CS3 (Table 4). The CS1 species include five migratory shorebirds, of which only the Common Greenshank was recorded in 2009 – 2010. Migratory shorebirds are only present in low numbers on occasion. For example, high counts between 1980 and 2002 were of 30 Red-necked Stints, eleven Common Greenshank, four Black-tailed Godwits and single Sharp-tailed Sandpipers and Common Sandpipers (Maddeford 2003). North Lake is not likely to be an important site for migratory shorebirds.

The remaining CS1 species recorded are the Eastern Great Egret, Cattle Egret, Glossy Ibis, Eastern Osprey and White-bellied Sea-Eagle. The Eastern Great Egret is likely to be a regular visitor to the lake, while the Cattle Egret is likely to be a very occasional visitor. Both species are likely to forage in the shallows when water levels are low.

Of the eight CS3 species, five were recorded in low numbers in 2009 – 2010 (Table 5). However, the highest number of breeding species of the 13 wetlands surveyed were present at North Lake (Table 7).

4.2.10 Lower Swamp and Roe Swamp

Roe Swamp and associated sumplands (Plates 10 and 11) is a 12ha wetland to the east of North Lake, of which Lower Swamp is a part. The wetland is mostly densely vegetated with *Melaleuca* woodlands and rushes, with a small area of seasonal open water in Lower Swamp, though this was mostly dry in 2009 – 2010.

A total of 23 wetland bird species are known from Lower Swamp and eleven species were recorded there during the 2009 - 2010 surveys (Tables 4 and 5). The total number of wetland birds present ranged from 28 in August down to 0 in December 2009 – June 2010, when the wetland was dry (Figure 19).

All waterbirds were present in very low numbers (Table 5). In previous studies in the 1990s and 1980s, waterbird numbers have been higher (Storey *et al*. 1993 and WetlandBase 2010). This may be due to higher water levels in those years.

Plate 10. Lower Swamp (north-west corner of Roe Swamp system).

Plate 11. Roe Swamp (south-east corner).

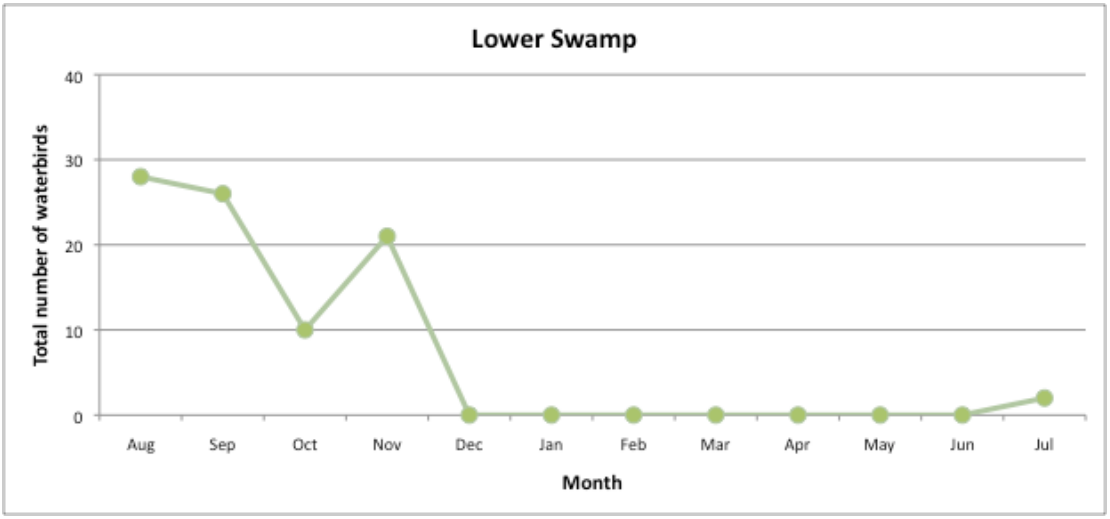

Figure 19. Total number of waterbirds on Lower Swamp, Aug 2009 - Jul 2010.

A total of six conservation significant species have been recorded from Lower Swamp, one of CS1 and 5 of CS3. The Eastern Great Egret is the only CS1 species recorded, and is likely to be an occasional visitor to the open areas in Lower Swamp. The CS3 species were all present in low numbers, however small numbers of Nankeen Night-Herons may roost in the woodlands, as two birds were recorded there in 2009 (M. Clunies-Ross, pers.comm. 2010).

4.2.11 South Lake

South Lake (Plate 12) is a moderate-sized wetland of 31.5ha, with seasonal open water.

A total of 41 wetland bird species are known from South Lake (Table 4), and 28 species were recorded there during the 2009 - 2010 surveys. The total number of wetland birds present ranged from 430 in January down to 0 in March, when the wetland was dry (Figure 20). The high count in January was due mainly to 305 Grey Teal (Appendix 4). In February, as the lake was drying and exposing more shoreline, the count was mostly of 98 Back-winged Stilt.

The most abundant waterbirds on South Lake were the Australian White Ibis (53.2 birds/survey), Grey Teal (30.8 bird/survey) and Black Swan (20.7 birds/survey) (Table 5).

A total of 15 conservation significant species have been recorded from South Lake, five of CS1, and ten of CS3 (Table 6). Three of the CS1 species are migratory shorebirds, all recorded sporadically in low numbers and of which only the Common Greenshank was recorded in 2009 – 2010. South Lake is not an important site for migratory shorebirds.

The remaining two CS1 species recorded on South Lake are the Eastern Great Egret and the Cattle Egret. The Eastern Great Egret is likely to be a regular visitor to the lake in low numbers, while the Cattle Egret is likely to be a very occasional visitor. Both species are likely to forage in the shallows when water levels are low.

The CS3 species were all present in low numbers. South Lake was the only wetland at which the Freckled Duck was recorded, but this species is likely to be an occasional visitor to any of the wetlands in the study area. It was also the only wetland at which the Red-kneed Dotterel was recorded in 2009 – 2010 (Table 5).

Plate 12. South Lake.

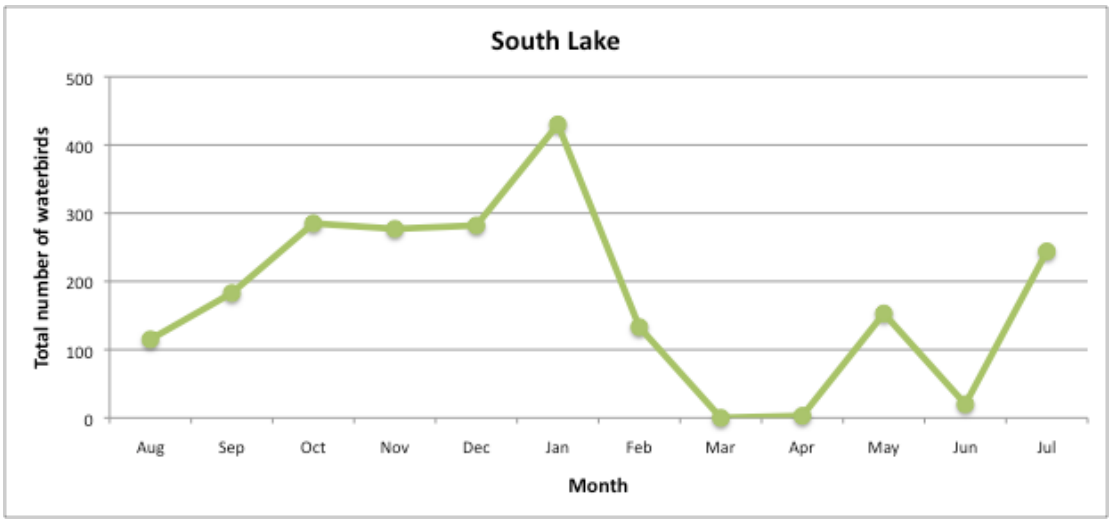

Figure 20. Total number of waterbirds on South Lake, Aug 2009 - Jul 2010.

4.2.12 Thomsons Lake

Thomson's Lake is listed by Environment Australia (2001) as a nationally important wetland. Of the 13 wetlands surveyed in 2009 - 2010, only Thomson's Lake has any formal recognition as an important site for wetland birds. It is part of Ramsar Site number 481, 'Forrestdale and Thomsons Lakes'. It is also listed as an internationally significant shorebird site due to large numbers of Curlew Sandpiper (Bamford *et al*. 2008) and a nationally significant shorebird site due to large numbers of Curlew Sandpiper, Red-capped Plover and Red-necked Avocet (Watkins 1993).

A total of 71 wetland bird species are known from Thomsons Lake (Table 4), which is the highest of the thirteen wetlands. A total of 43 species were recorded there during the 2009 - 2010 surveys, which was the second highest, after Bibra Lake. The total number of wetland birds present ranged from 4696 in January down to 14 in April, when the wetland was dry (Figure 21).

Plate 13. Thomsons Lake.

The most abundant waterbirds on Thomsons Lake in 2009 – 2010 were the Black-winged Stilt (207.6 birds/survey), Pacific Black Duck (138.2 birds/survey) and Black Swan (97.5 birds/survey) (Table 5). The Black Swan was also a breeding bird with up to 198 chicks recorded, a far higher number than any other wetland sampled. At least 16 species are known to breed at Thomsons Lake, including the only records of breeding by the Swamp Harrier and Ballion's Crake (Table 7).

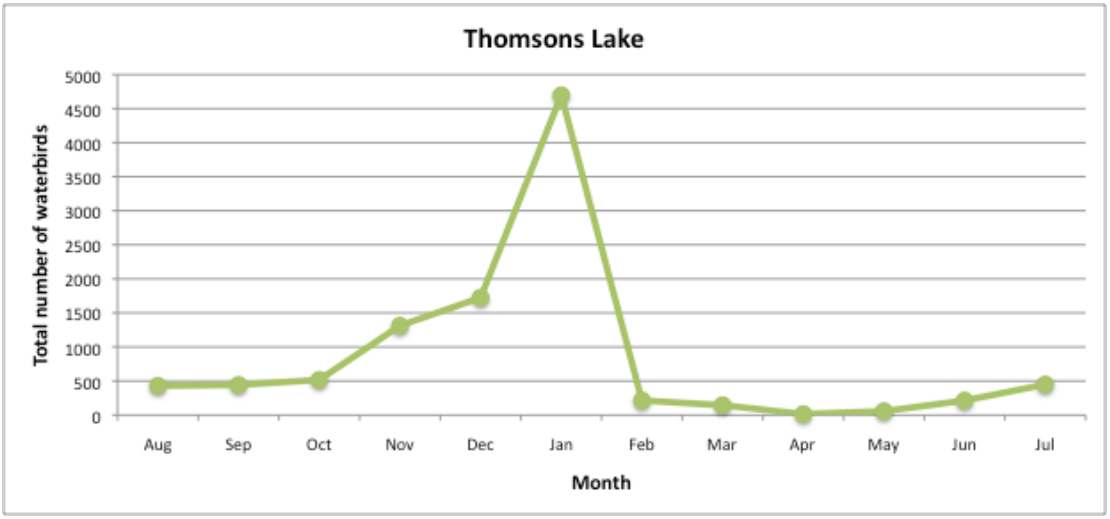

Figure 21. Total number of waterbirds on Thomsons Lake, Aug 2009 - Jul 2010.

A total of 31 conservation significant species have been recorded on Thomsons Lake, the highest for any wetland in the study area. Making up this total are 20 CS1 species, two CS2 species and nine CS3 species (Table 4).

The 20 CS1 species include 14 migratory shorebirds, of which seven were recorded in 2009 – 2010 (Tables 4 and 5). The maximum counts obtained for these species in four waterbird studies are given in Table 12. The counts of Curlew Sandpiper in the 1980s led to this site being named an internationally important shorebird site in Bamford *et al*. (2008), as it is greater than 1% of the flyway population of this species (Appendix 1). However, in recent studies no large counts were revealed, though Thomsons Lake still supports a relatively high species richness of migratory shorebirds. The decline in migratory shorebirds may be due to a number of factors, including low rainfall affecting lake water levels, encroachment of vegetation onto the lakebed (Bancroft and Bamford 2009) and possible impacts on shorebird populations outside of Australia (Bamford *et al*. 2008).

The remaining six CS1 species are the Australasian Bittern, Eastern Great Egret, Glossy Ibis, Eastern Osprey, White-bellied Sea-Eagle and White-winged Black Tern.

Thomsons Lake is the only lake in the study area at which the Australasian Bittern has been recorded (Table 4). Two birds were recorded at the lake in six of the seven years between 1981 and 1988 (Jaensch *et al*. 1988), and it was also recorded in 1991 (Storey *et al*. 1993). Although the current value of Thomsons Lake to this species is unknown, the presence of the Australasian Bittern is one of the reasons that this lake is named as a Ramsar site (DCLM 2003).

Counts of the Eastern Great Egret are relatively high compared with other wetlands in the study area, with maximum counts of 11 in 2009 – 2010 (Table 6), five in 1990 – 1992 (Storey *et al*. 1993) and 15 in 1981 - 1988 (Jaensch et al. 1988). This is likely a reflection of the large size of the wetland and the extensive areas of shallow water. Similarly, the Glossy Ibis is likely to be a regular summer visitor in small numbers, foraging in similar habitat.

Table 12. Counts of CS1 migratory shorebirds on Thomsons Lake.

Note: A = current study, B = Bamford (2009), C = Birds Australia Atlas Database (2010), D = Storey *et al*. (1993), E = WetlandBase (2010).

Species	Maximum count of species within survey period				
	2009 – 2010[A]	1999 - 2009[B]	1998 - 2010[C]	1990 - 1992[D]	1981 - 1988[E]
Black-tailed Godwit	1		2	6	15
Bar-tailed Godwit					1
Common Sandpiper					
Common Greenshank	6	15	29	8	40
Marsh Sandpiper	4			4	30
Wood Sandpiper	8			45	21
Great Knot					1
Red Knot					1
Red-necked Stint	2		600		2500
Long-toed Stint	1		2	3	11
Pectoral Sandpiper	6				3
Sharp-tailed Sandpiper			100	375	1000
Curlew Sandpiper			150	240	2500
Ruff					1
Number of species:	**7**	**1**	**6**	**7**	**13**

The Eastern Osprey and White-bellied Sea-Eagle are likely to be occasional visitors to the lake when water is present. The Eastern Osprey is mainly a coastal species and is not likely to breed at Thomsons Lake. Although the White-bellied Sea-Eagle is known to sometimes nest inland (Marchant and Higgins 1993), no breeding records have been noted.

Thomsons Lake is the only wetland in the study area at which the White-winged Black Tern has been recorded (Table 4). This CS1 species was not recorded during the 2009 – 2010 survey, but counts of 66 (Storey *et al.* 1993), 60 (Jaensch *et al*. 1988) and 150 (Jaensch *et al.* 1993) are known from past surveys. Although these counts do not approach 1% of the global population, these counts have been recognised as significant (CALM 2003).

Nine CS3 species are known from Thomsons Lake. Of particular significance are the Australasian Shoveler and Blue-billed Duck, both of which had counts that exceeded their IBA 1% global population criteria in the 1980s (Jaensch *et al*. 1988). Other species recognised as significant at Thomsons Lake are the Swamp Harrier, Ballions Crake, Black-winged Stilt, Red-necked Avocet and Red-capped Plover (CALM 2005).

Thomsons Lake is the only wetland in the study area at which the Swamp Harrier has been recorded breeding (Table 7), and is possibly the only wetland on the Swan Coastal Plain at which this species still breeds (CALM 2003). Similarly, it is one of the few wetlands where Ballions Crake has been recorded breeding (CALM 2003).

The Black-winged Stilt (3000 birds in January 1986), Red-necked Avocet (2000 birds in December 1983) and Red-capped Plover (1000 in February 1986) have all been recorded on Thomsons Lake with numbers exceeding 1% of their global populations. Most of these counts were obtained in the 1980s (Jaensch *et al*. 1988), and similarly high counts have not been recorded in this study. However, counts of Black-winged Stilt almost as high (2500 in December 2004) were obtained by Bamford (2009).

4.2.13 Yangebup Lake

Yangebup Lake (Plate 13) is a large, open wetland of 188ha that usually retains water all year round. The wetland is situated in a reserve, but the eastern boundary is close to a light industrial area, and Beeliar Dr and North Lake Rd are close to the northern and southern boundaries respectively. Yangebup Lake is fringed with rushes and woodland, but as a deeper wetland, lacks the extensive shallow areas present at other wetlands in the study area.

Plate 14. Yangebup Lake.

A total of 65 wetland bird species are known from Yangebup Lake (Table 4), and 43 species were recorded there during the 2009 - 2010 surveys (Table 5). The total number of wetland birds present ranged from 1758 in January down to 378 in August (Figure 22). The high numbers of waterbirds on the lake were due mainly to species that use open-water habitats, the waterfowl (ducks, swans and coots) and grebes. Yangebup Lake contained water all year in 2009 - 2010, so may be an important summer/autumn refuge for waterbirds on the Swan Coastal Plain.

The most abundant waterbirds on Yangebup Lake in 2009 – 2010 were the Pink-eared Duck (252.1 birds/survey), Blue-billed Duck (211.8 birds/survey) and Australian Shelduck (125.5 birds/survey) (Table 5). Both the mean and maximum counts of Pink-eared Duck and Blue-billed Duck were the highest of any wetland in the study.

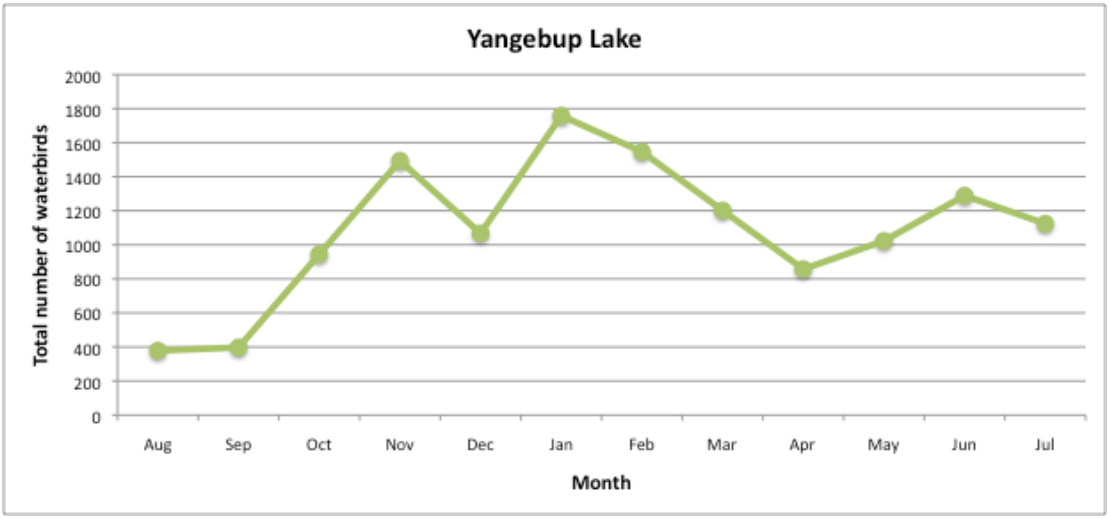

Figure 22. Total number of waterbirds on Yangebup Lake, Aug 2009 - Jul 2010.

A total of 23 conservation significant species have been recorded on Yangebup Lake, 15 of CS1, one of CS2 and nine of CS3 (Table 4).

Twelve of the CS1 species are migratory shorebirds, of which two species of migratory shorebird were recorded from Yangebup Lake in the 2009 – 2010 surveys (Table 5). No counts of migratory shorebirds exceed 1% of their global population estimate, and in the 1990s and 2000s, numbers were very low (Table 13). Although Yangebup Lake may occasionally support moderate flocks of some species, it appears not to be a significant site for CS1 migratory shorebirds.

Table 13. Counts of CS1 migratory shorebirds on Yangebup Lake.

Note: A = current study, B = Birds Australia Atlas Database (2010), C = Bamford (2009), D = Storey *et al*. (1993), E = WetlandBase (2010).

Species	Maximum count of species within survey period				
	2009 – 2010[A]	1998 - 2010[B]	1999 - 2009[C]	1990 - 1992[D]	1981 – 1988[E]
Pacific Golden Plover		present			
Grey Plover		present			
Little Ringed Plover		present			
Common Sandpiper	1	2			1
Common Greenshank	1	1			1
Wood Sandpiper		present		6	5
Red-necked Stint		15			1500
Long-toed Stint				2	15
Pectoral Sandpiper				1	
Sharp-tailed Sandpiper				1	80
Curlew Sandpiper		1		9	200
Ruff					1
Number of species:	**2**	**8**	**0**	**5**	**8**

The remaining CS1 species recorded at Yangebup Lake were the Eastern Great Egret, White-bellied Sea-Eagle and White-winged Black Tern. In 2009 – 2010 the Eastern Great Egret was recorded generally as a single bird on about half the surveys, and it is likely to be a regular visitor to the wetland to forage in the shallows. The White-bellied Sea-Eagle was not recorded in 2009 – 2010, but is likely to be an occasional visitor to the wetland. The White-winged Black Tern is an irruptive species that may be common in some years.

The nine CS3 species on Yangebup Lake were the Musk Duck, Pink-eared Duck, Australasian Shoveler, Hardhead, Blue-billed Duck, Nankeen Night-Heron, Whistling Kite, Dusky Moorhen and Red-kneed Dotterel (Table 4). Counts for Musk Duck, Australian Shoveler and Hardhead were generally low in 2009 – 2010, as well as in 1990 – 1992 (Storey *et al*. 1993) and in the 1980s (WetlandBase 2010). Nankeen Night-Herons are represented by sporadic counts of one or two birds, suggesting that although birds may roost in the trees surrounding the lake, a large roost is not present.

In 1989, the EPA reported on discussions with the Royal Australasian Ornithological Union (RAOU, now Birds Australia) about the significance of some of the Beeliar wetlands to waterbirds (Environmental Protection Authority 1989). Notes from these discussions pointed out the importance of Yangebup Lake, for supporting the largest number of Pink-eared Ducks and Blue-billed Ducks of any wetland in the south-west (Environmental Protection Authority 1989).

In the 2009 – 2010 surveys, the Blue-billed Duck was present in numbers greater than 1% of its global population according to the IBA criteria in Appendix 1. The Blue-billed Duck had a maximum count of 393 birds in January 2010 and a mean abundance of 211.8 birds/survey (Tables 5 and 6). In 28 surveys at Yangebup Lake between 1999 and 2009, the highest single count of Blue-billed Duck was 809 in February 2007 (Bamford 2009). Other high counts for Blue-billed Ducks include 640 birds in 1986, 708 birds in 1987 and 865 birds in 1988 (WetlandBase 2010). Therefore, it seems likely that Yangebup Lake regularly supports over 1% of the global population of the Blue-billed Duck, making it a significant site for this species.

Although not near 1% of the global population, counts of Pink-eared Duck were high at Yangebup Lake, with a maximum count of 985 birds in July 2010 and a mean abundance of 252.1 birds per survey (Tables 5 and 6). Counts of Pink-eared Ducks on Yangebup Lake in the 1980s includes a very high count of 2200 birds in July 1986, and lower counts of 928 in March 1987 and 702 in June 1988 (Wetlandbase 2010). Although these counts are far lower than 1% of the global population estimate for this species, Yangebup Lake appears to consistently support good numbers of Pink-eared Duck compared with other wetlands in the study area, suggesting it may be locally significant for this species.

Though not recorded in 2009 – 2010, the Red-kneed Dotterel is likely to be an irregular visitor to Yangebup Lake when water levels are low enough for the shore to be exposed. Yangebup Lake also has the only breeding record for this species (Table 7).

4.3 Wetland bird movements and population fluctuations

One of the difficulties with assessing changes in waterbird populations is the lack of long-term systematic data. This is especially the case with breeding records, which are often only opportunistic in nature. A complete review of the changes that waterbird populations of the study area have undergone are outside of the scope of this review. However, comments by Bamford *et al*. (2010) serve to put the results of the 2009 – 2010 study into context by summarising some of the reasons for the fluctuation in waterbird numbers between seasons and between years on the Jandakot wetlands:

- Local conditions that affect waterbird numbers include water depth and persistence, peak water levels, vegetation cover and habitat quality. These factors are usually not as important as regional conditions, except in extreme conditions, for example if the wetland is dry.

- There is some interaction between lake systems and the estuary systems on the Swan Coastal Plain.

- Populations of shorebirds have dropped in abundance due to the vegetation changes on the lakebeds that have resulted from persistent low water levels.

- When there is high rainfall in the south-west agricultural zone in winter and spring, there is a high availability of wetlands in this area. Birds that congregate in coastal wetlands in summer disperse inland to take advantage of these wetlands, possibly for breeding.

Most wetland birds are highly mobile. While the annual migration of shorebirds is an obvious example, many other groups of wetland birds make seasonal or nomadic movements within Australia. In summer, many species can be concentrated on permanent wetlands on the Swan Coastal Plain. In winter and spring, birds spread out on to seasonal and ephemeral wetlands (Storey *et al*. 1993). In a 1991 study on the Swan Coastal Plain, 977 marked Pacific Black Ducks showed three patterns of movement (Storey *et al*. 1993). Some birds appeared resident on a single wetland all year round. Others appeared resident on a particular wetland, but disappeared in late winter/ early spring, possibly to breed elsewhere, and some seemed to move widely among urban wetlands (Storey *et al*. 1993).

As rainfall varies from year to year, and varies in its distribution, patterns of waterbird distribution may also vary. For example, when there has been rainfall in inland regions, waterfowl such as ducks and coots may move away from the coast to take advantage of good conditions inland (Ford 1958, Bamford *et al*. 2009).

Data collected in the 1981 – 1985 survey of south-western Australian wetlands found that some species were abundant in one year then scarce the next (Jaensch *et al*. 1988). These species are described as ‘irruptive’, meaning that they occasionally occur in high numbers in a particular area. On the Swan Coastal Plain, this includes the Black-tailed Native-hen, White-necked Heron and White-winged Black Tern (Johnstone and Storr 1998).

As water levels in wetlands fluctuate, birds move to take advantage of available habitat or to leave undesirable habitat. An obvious example of this is with seasonal wetlands such as Thomsons Lake and North Lake. These wetlands support birds when water is present, with the birds moving to other areas when the wetland dries out in summer and autumn.

Although no data are available on specific movements of birds between Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp, it can safely be assumed that some level of movement does exist. As these wetlands are close together, movements between wetlands may potentially occur on a daily basis when water is present.

4.4 Comparisons between wetlands

In the comparisons between wetlands in this section, it is important to be aware of the limitations of the data that have been used. Although some of the best available, the datasets vary on the number of wetlands sampled, the number of sampling events and the times of year sampled.

4.4.1 Which wetlands support the highest overall species richness?

Thomsons Lake has the highest species richness of the 13 wetlands surveyed in this study, with 71 species known, followed by Bibra Lake, Yangebup Lake and North Lake (Table 14). In the 2009 – 2010 study, three of the four wetlands had the highest species richness, though the order was slightly different. Bibra Lake had the highest species richness (45 species), followed by Thomsons Lake and Yangebup Lake, both with 43 species, and Kogolup Lake with 40 species (Table 14). It is likely that the high total species richness at North Lake is influenced by the large number of surveys undertaken by Maddeford (2003). Many of the records for the lake are likely to be of species that have only occurred once or twice.

In a 1990 – 1992 study, Thomsons Lake, Kogolup Lake, Yangebup Lake and Bibra Lake ranked 2nd, 7th, 10th and 11th for total species richness out of the 251 Swan Coastal Plain wetlands surveyed (Storey *et al*. 1993). This indicates that these four wetlands are regionally significant for the number of waterbird species present.

In general, the larger the wetland, the more species they support, and the five most species rich wetlands are also the five largest. In addition, these wetlands tend to support a high number of migratory species, particularly migratory shorebirds.

Table 14. Wetlands ranked by total species richness.

Note: A = current study, B = Storey *et al*. (1993), C = WetlandBase (2010).

Wetland	Rank	Total species richness	Species richness in each study		
			2009 – 2010[A]	1990 – 1992[B]	1981 – 1988[C]
Thomsons Lake	1	71	43	47	66
Bibra Lake	2	66	45	35	48
Yangebup Lake	3	65	43	36	48
North Lake	4	57	26	29	30
Kogolup Lake	5	56	40	39	37
Lake Coogee	6	50	31	-	17
Little Rush Lake	7	43	30	-	19
South Lake	8	40	28	-	23
Market Garden Swamp	9	33	27	-	-
Manning Lake	10	32	20	-	23
Lower Swamp	11	23	11	-	22
Horse Paddock Swamp	11	23	0	17	22
Fawcett Rd Wetland	12	13	18	-	-

4.4.2 Which wetlands support the most birds?

The highest total count on a wetland gives an idea of the maximum number of waterbirds that a wetland can support. In most of the studies presented below (Table 15), the same two large, open wetlands (Bibra Lake and Thomsons Lake) ranked within the top two wetlands for supporting high numbers of birds. In the 2009 – 2010 study, Bibra Lake ranked highest with a high count of 9,947 birds. In all other studies presented, Thomsons Lake ranks highest, with a particularly high count of 20,196 birds in the 1980s. Yangebup Lake, another large, open wetland, usually ranked within the top three.

Many smaller wetlands lack systematic survey data for earlier years, so comparisons are difficult to make. However, in general the smaller wetlands support lower total counts of birds. Horse Paddock Swamp had no birds in 2009 – 2010 as it was dry, but in previous studies it has supported a moderate number of birds.

Table 15. Wetlands ranked by highest total count in 2009 - 2010.

Note: A = current study, B = Bamford (2009), C = Storey *et al*. (1993), D = WetlandBase (2010).

Wetland	Rank	Highest Total Count in each study (rank)			
		2009 – 2010[A]	1999 - 2009[B]	1990 – 1992[C]	1981 – 1988[D]
Bibra Lake	1	9947	3378 (3)	7598 (2)	8848 (2)
Thomsons Lake	2	4696	11525 (1)	18472 (1)	22196 (1)
Yangebup Lake	3	1758	3897 (2)	1404 (4)	4976 (3)
North Lake	4	1357	-	521 (5)	1449 (4)
Lake Coogee	5	792	-	-	398 (6)
Kogolup Lake	6	670	1281 (4)	1732 (3)	273 (8)
South Lake	7	430	-	-	165 (9)
Manning Lake	8	379	-	-	397 (7)
Little Rush Lake	9	300	-	-	59 (11)
Market Garden Swamp	10	163	-	-	-
Fawcett Rd Wetland	11	99	-	-	-
Lower Swamp	12	28	-	147 (7)	156 (10)
Horse Paddock Swamp	13	0	-	178 (6)	604 (5)

Many wetlands on the Swan Coastal Plain are seasonal, drying out in summer and autumn. Wetlands that hold water for all or most of the year can be important as summer refuges for waterbirds. Waterbirds congregate in larger numbers on the remaining wetlands that hold water. In the 2009 - 2010 study, Yangebup Lake held water all year round and Bibra Lake held water for most of the year. Many of the smaller wetlands were completely dry over the summer months.

4.4.3 Which wetlands support the most species of conservation significant birds?

Thomsons Lake supports the highest number of conservation significant species, with an overall total of 31, and it also has the highest number of CS1 species (Table 16). Bibra Lake, Kogolup Lake and Yangebup Lake all support more than 20 conservation significant species. Wetlands with high numbers of CS1 species are those that support several migratory shorebird species.

Most wetlands support several CS3 species, with Bibra Lake and South Lake supporting all ten species, and Thomsons Lake, Kogolup Lake and Yangebup Lake supporting nine (Table 16).

Small wetlands such as Fawcett Rd Wetland and Lower Swamp support very few conservation significant species. This may be related both to their small area, and to the lack of waterbird data for these wetlands in sources such as Storey *et al.* (1993). Smaller wetlands also lack the expanses of open lakebed suitable for conservation significant migratory shorebirds.

Table 16. Wetlands ranked by total number of conservation significant (CS) species.

Wetland	Rank	Total CS species	Number of each CS category		
			CS1	CS2	CS3
Thomsons Lake	1	31	20	2	9
Yangebup Lake	2	24	14	1	9
Bibra Lake	2	24	13	1	10
Kogolup Lake	3	22	12	1	9
North Lake	4	19	10	0	9
Lake Coogee	5	18	11	0	7
South Lake	6	15	5	0	10
Little Rush Lake	7	12	5	0	7
Manning Lake	8	10	2	0	8
Market Garden Swamp	9	9	2	0	7
Horse Paddock Swamp	10	7	2	0	5
Lower Swamp	11	6	1	0	5
Fawcett Rd Wetland	12	3	0	0	3

Although the number of conservation significant birds present can be important, some wetlands have significance for supporting one species in particular, or a group of species such as migratory shorebirds.

4.4.4 Which wetlands support the highest numbers of CS1 migratory shorebirds?

Migratory shorebirds include the plovers, sandpipers and related birds that are listed under the EPBC Act, and 18 species are likely to occur on wetlands of the study area. The numbers presented in Table 17 must be viewed with caution, as they are based on only a small number of studies. There are larger counts of individual shorebird species available (e.g. Watkins 1993, Jaensch *et al.* 1993), but necessarily, the figures used were from sources that included counts of every species on the wetland.

Only Thomsons Lake and Kogolup Lake have any recognition as sites of importance for migratory shorebirds. Thomsons Lake is well known for supporting high numbers of migratory shorebirds (e.g. Jaensch *et al*. 1988), though in 2009 – 2010 that was not the case. This may be due to below average rainfall in the 1990s and 2000s, resulting in the lake drying too quickly in the summer months (Bancroft and Bamford 2009, Appendix 7). However, Thomsons Lake has recognition as both an internationally and nationally important site for shorebirds (Bamford *et al.* 2008, Watkins 1993), both for the overall number of birds the lake supports, and for high counts of individual species such as the Curlew Sandpiper. Based on a count of 60 birds, Kogolup Lake has recognition as a nationally important site for Wood Sandpiper (Watkins 1993).

Table 17. Wetlands ranked by mean number of CS1 migratory shorebirds.

Note: A = current study, B = Bamford (2009), C = Storey *et al*. (1993), D = WetlandBase (2010).

Wetland	Rank	Mean across studies	Maximum total count in each study (rank)			
			2009 – 2010[A]	1999 - 2009[B]	1990 – 1992[C]	1981 – 1988[D]
Thomsons Lake	1	1542.5	25 (2)	15 (2)	681 (1)	5449 (1)
Yangebup Lake	2	387.8	1	0	18 (2)	1532 (2)
Bibra Lake	3	30.0	42 (1)	71 (1)	0	7
Kogolup Lake	4	12.0	9 (3)	2 (3)	14 (3)	23 (3)
Little Rush Lake	5	4.5	9 (3)	-	-	0
Lake Coogee	6	3.5	1	-	-	6
South Lake	7	2.0	2	-	-	2
Lower Swamp	8	1.0	0	-	0	3
North Lake	9	0.7	2	-	0	0
Manning Lake	10	0.5	0	-	-	1
Horse Paddock Swamp	11	0.3	0	-	0	1
Market Garden Swamp	12	0	0	-	-	-
Fawcett Rd Wetland	12	0	0	-	-	-

Yangebup Lake supported moderate numbers of migratory shorebirds in the 1980s, but there were few recent records (Table 17). The remaining wetlands support very low or negligible numbers of migratory shorebirds. No counts in the 2009 – 2010 study exceeded 1% of the global or Australian population for individual species.

4.4.5 Which wetlands are important for other CS1 species?

There are seven CS1 species that are not migratory shorebirds; the Eastern Great Egret, Cattle Egret, Glossy Ibis, Eastern Osprey, White-bellied Sea-Eagle, Australasian Bittern and White-winged Black Tern. All except the Australasian Bittern are listed because they are migratory species, and generally have large global populations.

The Eastern Great Egret is common on the Swan Coastal Plain. As large open wetlands, Bibra Lake, Kogolup Lake and Thomsons Lake support some of the higher counts of this species (Table 6, Appendix 5), though overall the numbers are low. Other wetlands in the study area generally support one or two birds intermittently throughout the year. No wetland is likely to be of particular significance to the Eastern Great Egret.

The Cattle Egret may be an occasional non-breeding visitor to any of the wetlands in the study area. No wetland is likely to be of particular significance to this species.

The Glossy Ibis is likely to be a regular non-breeding summer visitor to wetlands with shallow water foraging habitats. No wetland is likely to be of particular significance to this species, though some of the highest counts occur on Thomsons Lake (Table 6, Appendix 5).

The Eastern Osprey and White-bellied Sea-Eagle are generally coastal species, though they occasionally visit larger wetlands in the study area. No wetland in the study area is likely to be of particular significance to these species.

The Australasian Bittern is a very uncommon species that has declined in both range and abundance. Thomsons Lake is the only site in the study area and possibly on the Swan Coastal Plain where the Australasian Bittern has been recorded (CALM 2003, CALM 2005, Jaensch *et al*. 1988). It is possible that this species may occur in areas of shallow water and emergent rushes in other wetlands in the study area, including Bibra Lake and North Lake. Given the lack of records at these wetlands, the likelihood of the Australasian Bittern being present is probably low. It may be that the habitat present at other wetlands is unsuitable, perhaps due to deeper water levels, insufficient area of emergent rushes or high levels of disturbance. However, if Australasian Bitterns were present, it would be of very high significance.

Thomsons Lake has also been recognised as being significant for the White-winged Black Tern (CALM 2003), with counts of up to 150 birds (Jaensch *et al*. 1993). Although the White-winged Black Tern is a globally common species, Thomsons Lake is one of the few locations on the Swan Coastal Plain to support this species in any abundance. The White-winged Black Tern has not been recorded from the wetlands in close proximity to the highway extension, and it appears unlikely that these wetlands are of particular importance to this species.

4.4.6 Which wetlands are important for CS2 species?

There are three CS2 species that may occur in the study area; the Australian Little Bittern, Hooded Plover and Fairy Tern.

Thomsons Lake and Lake Kogolup are the only wetlands in the study area known to have supported the Australian Little Bittern (Table 4), so may be regionally significant for this species. Lake Kogolup also has the only breeding record of the Australian Little Bittern in the study area (Table 7). These wetlands may be important for the Australian Little Bittern due to the large areas of emergent rushes. The Australian Little Bittern has not been recorded at wetlands in close proximity to the highway extension, but may be present in areas where there are emergent rushes.

Although the Hooded Plover and Fairy Tern have been recorded at wetlands in the study area, they are likely to be only occasional visitors. The Hooded Plover is likely to favour habitats other than freshwater wetlands, and the Fairy Tern usually breeds on offshore islands and is a visitor to near coastal wetlands. No wetland in the study area is likely to be of particular significance to these species.

4.4.7 Which wetlands are important for CS3 species?

There are 10 CS3 species in the study area, all of which are listed as species declining on the Swan Coastal Plain in Bush Forever (Government of Western Australian 2000). A wetland may be nationally significant for a CS3 species if it supports 1% or more of the global population of that species. A wetland may also be of local significance on the Swan Coastal Plain if it regularly supports high numbers or breeding records of a particular species.

No wetlands are likely to have particular significance for the Freckled Duck, as this species is likely to only be an occasional non-breeding visitor to wetlands in the study area.

No wetlands in the study area are known to support at least 1% of the global population of Musk Duck (500 birds), Pink-eared Duck (10,000 birds) or Hardhead (10,000 birds). Although relatively low in the 2009 – 2010 study, counts of Musk Duck on Bibra Lake and Yangebup Lake in previous studies are relatively high compared to other wetlands in the study area, indicating they may be of local significance.

Counts of Pink-eared Duck are relatively high on Bibra Lake, Kogolup Lake, Thomsons Lake and Yangebup Lake, probably because these are large open wetlands (Table 6, Appendix 5). Counts on Thomsons Lake are relatively low in more recent studies, including the 2009 – 2010 study where it was not recorded at all (Table 6). Yangebup Lake has previously been recognised for supporting large numbers of Pink-eared Duck (Environmental Protection Authority 1989) and is likely to be at least locally significant for this species.

In the 2009 – 2010 study, the Hardhead was recorded in the highest numbers on Bibra Lake and Yangebup Lake. Counts of this species seem to fluctuate from study to study, suggesting that this species may vary in abundance on the Swan Coastal Plain. No wetland is likely to be of particular significance for the Hardhead, though the large open wetlands (Bibra Lake, Kogolup Lake, Thomsons Lake and Yangebup Lake) are likely to support the highest numbers.

The Australasian Shoveler was recorded in large numbers on Thomsons Lake in the 1980s (Appendix 5), exceeding 1% its global population (1,500 birds). Thomson's Lake may be locally significant for this species, though more recent counts have been much lower. No wetland is likely to be of particular significance for the Australasian Shoveler, though the large open wetlands (Bibra Lake, Kogolup Lake, Thomsons Lake and Yangebup Lake) are likely to support the highest numbers.

The Blue-billed Duck has been recorded in numbers exceeding 1% of its global population (150 birds) at Bibra Lake (Appendix 5), North Lake (Appendix 6) and Yangebup Lake (Table 6, Appendix 5). Yangebup Lake is the only one at which numbers of Blue-billed Ducks have remained high, and this wetland is likely to be nationally significant for this species. North Lake generally supports very low numbers of Blue-billed Duck and Maddeford (2003) notes that this species is declining. Bibra Lake and Thomsons Lake supported high numbers in the 1980s and early 1990s, however, they appear to have declined in importance.

A wetland would be significant for the Nankeen Night-Heron if a large roost was present, and no such roosts are known from the study area. This species is likely to roost singly and in small groups at any wetland in the study area with fringing vegetation of trees and large shrubs. This includes the area of *Melaleuca* woodland surrounding Roe Swamp. The only wetland with particularly high counts of this species is Kogolup Lake (Appendix 5), though the Nankeen Night-Heron is likely to be under-surveyed as it generally roosts during the day.

The Dusky Moorhen is not a congregatory waterbird, so is not likely to occur in large groups on particular wetlands. However, wetlands with extensive emergent rushes and fringing vegetation may support this species on a regular basis. Bibra Lake and Kogolup Lake may be locally significant for the Dusky Moorhen, based on high numbers and records of breeding at Bibra Lake (Tables 5 and 7, Appendix 5).

In 2009 – 2010, the Whistling Kite was most abundant at Thomsons Lake. Thomsons Lake is a large open wetland with good foraging opportunities for this species, and large areas of fringing vegetation for roosting and nesting. Thomsons Lake may have local significance for the Whistling Kite.

The Red-kneed Dotterel is represented by a few records at some wetlands in the study area. It is likely to favour wetlands with open shorelines for foraging, and counts appear to be declining since the 1980s (Appendix 5). No wetland is likely to be of particular significance to this species, though Yangebup Lake is the only wetland in the study area at which breeding has been recorded.

4.4.8 Which wetlands are important for waterbird breeding?

Records of breeding birds on the Swan Coastal Plain are generally opportunistic. The nests of many wetland birds are difficult to observe as they are hidden amongst vegetation. The lack of systematic counts means that data from different wetlands and different years are difficult to compare, as breeding often goes unrecorded.

Overall, North Lake appears to support the highest number of breeding species (Table 18), followed by the four largest wetlands. This may be an artefact of the available data however, as North Lake is the only wetland sampled heavily by Maddeford (2003). In 1989, the EPA reported on discussions with the RAOU (now Birds Australia), where the importance of North Lake for breeding ducks was indicated (Environmental Protection Authority 1989).

No CS1 species have been recorded breeding at any of the wetlands sampled in 2009 – 2010 (Table 7). Kogolup Lake is the only wetland at which a CS2 species (the Australian Little Bittern) was recorded breeding, so it may be important for this species. Seven CS3 species have been recorded breeding, five duck species, the Dusky Moorhen and Red-kneed Dotterel (Table 7). The Red-kneed Dotterel was only recorded breeding at Yangebup Lake, and all seven CS3 species have been recorded breeding at North Lake.

Thomsons Lake also supports significant numbers of breeding Black Swans compared to the other wetlands sampled, with 198 chicks recorded in 2009 – 2010 (Table 8). Bancroft and Bamford (2009) also found Thomsons Lake to support high numbers of breeding Black Swans. Black Swan breeding has been increasing on Thomsons Lake as the encroachment of riparian vegetation onto the lakebed has favoured swans (Bancroft and Bamford, 2009).

Breeding success may very between the wetlands depending on a number of factors, including the availability of nesting sites that are adequately protected from predators, as predation is usually a primary cause of chick mortality. Predators on the Swan Coastal Plain include the Fox (*Vulpes vulpes*), Silver Gull, Swamp Harrier, Australian Raven and Oblong Tortoise (*Chelodina oblonga*) (Storey *et al*. 1993, Johnstone and Storr 1998). Levels of breeding success on each wetland could not be measured with data from the 2009 – 2010 study. However, some broad generalisations can be made about what constitutes good habitat for breeding waterbirds.

Table 18. Wetlands ranked by total number of breeding species.

Note: A = current study, B = Bamford (2009), C = Storey *et al*. (1993), D = WetlandBase (2010).

Wetland	Rank	Total breeding species	Total breeding species in each study (rank)			
			2009 – 2010[A]	1999 - 2009[B]	1990 – 1992[C]	1981 – 1988[D]
North Lake	1	17	2 (4)	-	4 (3)	10 (2)
Thomsons Lake	2	16	4 (2)	-	4 (3)	13 (1)
Bibra Lake	3	14	3 (3)	-	8 (1)	8 (3)
Yangebup Lake	4	12	2 (4)	-	3 (4)	10 (2)
Kogolup Lake	5	10	4 (2)	-	6 (2)	4 (6)
Manning Lake	6	10	1 (5)	-	-	-
Market Garden Swamp	7	9	9 (1)	-	-	-
Lower Swamp	8	7	0 (6)	-	2 (5)	7 (4)
South Lake	9	6	2 (4)	-	-	6 (5)
Little Rush Lake	10	4	1 (5)	-	-	1 (8)
Lake Coogee	11	3	2 (4)	-	-	-
Horse Paddock Swamp	12	3	0 (6)	-	2 (5)	2 (7)
Fawcett Rd Wetland	13	2	2 (4)	-	-	-

Storey *et al*. (1993), found that small winter-wet wetlands are important for breeding waterbirds, at least for the species there was sufficient data for, the Pacific Black Duck and Grey Teal. As winter-wet areas, Horse Paddock Swamp and Lower Swamp may well be locally important for waterbird breeding when they hold water.

Wetlands with a dense and complex riparian fringe of emergent rushes, low shrubs and trees are also likely to be important for waterbird breeding. These areas provide nesting sites that may be more difficult for predators to locate. Similarly, wetlands with islands may provide nesting sites that are protected from land-based predators such as foxes. In the 2009 – 2010 study, the wetland with the highest number of breeding species was Market Garden Swamp (Table 18). The island and sump areas around Market Garden Swamp are probably what make this wetland attractive breeding habitat for a range of species.

Bibra Lake has substantial areas of dense riparian vegetation, particularly on the northern and eastern edges. These areas are likely to be the most important for waterbird breeding on this wetland, as most of the species recorded in Table 7 are those that use emergent rushes for breeding.

4.5 Road mortalities of birds on Hope Rd

No road mortalities were recorded during the survey. This is not to say that no mortalities occur, as it is likely that foxes, birds of prey or other scavengers remove dead birds. However, it does suggest that road mortalities are not a major issue on Hope Rd. This may be due to birds generally flying above traffic height or otherwise not straying on to the road. In addition, birds may not forage on the road edge, or may have learned to avoid the road.

5. ENVIRONMENTAL IMPACT ASSESSMENT

The preliminary impact assessment considers a range of potential impacts on wetland and migratory birds. Aspects of the Roe Highway alignment that could impact on wetland and migratory birds include:

- Habitat loss
- The road as a barrier to movement
- Noise from road construction and traffic
- Artificial night lighting
- Road mortalities
- Traffic emissions and pollution

In urbanised areas, roads and transport-related surfaces can comprise up to 70% of the land surface (Wong *et al*. 2000). Over the last decade there have been many studies on the impacts of roads on fauna (Fahrig and Rytwinski 2009). The impacts of a road on biodiversity may not be immediate, instead appearing gradually after construction (Findlay and Bourdages 2000).

Roads may have impacts on birds that are not readily attributable to a particular aspect, such as noise or light, but rather can be treated as the general impact of roads on bird populations. For example, birds of prey have been found to avoid nesting near roads, or have reduced nesting success near roads (Trombulak and Frissell 2000). This may have implications for the four birds of prey listed in Table 3, though the likelihood of the Eastern Osprey or White-bellied Sea-Eagle nesting in the vicinity is minimal, and the Swamp Harrier is not known to nest at either Bibra Lake or North Lake. Escape responses have also been found to alter near roads, with birds quicker to take flight near roads (Trombulak and Frissell 2000). This has implications for the buffer distances required between the highway and wetland birds, and is discussed further below.

5.1 Habitat loss

The wetland habitats used by waterbirds in the study area can be divided into seven broad groups, as listed below and given in Appendix 3:

- Open water (referring to the water surface, used by many species for resting)
- Deep water
- Shallow water (usually around the wetland margins and important for foraging)
- Shorelines and drying lakebeds (areas for birds to roost and for shorebirds to forage)
- Emergent rushes (important for nesting and shelter for many species)
- Fringing woodlands (important for nesting, roosting and shelter for some species)
- Parkland/grass (modified habitat, used by some species for foraging)

Overall, the area of wetland habitat affected by the Roe Highway extension is likely to be small. However, the Beeliar Wetlands are regionally significant and already fragmented by roads, so any further habitat loss must be carefully managed and mitigated if possible. The main areas the Roe Highway extension footprint is likely to impact are the following:

- The southern edge of Horse Paddock Swamp
- A corridor bisecting Roe Swamp, though not near the open area of Lower Swamp, and following an existing transmission line corridor
- The northern edge of Bibra Lake
- Areas of upland terrestrial vegetation surrounding the wetlands.

The Roe Highway extension footprint is unlikely to impact directly on open water habitats, but many wetland birds forage, roost and breed in the vegetation on the edges of wetlands (Appendix 3). Where riparian vegetation such as *Melaleuca* woodlands are impacted, roosting habitat may be lost for species such as the Nankeen Night-Heron. However, no significant roost sites for this or any other species were recorded in the study area.

Conservation significant species such as the Australasian Bittern and Australian Little Bittern favour dense rushes on the edges of wetlands, but have not been recorded from Bibra Lake or Lower Swamp. Members of the family Rallidae, such as crakes, rails, the Dusky Moorhen, and Purple Swamphen also favour the well-vegetated margins of wetlands, and have been recorded at least on Bibra Lake. These species may lose some habitat if emergent rushes and other riparian vegetation are impacted.

Populations of migratory shorebirds are unlikely to be impacted by habitat loss, as Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp do not support significant numbers of these birds. In addition, there should be little or no loss of the shore or lakebed habitats that shorebirds utilise.

Where terrestrial vegetation is affected, there may be the loss of tree hollows suitable for breeding by the Grey Teal, Australian Wood Duck, Australian Shelduck and Pacific Black Duck. These species have all been recorded in Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp. There are breeding records of some of these species at these wetlands (Table 7). If nesting trees are affected, nest boxes could be provided, though these would need to be managed to prevent infestation by Honeybees (*Apis mellifera*).

In order to mitigate some of the habitat loss, the degraded parts of Horse Paddock Swamp and Roe Swamp could be rehabilitated with the focus on providing shoreline and riparian habitat for breeding and roosting waterbirds. During construction, damage to surrounding habitats outside the highway footprint should be minimised by fencing or otherwise clearly delineating the construction site boundaries. Constructed wetlands used to treat stormwater runoff can provide habitat for waterbirds. It should be remembered that the purpose of these wetlands is to strip pollutants from incoming runoff, so by their nature, are polluted habitats (Longcore and Rich 2001). However, as Bibra and Yangebup Lakes receive some polluted runoff already, they are not pristine wetlands.

5.2 The road as a barrier to movement

At least three components of a road reserve act to limit animal movement, the bare road surface, the altered roadside habitat and the light, noise, emissions and movement associated with traffic (Bennett 1991). Natural animal movements can be disrupted, and if a complete barrier is formed between populations, genetic isolation results (Bennet 1991). While roads can act as barriers to the movement of mammals, insects, herpetofauna and understorey birds (Coffin 2007), wetland and migratory birds are less likely to be constrained due to their inherent mobility.

Six species for which the Roe Highway may be a physical barrier are the Grey Teal, Australian Shelduck, Pacific Black Duck, Australian Wood Duck, Australian Reed-Warbler and Little Grassbird. The ducks may walk flightless ducklings from a nest in a hollow tree to Bibra Lake or North Lake. As small passerines that skulk in the emergent vegetation around wetlands, the Australian Reed-Warbler and Little Grassbird may be reluctant to cross the bare road surface between wetlands.

One way to mitigate this physical effect may be to provide an underpass or overpass for birds to travel underneath or over the highway between Bibra Lake and North Lake. Large underpasses and overpasses have most notably been used for large mammals, such as the Black Bear (*Ursus americanus*) in Canada (Clevenger *et al*. 2009). In Australia, the focus is also often on mammals, for example, rainforest species of wallaby, possum, glider and tree kangaroo in Queensland (Goosem *et al*. 2006, Bond and Jones 2008).

However, underpasses have also been used by birds such as the Buff-banded Rail in the Queensland wet tropics (Goosem 2002). The underpass design in this case allowed the animals at one end to see through to the habitat at the other end, included habitat inside the underpass to provide safety from predators, and in this case were 3.7m wide by 3.4m high (Goosem 2002, Goosem *et al*. 2006). Although they present no data, Goosem *et al.* (2006) note that the number of birds flying through the underpasses has increased over the four years since construction, and continues to increase.

South of Brisbane, two underpasses 2.5m wide by 2.4m high and 48m long was monitored using 'sand traps' to see what species used the underpasses (Bond and Jones 2008). Overall, birds made up only 5.7% of the fauna recorded, though the focus of the study was on mammals, and sand-traps do not record flying birds.

5.3 Noise from road construction and traffic

Noise can potentially have an effect on bird populations by masking their vocalizations and by causing physiological stress (Dooling and Popper 2007). This can result in the reduced abundance, species richness or breeding of birds in close proximity to roads (e.g. Forman *et al*. 2002). Although several studies have been carried out on the effects of traffic noise on birds, most fail to separate the possible effects of pollution, visual impacts or lack of prey near roads (Dooling and Popper 2007).

Bird song and vocalisations are important for communication, defence and mate selection among birds. Many studies have been carried out looking at the impact of traffic noise on bird song. For example, an Australian study found that the Grey Shrike-Thrush (*Colluricincla harmonica*) sings at a higher frequency in traffic noise, and the Grey Fantail (*Rhipidura fuliginosa*) is less likely to be present in noisier sites (Parris and Schneider 2008). In a Queensland study, Dawe and Goosem (2008) found that 5 of 18 rainforest birds studied showed differences in dominant song frequencies due to traffic noise. Of these, at least three species seemed to overcome the masking affect of traffic noise by modifying their songs (Dawes and Goosem 2008). However, changing their song frequencies could lead to deleterious effects including increased energy use and reduced reproduction success (Dawes and Goosem 2008). Although most wetland birds are not song-birds, increased traffic noise may interfere with their vocalisations.

There are very few, if any, studies on the physiological effects of noise on birds (Dawes and Goosem 2008). Large birds (such as most of the wetland birds in this study) generally have better hearing at low frequencies and smaller birds at high frequencies, but overall with birds hearing best between 1 and 6 kHz (Dooling and Popper 2007). Human hearing is most responsive within the range of 1 to 10 kHz (Dawe and Goosem 2008). Therefore, many authors use human responses to noise stress as an indication of the sort of responses noise may have on birds.

A number of studies have examined the effect of traffic noise on surrounding bird populations. Five species of grassland birds around Boston, USA, were found to have reduced breeding and presence within 1,200m of a multilane highway carrying 30,000 cars/day (Forman *et al*. 2002). Where roads with 15,000 to 30,000 cars per day, the distance of the impact was reduced to 700m, and no impact was found from roads carrying less than 8,000 cars/day (Forman *et al*. 2002).

In The Netherlands however, only 5,000 cars/day was found to disturb grassland birds out to 120m on average, but for the various species tested, the distance ranged from 20m to 1,700m (Riejnen *et al*. 1996). For 50,000 cars/day, the average disturbance distance was 560m, with a range of 75m to 3,530m (Riejnen *et al*. 1996). In this study the Eurasian Coot was the species with the lowest disturbance distance (20m for 5,000 cars/day – 75m for 50,000 cars/day). The Northern Shoveler (*Anas clypeata*) had an intermediate disturbance distance (65 – 320m) and the Black-tailed Godwit had a high disturbance distance (230 – 930m).

A decline in bird abundance near a new road may not be immediate. For example, in a European study of a highway constructed through coastal wetlands, within 200m of the highway, the abundance of breeding shorebirds had fallen by 50% during highway construction and by 80% two years after the highway was opened for traffic (Hirvonen 2001). On a study of birds on a British tidal mudflat, Burton *et al*. (2002) concluded that extended disturbance from construction of a barrage and bridge reduced the densities of five species. One of these was a duck (the Green-winged Teal, *Anas crecca*) and four were shorebirds (Burton *et al*. 2002).

In a Spanish study, about 15% of the breeding bird species in pasture-woodlands were negatively affected by traffic noise, and about 55% were not affected (Peris and Pescador 2004). Particular groups of wetland birds in the study area are more likely to be impacted by noise than others. Studies on waterbird disturbance distances usually focus on impacts such as walkers, dogs and jet skis (e.g. Paton et al. 2000). Paton *et al*. (2000) found that small shorebirds had disturbance distances of 25 – 110m, large shorebirds and stilts had disturbance distances of 26 – 204m and larger waterbirds such as ducks, cormorants, swans and ibis, had disturbance distances of 85 – 347m. However, a road provides a constant source of disturbance rather than a point source such as a walker, and it is likely that birds will become habituated to the noise to some extent.

Many wetlands in the Perth Metropolitan Area are surrounded by urban areas and are in close proximity to roads. Road noise is audible even at the wetland edge, for example, Beeliar Drive at Lake Yangebup or the Mitchell Freeway at Lake Monger. These wetlands still support significant numbers and species richness of birds, although there are no studies examining whether noise has had an impact on the birds using these wetlands.

Thresholds for traffic noise are given by Dooling and Popper (2007) from their laboratory tests and literature review. They state that in relatively quiet suburban areas, levels of highway noise approaching 50 – 60 dB(Ambient) can be assumed to begin measurably interfering with bird acoustic communication. When noise is continuous at 110 dB(A) permanent hearing damage may occur, and between 110 dB(A) and 93 dB(A), some physiological or behavioural effects may still manifest (Dooling and Popper 2007). In a European study, the abundance of breeding shorebirds declined where traffic noise levels exceeded 56 dB (Hirvonen 2001).

The effects of noise on wetland birds in the study area is likely to be highest at the north end of Bibra Lake and at Horse Paddock Swamp. The potential effects are difficult to quantify due to the lack of published information, but include:

- Avoidance of noisy habitats, with reductions in bird abundance, breeding and species richness, potentially over the entirety of Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp.
- Physiological stress and masking of vocalisations at noise levels from 50 dB(A).

Dawes and Goosem (2006) recommend the usage of barriers for noise reduction, but in their literature review found no studies on the effectiveness of such barriers on mitigating noise effects on fauna. As the highway extension passes very close to the northern end of Bibra Lake and the southern end of Horse Paddock Swamp, noise barriers could be employed between the highway and these wetlands as a precautionary measure.

5.4 Artificial night lighting

Artificial night lighting is increasingly recognised as a potential problem for nocturnal fauna. However, lighting of roads and highways is usually deemed necessary for the increased safety of drivers. Artificial lighting at night can potentially have significant impacts on plants, aquatic and terrestrial invertebrates, amphibians, fish, birds and mammals (Longcore and Rich 2001).

Artificial night lighting can have a range of direct and indirect effects on wetland and migratory birds (Longcore and Rich 2001, Molenaar *et al*. 2006). These effects include:

- Distraction of migrating birds
- Changes in bird community composition (e.g. by some species using light to avoid predators, thus increasing in abundance)
- Changes to bird foraging and singing times
- Impacts on prey (e.g. invertebrates, fish and frogs)
- Impacts on choice of roosting sites (e.g. some waterbirds roost or forage under artificial lights)
- Impacts on mammalian predators
- Timing of reproductive cycles and other physiological effects

Some of these impacts have the potential to reduce the fitness of waterbird populations by increasing the amount of energy birds need to expend on survival. However, whether these impacts are sufficient to affect the conservation status of bird populations is unclear.

Artificial light sources can potentially distract or disorient nocturnally migrating birds (Poot *et al*. 2008). This can cause direct mortality or indirectly affect birds by depleting their energy reserves. In the study by Poot *et al*. (2008), nocturnal birds were found to be more disoriented and attracted by white and red light, and less so with blue and green light. While the study by Poot *et al*. (2008) related to lighting on off-shore oil platforms, they suggest that 'bird-friendly lighting' could be developed for other applications including highway lighting.

Many wetland birds forage for a variety of animal prey such as frogs, fish and invertebrates. If prey populations decline significantly, this could result in the decline in some wetland bird species such as herons and egrets. Artificial night lighting affects the behaviour of frogs as many species only forage at certain light levels, so some species may decline or disappear from artificially lit areas Longcore and Rich (2001). Fish may be attracted to light, but others will not forage on nights with a full moon or artificially lit areas (Longcore and Rich 2001).

There is also the potential that artificial night lighting could affect the diurnal movements of aquatic invertebrates. Longcore and Rich (2001) report on an unpublished study suggesting that *Daphnia* (water-fleas) may not graze on algae where light levels are high, having potential effects on algae concentrations and thus wetland water quality. Terrestrial invertebrates are notoriously attracted to lights, though low-pressure sodium lamps attract the fewest insects (Longcore and Rich 2001). Invertebrates attracted to lights suffer an increased risk of predation, but whether this impacts on local invertebrate populations is unclear.

A study on road lighting on shorebird breeding in grassland found a small but statistically significant negative effect on breeding habitat quality, particularly within 300m of the road. This was thought to be due to the visibility of the lights themselves, as illumination from the lights petered out within 50m (Molenaar *et al*. 2006).

In order to mitigate the impact of night lighting on wetland birds, highway lighting should be minimised where possible. Where lighting is required for human safety, consideration should be give to making the light height as low as possible to reduce light spill. Any light spill should be screened from the wetlands, preferably with tall native vegetation, but also potentially with artificial barriers. Consideration could also be given to switching lights off during quiet times. Dutch guidelines for lighting in nature areas suggest switching lights off between 11pm and 6am, instead switching on weak (9 Watt) lights two-thirds the way up the light poles, to allow for driver orientation (Molenaar *et al*. 2006). As studies have found that green wavelengths of light are less disturbing to birds (Poot *et al*. 2008), consideration could also be given to researching the availability of such lighting.

5.5 Road mortalities

Road mortalities are undesirable as they may have impacts on local wildlife populations, may have ethical issues (e.g. injured or orphaned wildlife) and can affect human safety on the road (Magnus 2006). Direct mortality of birds may occur during both road construction and road operation (Trombulak and Frissell 2000). Road mortalities can have significant impacts on some bird populations. For example, in a study of the Little Owl (*Athene noctua*) in Spain, road mortalities accounted for 82% of non-natural deaths in this species (Hernandez 1988). However, except for threatened species, road mortality has not been found to significantly impact bird population sizes at a national level, at least in England (Forman and Alexander 1998).

The world annual bird mortality due to vehicle collisions is estimated by Erickson *et al*. (2005) to be 80 million birds and mortality rates vary from study to study (Table 19).

Slow-moving species can potentially be crushed by earth-moving equipment during road construction. While most birds are highly mobile, breeding birds, eggs and nestlings may be vulnerable. Most wetland and migratory birds are either non-breeding visitors to the study area or nest close to the wetland shore, but some species (Buff-banded Rail and Black-fronted Dotterel) can nest up to 500m from the shore (Johnstone and Storr 1998).

Wetland and migratory birds may be vulnerable to road mortality when either walking or flying across roads. Adult ducks leading ducklings to water (e.g. Grey Teal or Australian Shelduck), may be walking across roads. In addition, birds that forage in areas of grass or pasture (e.g. Australian Wood Duck or ibis species) may be vulnerable if suitable habitat is present on road verges. The Whistling Kite often feeds on road-kill (Johnstone and Storr 1998), so may also be vulnerable.

Table 19. Rates of bird mortality on roads.

Location	Bird road mortality	Source
Ontario, Canada. 3.6km of road between wetlands.	139 birds/km/year	Ashley and Robinson (1996)
Illinois, USA. 7km road traversed.	21 birds/km/year	Decker (1987)
North and South Dakota, USA. Interstate highways.	0.156 ducks/km/year	Sargeant (1981)
Florida, USA. 4km of road traversed in a mix of uplands and wetlands.	2.2 birds/km/year	Smith *et al*. (2003)
Bulgaria, Europe	7 million/yr	Forman and Alexander (1998)
The Netherlands, Europe	650,000/yr	Forman and Alexander (1998)

There appears to be little published information on the flight height of birds over roads. In a Perth study, birds flying over a busy road adjacent to Kings Park were found to fly at a height below 16m, 62% of the time (Wilcox 1999). However, the only wetland bird in the study (the Australian Shelduck) was only observed flying higher than 16m. There have been a number of studies on the flight behaviour of birds in relation to high voltage transmission lines and wind farms. Winning and Murray (1997) observed birds flying past a 42m high transmission line between a wetland and a roost site in Newcastle, New South Wales. Of the 22 wetland birds recorded, egrets flew below 42m 62 – 85% of the time, ibis and spoonbills flew below 42m 43 – 67% of the time and cormorants flew below 42m 40 – 51% of the time. In contrast,

the Silver Gull flew below 42m only 13% of the time (Winning and Murray 1997). This suggests that where suitable habitat is available on both sides of the highway extension, some birds may fly at relatively low elevations.

Bevanger (1998) generalises the features of birds that are vulnerable to collision with transmission lines. Birds that have rapid flight, and a combination of small wings and a heavy body are more vulnerable to collisions, as their reaction to obstacles is restricted (Bevanger 1998). While this generalisation may be broadly applicable in case of birds reacting to roads or traffic on roads, roads are a much more visible feature than transmission lines. However, many waterbirds, such as ducks and swans, are heavy bodied

Techniques for mitigating road mortality include the provision of underpasses, reducing the favourability of habitat on the road verge, installation of signage for drivers, installing physical slow-points and using light-coloured road surfaces (Magnus 2006). Not all of these measures are practical on a suburban highway. In Florida, Royal Terns (*Sterna maxima*) are a conservation significant species, and were experiencing high road mortality on a 5km stretch of road and bridge (Shwiff *et al*. 2003). In order to mitigate road mortality of Royal Terns and other marine birds, 3m vertical poles, 5.1cm in diameter, were installed at 3.7m intervals across the bridge. The result was a drop in the number of moralities from 19.4 to 5.2 terns/year average of 14.2 terns/year saved, after the pole installation (Shwiff *et al*. 2003). For a highly conservation significant species, this can be a considerable benefit.

The majority of the time, wetland birds are likely to fly directly from one wetland to another, in this case between Bibra Lake, Horse Paddock Swamp, Lower Swamp and North Lake, without using terrestrial habitats in between. Road configurations with the highway exposed at elevations above the natural ground level should be avoided for this reason. However, as a bridge is desirable for terrestrial fauna species, the focus should be on encouraging birds to fly over the height of the traffic so that road mortalities are minimised. This could be through the use of solid artificial barriers, visual barriers such as poles as described by Shwiff *et al*. (2003) or natural barriers of native trees, provided they can be grown to sufficient height.

5.6 Traffic emissions and other pollution

Vehicle emissions include carbon monoxide, nitrogen oxides, sulphur dioxide, methane, lead, volatile organic compounds, particulates, and toxins such as formaldehyde and benzene (Coffin 2007). Wetlands can receive substantial inputs of nitrogen, metals and hydrocarbons from atmospheric deposition (Coffin 2007).

Stormwater runoff from roads can also be a source of pollution into wetlands (Coffin 2007). Although highways and freeways account for a minor proportion of road surface overall, stormwater runoff from highways and freeways can be a significant pollution source (Wong *et al*. 2000). Pollutants in stormwater include gross items (such as litter) as well as sediments, heavy metals and organic pollutants like polyaromatic hydrocarbons (Wong *et al*. 2000). Sources of pollutants include road wear, tyre wear, brake lining wear, vehicle exhaust, oil spills, corrosion of street furniture (e.g. railings) and atmospheric deposition onto roads (German *et al*. 2006).

A Swedish study found that in a catchment area with 116ha of road and a daily traffic load of 140,000km, a total of 31kg of copper, 100kg of zinc, 4kg of lead, 0.1kg of cadmium, 35kg of phosphorus and 335kg of nitrogen and 0.4kg of polyaromatic hydrocarbons was contributed to road runoff (German *et al*. 2006).

Sources of sediment in runoff include soil particles, eroded materials from streets and buildings and vegetation debris (Wong *et al*. 2000). Construction of roads and other urban infrastructure can contribute large amounts of sediment to runoff (Wong *et al*. 2000). When excess sediment flows into wetlands, it can lead to increased turbidity, reducing the amount of light penetrating the water (Wong et al. 2000). This could have negative effects on the aquatic plants and animals on which waterbirds feed. In an American study, fish and aquatic

insect diversity declined in streams, as the amount of impervious surfaces in the catchment increased, and aquatic macro-invertebrate communities changed to favour species that tolerate unstable conditions (Schueler 1995).

Toxic pollution may cause death to birds from acute effects, chronic exposure or bioaccumulation of toxins through the food chain (Wong *et al*. 2000). After reviewing the literature, Trombulak and Frissel (2000) describe five patterns exhibited by heavy metal contamination, three of which are relevant here:

- The amount of contamination is related to the amount of traffic.
- Contamination of soils, plants and animals decreases exponentially away from the road, mostly within 20m, but up to 200m and increasing if heavy metals reach aquatic environments.
- Heavy metals accumulate in the tissues of plants and animals

There is little research on which wetland bird species are more likely to be affected by pollution than others. Generic assumptions can be made, such as birds that are higher in the food chain may be more vulnerable to bioaccumulation of toxins. This includes birds of prey such as the Whistling Kite and Swamp Harrier. Other groups that feed on vertebrate prey include the herons and egrets, cormorants, the Australian Darter and Australian Pelican. Herbivorous species such as ducks, Black Swans and Eurasian Coots, are likely to be less affected.

Sedentary species that live on the wetlands all year round are also more likely to be affected. This may pertain to some waterfowl, such as the Pacific Black Duck. Species that only occur in one season (such as shorebirds or stilts and avocets) are likely to be less exposed to pollution as their exposure time is reduced.

In order to mitigate the effect of vehicle emissions and other pollution, it is best to try and prevent them entering the wetlands in the first instance. The design of the stormwater management system should aim to strip harmful substances from highway runoff prior to the water entering any of the wetlands in the vicinity. Constructed runoff treatment wetlands may be used for this purpose, and have been used in other developments around Perth, such as Point Fraser in the City of Perth and the Liege St Wetlands in the City of Canning. Constructed wetlands are can remove a high proportion of litter, sediment, nitrogen, phosphorus and heavy metals from stormwater. Care must be taken to ensure that treatment wetlands are constructed to a standard that does remove a high proportion of pollutants, as not all treatment wetlands have been found to be effective for all types of pollutants (Taylor *et al*. 2001). Further guidance on the design of constructed wetlands is given in the Stormwater Management Manual for WA (Department of Water 2004 – 2007).

Table 20. Summary of potential impacts and possible mitigation measures.

Potential impacts	Possible mitigation measures
Habitat loss	
• Loss of part of Horse Paddock Swamp, Roe Swamp and Bibra Lake	• Re-vegetate degraded parts of Horse Paddock Swamp and Roe Swamp.
• Loss of nest trees with hollows	• Provide nesting boxes suitable for ducks if required.
• Damage to remnant riparian vegetation during construction	• Minimise disturbance to surrounding vegetation by clearly delineating or fencing protected areas. • Situate lay-down areas away from wetlands.
Noise	
• Construction noise	• Avoid construction during the main breeding period (late winter-early summer).
• Traffic noise	• Situate highway so that noise levels on wetlands don't exceed 56dB(A). • Use quiet road surfaces. • Install barriers to traffic noise near Bibra Lake and Horse Paddock Swamp, if required.
Artificial night lighting	
• Highway lighting	• Avoid lighting except where required for human safety. • Make lighting height as low as possible. • Make lighting directional (onto the road) to reduce light spill. • Consider using light wavelengths that are less disturbing to birds (i.e. green wavelengths). • Shield lights from wetlands using artificial barriers or barriers of native vegetation.
• Vehicle lights	• Shield lights from wetlands using artificial barriers or barriers of native vegetation.
Road mortalities	
• Flying birds	• Use artificial barriers (such as vertical poles), or preferably tall native plant barriers, to encourage birds to fly above the level of the traffic. • Avoid raised areas of road surface.
• Walking birds (e.g. ducklings or species foraging on grass)	• Provision of underpasses or bridges to allow for ducklings to walk from breeding areas to wetlands. • Create barriers to prevent ducklings walking or dropping on to the road surface. • Avoid creating foraging habitat (such as damp grass areas) next to the highway or in median strips.
Vehicle emissions and pollution	
• Gross pollutants (e.g. litter)	• Pollutant traps and runoff treatment wetlands.
• Sediment load	• Avoid erosion during construction. • Construct runoff treatment wetlands.
• Heavy metals & organic pollutants	• Construct runoff treatment wetlands.

6. Conclusions

Of the 13 wetlands in the study area, four are in close proximity to the footprint of the proposed Roe Highway extension; Bibra Lake, North Lake, Horse Paddock Swamp and Lower Swamp. Lower Swamp is part of the Roe Swamp and surrounding sumplands area.

6.1 Bibra Lake – a summary

Bibra Lake is a large wetland that is usually permanent, though in 2009 – 2010 it was mostly dry in February to May. Compared to other wetlands in the study area, Bibra Lake demonstrated:

- a high species richness,
- a high maximum number of waterbirds, particularly in summer
- a high numbers of conservation significant species
- a low number of CS1 migratory shorebirds
- a high number of breeding species

Bibra Lake also may support locally significant populations of two CS3 species; the Musk Duck and Dusky Moorhen. It has also supported high numbers of other CS3 duck species as it has large areas of open water.

It also usually supports wetland birds all year round, so is likely to be an important refuge for birds in summer and autumn. Bibra Lake also ranked in the top 25% of wetlands out of 1063 wetlands in the southwest for species richness, total number of waterbirds, and high numbers of breeding species (Raines, 2010). Storey *et al*. (1993), ranked Bibra Lake 11th out of 251 Swan Coastal Plain wetlands for species richness and 13th for number of breeding species. This indicates that Bibra Lake, despite lacking formal recognition, is a highly significant wetland for waterbirds on the Swan Coastal Plain.

6.2 North Lake – a summary

North Lake is a seasonal wetland that in 2009 – 2010 was mostly dry between January and May. Compared to other wetlands in the study area, North Lake demonstrated:

- a moderate species richness
- a moderate maximum number of waterbirds
- a high numbers of conservation significant species
- a low number of CS1 migratory shorebirds
- a high number of breeding species

Out of 1063 wetlands in the southwest, North Lake still ranked in the top 25% for species richness and number of breeding species (Raines 2010), but it was not one of the twenty most species rich as ranked by Storey *et al*. (1993). This indicates that North Lake is a moderately significant wetland on the Swan Coastal Plain, though it may have high significance as a breeding site.

6.3 Horse Paddock Swamp – a summary

Horse Paddock Swamp is a small seasonal wetland that in 2009 – 2010 did not hold water, so this wetland has been examined using historical data only. Compared to other wetlands in the study area, Horse Paddock Swamp demonstrated:

- a low species richness
- a low number of total number of waterbirds
- a low number of conservation significant species
- a low number of CS1 migratory shorebirds
- a low number of breeding species

Although in comparison to the other wetlands in the study area, species richness was low, Horse Paddock Swamp still ranked in the top 25% of wetlands out of 1063 wetlands in the southwest for species richness (Raines 2010). This indicates that Horse Paddock Swamp may have moderate significance for waterbirds of the Swan Coastal Plain, though it is likely to be of lower significance than North Lake, Bibra Lake and Lower Swamp.

6.4 Lower Swamp – a summary

Lower Swamp is a small seasonal wetland that in 2009 – 2010 was mostly dry between December and July. It is the only open water within the Roe Swamp and surrounding sump-lands area. Compared to other wetlands in the study area, Lower Swamp demonstrated:

- a low species richness
- a low number of total number of waterbirds
- a low number of conservation significant species
- a low number of CS1 migratory shorebirds
- a moderate number of breeding species

Lower Swamp ranked in the top 25% of 1063 wetlands in the southwest for species richness and the number of breeding species (Raines 2010). This indicates that Lower Swamp may have moderate significance to waterbirds on the Swan Coastal Plain.

6.5 Potential impacts - a summary

The potential impacts of the Roe Highway extension, and possible mitigation strategies, are summarised in Table 20. The main impacts considered were:

- Habitat loss
- The road as a barrier to movement
- Noise from road construction and traffic
- Artificial night lighting
- Road mortalities
- Traffic emissions and other pollution

Bibra Lake is an important wetland for multiple reasons, and North Lake, Horse Paddock Swamp and Lower Swamp all have some value to waterbirds on the Swan Coastal Plain. Therefore, it is appropriate to minimise the impacts of the Roe Highway extension on these wetlands.

Table 21 summarises each of the conservation significant wetland and migratory birds in the study area. Many species are listed as migratory under the EPBC Act, but globally their populations are large and relatively secure. These species (particularly migratory shorebirds) are also uncommon in the wetlands adjacent to the Roe Highway extension. Although Bibra Lake supports a high number of migratory shorebird species, the number of individuals present is usually very low.

Generally, the scale of impact on conservation significant species is thought to be negligible or low for a species if it only occurs as an occasional vagrant and the habitat present at the wetlands is not known to be important for that species.

Of more concern are species that have small population sizes, and that may use areas of shallow water and emergent rushes that may be impacted by the Roe Highway extension. This includes the Australasian Bittern (CS1) and Australian Little Bittern (CS2). Although neither species has been recorded in wetlands adjacent to the Roe Highway extension, they have been recorded in other wetlands in the study area and may occur in areas of suitable habitat (emergent rushes and shallow water).

Of the wetlands in close proximity to the highway extension, Bibra Lake in particular appears to have local significance to CS3 species. This is likely to be partly due to the large size of the wetland, the presence of breeding habitat (fringing vegetation and emergent rushes) and open water for duck species.

Table 21. Summary of conservation significant (CS) wetland and migratory birds in the study area.

Note that for scale of impact:

- **Negligible:** no change in species population status.
- **Low:** population change/decline within project area but no change in population in the surrounding local area.
- **Moderate:** population change/decline/loss within the project area, some change/decline in population in the surrounding local area.
- **High:** population change/decline/loss in the project area, resulting in the change/decline/loss of population of the surrounding local area.
- **Extreme:** loss of species from the bioregion.

Species	CS	Records in study area, 1981 - 2010	Recorded 2009-2010	Breeds in study area	Scale of potential impact	Explanation
Australasian Bittern	1	Thomsons Lake	-	Unknown.	Moderate	A species extremely rare on the Swan Coastal Plain, having declined severely since colonial settlement. Any records are likely to be significant, and although it has not been recorded from wetlands immediately adjacent to the highway extension, it may occur there in suitable habitat. Potential impacts are from some habitat loss (emergent rushes and shallow water) and the effects of noise, light spill and pollution.
Eastern Great Egret	1	Most wetlands	Yes	Unknown but may on occasion.	Low to moderate	A species rare in the southwest prior to 1917, but increasing since then. Most wetlands support low numbers of this species. Globally this species has a very large range and large population size. While no wetland adjacent to the highway extension is of particular importance for this species, the population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities, and as Bibra Lake had some of the highest counts of this species, these impacts may carry over to other wetlands in the study area.
Cattle Egret	1	North Lake & South Lake	Yes	Unknown but unlikely.	Negligible	A species only known from occasional records in the study area. Globally, it has a very large range and population, and the population seems to be increasing. The highway extension is unlikely to have a significant impact on populations of this species.
Glossy Ibis	1	Bibra Lake, Kogolup Lake, Little Rush Lake, North Lake & Thomsons Lake	Yes	Unknown but unlikely.	Low	A species unrecorded in the southwest prior to 1898, but increasing since then. Globally, it has a large range and population. This species occurs as a non-breeding summer visitor on some of the wetlands adjacent to the highway extension. The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities.
Eastern Osprey	1	Bibra Lake, Lake Coogee, North Lake & Thomsons Lake	-	Unknown but unlikely.	Negligible	A generally coastal species that has been recorded at some wetlands on occasion. Wetlands adjacent to the highway extension are not likely to be of particular importance to this species as it is only an occasional visitor.
White-bellied Sea-Eagle	1	Bibra Lake, Lake Coogee, North Lake, Thomsons Lake & Yangebup Lake	Yes	Unknown but unlikely.	Negligible	A generally coastal species that has been recorded at some wetlands on occasion. Wetlands adjacent to the highway extension are not likely to be of particular importance to this species as it is only an occasional visitor.

Table 21. (cont.)

Species	CS	Records in study area, 1981 - 2010	Recorded 2009-2010	Breeds in study area	Scale of potential impact	Explanation
Pacific Golden Plover	1	Yangebup Lake	-	No – non-breeding visitor to Australia.	Negligible	A vagrant to wetlands in the study area as this species favours coastal habitats. This species is represented by records at one wetland only, and the highway extension is unlikely to have a significant impact on populations of this species.
Grey Plover	1	North Lake & Yangebup Lake	-	No – non-breeding visitor to Australia.	Negligible	Although this species occurs on drying freshwater wetlands, it also uses coastal and estuarine habitats and has only been recorded from the study area on occasion. The wetlands in the study area are unlikely to be important for this species so the highway extension is unlikely to have a significant impact on populations of this species.
Little Ringed Plover	1	Bibra Lake & Yangebup Lake	-	No – non-breeding visitor to Australia.	Negligible	A vagrant species, as most birds migrate to Asia and Africa, only a few flying on to Australia. This species is represented by sporadic records only, so is not likely to be ecologically significant on the Swan Coastal Plain. The highway extension is unlikely to have a significant impact on populations of this species.
Black-tailed Godwit	1	Bibra Lake, North Lake, South Lake & Thomsons Lake	Yes	No – non-breeding visitor to Australia.	Low	This species favours coastal habitats but also uses near-coastal wetlands and has been recorded in very low numbers at some of the wetlands adjacent to the highway extension. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution, but given the low numbers present, this is unlikely to affect the population overall.
Bar-tailed Godwit	1	Lake Coogee & Thomsons Lake	-	No – non-breeding visitor to Australia.	Negligible	This species favours coastal habitats such as inter-tidal mudflats, so is unlikely to occur on wetlands in the study area except as an occasional visitor. It was not recorded from wetlands adjacent to the highway extension, and the highway extension is unlikely to have a significant impact on populations of this species.
Common Sandpiper	1	Bibra Lake, Kogolup Lake, Lake Coogee, North Lake, Thomsons Lake & Yangebup Lake	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and the wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Grey-tailed Tattler	1	Lake Coogee	-	No – non-breeding visitor to Australia.	Negligible	A vagrant species, as most birds only inhabit marine or estuarine habitats. This species is represented by records at one wetland only, and is unlikely to occur on wetlands adjacent to the highway extension except as an occasional vagrant. As such, the highway extension is unlikely to have a significant impact on populations of this species.

Table 21. (cont.)

Species	CS	Records in study area, 1981 - 2010	Recorded 2009-2010	Breeds in study area	Scale of potential impact	Explanation
Common Greenshank	1	Most wetlands	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and the wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Marsh Sandpiper	1	Bibra Lake, Kogolup Lake, Lake Coogee, Little Rush Lake & Thomsons Lake	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and the wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Wood Sandpiper	1	Bibra Lake, Kogolup Lake, Horse Paddock Swamp, Little Rush Lake, Thomsons Lake & Yangebup Lake	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and the wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Great Knot	1	Lake Coogee & Thomsons Lake	-	No – non-breeding visitor to Australia.	Negligible	A vagrant species, as most birds only inhabit marine or estuarine habitats. It is unlikely to occur on wetlands adjacent to the highway extension except as an occasional vagrant. As such, the highway extension is unlikely to have a significant impact on populations of this species.
Red Knot	1	Lake Coogee	-	No – non-breeding visitor to Australia.	Negligible	A vagrant species, as most birds only inhabit marine or estuarine habitats. It is unlikely to occur on wetlands adjacent to the highway extension except as an occasional vagrant. As such, the highway extension is unlikely to have a significant impact on populations of this species.
Red-necked Stint	1	Bibra Lake, Kogolup Lake, Lake Coogee, North Lake, Thomsons Lake & Yangebup Lake	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and is known to be more abundant on other wetlands in the study area (Thomsons Lake, Yangebup Lake). The wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Long-toed Stint	1	Kogolup Lake, Thomsons Lake & Yangebup Lake	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at a few wetlands, and the wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.

Table 21. (cont.)

Species	CS	Records in study area, 1981 - 2010	Recorded 2009-2010	Breeds in study area	Scale of potential impact	Explanation
Pectoral Sandpiper	1	Kogolup Lake, Thomsons Lake & Yangebup Lake	-	No – non-breeding visitor to Australia.	Low to negligible	Although not recorded on wetlands adjacent to the highway extension, it may be an occasional summer visitor. If present, there may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Sharp-tailed Sandpiper	1	Bibra Lake, Kogolup Lake, North Lake, Thomsons Lake & Yangebup Lake	Yes	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and the wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Curlew Sandpiper	1	Bibra Lake, Kogolup Lake, Lake Coogee, South Lake, Thomsons Lake & Yangebup Lake	-	No – non-breeding visitor to Australia.	Low	This species occurs in low abundances at many wetlands, and is known to be very abundant on other wetlands in the study area (Thomsons Lake). The wetlands immediately adjacent to the highway extension are not of particular significance to this species. There may be some local effects on the abundance of this species due to the effects of noise, light and pollution.
Ruff (Reeve)	1	Thomsons Lake & Yangebup Lake	-	No – non-breeding visitor to Australia.	Negligible	A vagrant species, as most birds migrate to Africa, south Asia and southern Europe, only a few flying on to Australia. It was not recorded at any of the wetlands adjacent to the highway extension. This species is only represented by sporadic records, and the highway extension is unlikely to have a significant impact on populations of this species.
White-winged Black Tern	1	Thomsons Lake, Lake Yangebup	-	No – non-breeding visitor to southwest WA.	Negligible	An irruptive species, this tern has not been recorded at wetlands adjacent to the highway extension. Other wetlands in the study area (Thomsons Lake and Yangebup Lake) may have some importance to this species, but the highway extension is unlikely to have a significant impact on populations of this species.
Australian Little Bittern	2	Kogolup Lake & Thomsons Lake	-	Yes – Kogolup Lake.	Moderate	A species very rare on the Swan Coastal Plain, having declined severely since colonial settlement. Any records are likely to be significant, and though it has not been recorded from wetlands adjacent to the highway extension, it may occur there in suitable habitat. Potential impacts are from some habitat loss (emergent rushes and shallow water) and the effects of noise, light spill and pollution.
Hooded Plover	2	Thomsons Lake	-	No – usually inhabits beaches and saltlakes.	Negligible	Although declining on the coastal plain, this bird usually inhabits habitats other than freshwater wetlands (e.g. beaches and salt-lakes). It is unlikely to occur on wetlands adjacent to the highway extension except as an occasional vagrant, so the highway extension is unlikely to have a significant impact on populations of this species.

Table 21. (cont.)

Species	CS	Records in study area, 1981 - 2010	Recorded 2009-2010	Breeds in study area	Scale of potential impact	Explanation
Fairy Tern	2	Bibra Lake	-	No – rare visitor to southwest.	Negligible	Although a declining species, the Fairy Tern is only likely to be an occasional non-breeding visitor to the larger wetlands adjacent to the highway extension. As such, populations of this species are unlikely to be impacted by the highway extension.
Musk Duck	3	All 13 wetlands	Yes	Yes	Moderate	A species thought to be declining on the Swan Coastal Plain, the Musk Duck was recorded as a breeding bird at wetlands adjacent to the highway extension, with counts at Bibra Lake some of the highest in the study area, at least in the past. The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities. As Bibra Lake appears locally important for this species, these impacts may affect populations on other wetlands in the study area.
Freckled Duck	3	South Lake	Yes	Unknown but unlikely.	Negligible	Although thought to be declining on the Swan Coastal Plain, this species is very uncommon in the study area. Although it may occur on wetlands adjacent to the highway extension, it is likely to be only an occasional non-breeding visitor.
Pink-eared Duck	3	Most wetlands	Yes	Yes – Market Garden Swamp & Manning Lake.	Moderate	A species thought to be declining on the Swan Coastal Plain, the Pink-eared Duck was recorded at wetlands adjacent to the highway extension, with counts at Bibra Lake some of the highest in the study area, though not as high as Yangebup Lake. The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities. As Bibra Lake appears locally important for this species, these impacts may affect populations on other wetlands in the study area.
Australasian Shoveler	3	Most wetlands	Yes	Yes – Manning Lake, North Lake & Lower Swamp.	Moderate	A species thought to be declining on the Swan Coastal Plain, the Australasian Shoveler was recorded as a breeding bird at wetlands adjacent to the highway extension, with counts at Bibra Lake some of the highest in the study area. The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities. As Bibra Lake appears locally important for this species, these impacts may affect populations on other wetlands in the study area.
Hardhead	3	Most wetlands	Yes	Yes	Moderate	A species thought to be declining on the Swan Coastal Plain, the Hardhead was recorded as a breeding bird at wetlands adjacent to the highway extension, with counts at Bibra Lake some of the highest in the study area. The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities. As Bibra Lake appears locally important for this species, these impacts may affect populations on other wetlands in the study area.
Blue-billed Duck	3	Most wetlands	Yes	Yes	Low	A species thought to be declining on the Swan Coastal Plain, the Blue-billed Duck also has a low global population overall. It was recorded as a breeding bird at wetlands adjacent to the highway extension, though the highest counts were obtained at wetlands away from the highway extension (Yangebup Lake). The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities.

Table 21. (cont.)

Species	CS	Records in study area, 1981 - 2010	Recorded 2009-2010	Breeds in study area	Scale of potential impact	Explanation
Nankeen Night-Heron	3	Most wetlands.	Yes	Unknown but likely.	Low	A species thought to be declining on the Swan Coastal Plain, the Nankeen Night-Heron has been recorded as a non-breeding species from most wetlands adjacent to the highway extension. Birds are likely to roost in *Melaleuca* woodlands, particularly around Roe Swamp, but no significant roost sites are known. The population in the local area may be affected by some habitat loss, noise, light spill, pollution and road mortalities.
Whistling Kite	3	Most wetlands	Yes	Unknown but likely.	Low	A species thought to be declining on the Swan Coastal Plain, the Whistling Kite was recorded at most wetlands near the highway extension. The population in the local area may be affected by some habitat loss (nesting or roost trees), noise, light spill, pollution and road mortalities.
Dusky Moorhen	3	Most wetlands	Yes	Yes	Moderate	A species thought to be declining on the Swan Coastal Plain, the Dusky Moorhen was recorded at all wetlands near the highway extension (some as a breeding species). The population in the local area may be affected by some habitat loss (emergent rushes), noise, light spill, pollution and road mortalities, and as Bibra Lake had some of the highest counts of this species, these impacts may carry over to other wetlands in the study area.
Red-kneed Dotterel	3	Bibra Lake, Kogolup Lake, Lake Coogee, South Lake, Thomsons Lake & Yangebup Lake	Yes	Yes – Yangebup Lake	Low to negligible	A species thought to be declining on the Swan Coastal Plain, the Red-kneed Dotterel occurs as an occasional visitor to some of the wetlands adjacent to the highway extension, though it is not known to breed there. The population in the local area may be affected by some habitat loss (shoreline and drying lakebed), noise, light spill, pollution and road mortalities.

7. References

Ashley, E.P. and Robinson, J.T., (1996). Road mortality of amphibians, reptiles and other wildlife on the Long Point causeway, Lake Erie, Ontario. *Canadian Field Naturalist* 110: 403-412.

Bamford, M. (2009). Unpublished bird count data from Bibra Lake, Thomson's Lake, Kogolup Lake and Yangebup Lake, collected June 1999 – Feb 2009.

Bamford, M. Bancroft, W and Raines, J. (2010). *Environmental Investigations for the Jandakot Groundwater Scheme Stage 2: Effects of remote rainfall events on waterbird populations on the Jandakot mound wetlands.* Unpublished report to the Water and Rivers Commission.

Bamford, M., Watkins, D., Bancroft, W., Tischler, G. and Wahl, J. (2008). *Migratory Shorebirds of the East Asian – Australasian Flyway: Population Estimates and Internationally Important Sites*. Wetlands International, Oceania.

Bancroft, W. and Bamford, M. (2009). *Environmental Investigations for the Jandakot Groundwater Scheme Stage 2: Wetland Waterbird Monitoring 1996 – 2008*. Unpublished report to the Water and Rivers Commission.

Bennett, A.F. (1991). Roads, roadsides and wildlife conservation: a review. In: *Nature Conservation 2: the role of corridors.* Ed by D.A. Saunders and R.J. Hobbs, Surrey Beatty, Chipping Norton, Australia: pp 99-118.

Bevanger, K. (1998). Biological and conservation aspects of bird mortality caused by electricity power lines: a review. *Biological Conservation* 86(1): 67-76.

Birds Australia Atlas Database (2010). Accessed 12/03/2010 for the area 32.05°S to 32.18333°S and 115.75°E to 115.8833°E.

Boehm, E.F. (1962). Some habits of the Fork-tailed Swift. *Emu* 61(4) 281-282.

Burton, N.H.K. (2007). Landscape approaches to studying the effects of disturbance on waterbirds. *Ibis* 149 (suppl. 1): 95-101.

Burton, N.H.K., Rehfisch, M.M. and Clark, N.A. (2002). Impacts of disturbance from construction work on the densities and feeding behaviour of waterbirds using the intertidal mudflats of Cardiff Bay, UK. *Environmental Management* 30(6): 865-871.

Braithwaite, L.W. and Miller, B. (1975). The Mallard, Anas platyrhynchos, and Mallard-Black Duck, Anas superciliosa rogersi, hybridization. *Australian Wildlife Research 2(1): 47-61.*

CALM (2003a) *Ramsar Information Sheet Forrestdale and Thomsons Lakes, Western Australia – 35*. Unpublished draft.

CALM (2006). *Beeliar Regional Park: Final Management Plan 2006*. CALM, Western Australia.

CALM (2005). Thomsons Lake Nature Reserve Management Plan 2005. CALM, Western Australia.

Christidis, L. and Boles, W.E., (2008). Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Australia.

Coffin, A.W. (2007). From roadkill to road ecology: A review of the ecological impacts of roads. *Journal of Transport Ecology* 15: 396-406.

Dawe, G. and Goosem, M. (2008). *Noise Disturbance along Highways: Kuranda Range Road Upgrade Project.* Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns.

DCLM (Department of Conservation and Land Management) (2003). Information Sheet on Ramsar Wetlands: Thomsons Lake.

Decker, D. (1987) A limited survey of roadkills on the Warsaw-Hamilton blacktop. Illinois Birds and Birding 3: 63-64.

Delany, S. and Scott, D. (2006). *Waterbird Population Estimates: Fourth Edition.* Wetlands International.

Department of Water (2004 – 2007). Stormwater management Manual for WA. Accessed online 21/7/2010 at URL: http://www.water.wa.gov.au/Waterways+health/Stormwater+and+drainage/Stormwater+management+manual/default.aspx

Dooling, R.J. and Popper, A.N. (2007). The effects of highway noise on birds. Report to the California Department of Transportation, Division of Environmental Analysis. Accessed online 10/5/2010 at URL: http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf

Ecoscape (1996). *Market Garden Swamp Environmental Management Plan*. Report to the City of Cockburn.

Environmental Protection Authority (1989). *Drainage management in South Jandakot and for the Beeliar Wetlands.* Bulletin 371, Environmental Protection Authority, Perth, Western Australia.

Environment Australia (2001). *A Directory of Important Wetlands in Australia, 3rd Edition*. Environment Australia, Canberra.

Erickson, W.P., Johnson, G.D. and Young, D.P. (2005). A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report, 1029-1042.

Fahrig, L. and Rytwinski, T. (2009). Effects of roads on animal abundance: an empirical review and synthesis. *Ecology and Society* 14(1): 21.

Findlay, C.S. and Bourdages, J. (2000). Response time of wetland biodiversity to road construction on adjacent lands. *Conservation Biology* 14(1): 86-94.

Forman, R.T.T. and Alexander, L.E. (1998). Roads and their major ecological effects. *Annual Review of Ecology and Systematics* 29: 207-231.

Forman, R.T.T., Reineking, B. and Hersperger, A.M. (2002). Road traffic and nearby grassland bird patterns in a suburbanising landscape. *Environmental Management* 29: 782-800.

Garnett, S.T. and Crowley, G.M. (2000). *The Action Plan for Australian Birds*. Environment Australia, Canberra.

Geering, A., Agnew, L. and Harding, S. (2007). *Shorebirds of Australia.* CSIRO Publishing, Victoria, Australia.

German, J. Ahlman, S., Jacobsson, D. and Svensson, G., (2006). Modelling of road runoff pollution load and sources in the city of Göteborg, Sweden. Abstract for presentation at 'Urban drainage modelling and water sensitive urban design 2006', Australia.

GHD (2009). *Report for Market Garden Swamps Environmental Management Plan*. Report to the City of Cockburn.

Goosem, M. (2002). Using Rainforest Research, Faunal Underpasses: assuring animal safety in on wet tropics roads. Leaflet produced by the Cooperative Research Centre for Tropical Rainforest Ecology and Management. URL: www.jcu.edu.edu.au/rainforest/infosheets/faunal-underpasses.pdf. Accessed 16 June 2010.

Goosem, M.W., Bushnell, S.L. and Weston, N.G. (2006). *Effectiveness of Rope Bridge Arboreal Overpasses and Faunal Underpasses in Providing Connectivity for Rainforest Fauna*. In: Proceedings of the 2005 International Conference on Ecology and Transportation, Centre for Transport and the Environment, North Carolina, USA: pp. 304-316.

Government of Western Australia (2000). *Bush forever volume 2: directory of bush forever sites*. Department of Environmental Protection, Perth, Western Australia.

Halse, SA, Pearson, G.B., Vervest, R.M. and Yung, F.H. (1995). Annual waterfowl counts in south-west Western Australia 1991/92. *CALMScience* 2(1): 1-24.

Hernandez, M. (1988). Road mortality of the Little Owl (*Athene noctua*) in Spain. *Journal of Raptor Research* 22(3): 81-84.

Hirvonen, H. (2001). *Impacts of highway construction and traffic on a wetland bird community.* In: Proceedings of the 2001 International Conference on Ecology and Transportation, Eds. Irwin, C.L., Garrent, P. and McDermott, K.P. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC: pp. 369-372.

IUCN (2010). IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Accessed 09 June 2010.

Jaensch, R.P., Vervest, R.M. and Hewish, M.J. (1988). *Waterbirds in nature reserves of south-western Australia 1981-1985: reserve accounts.* RAOU Report No. 30, Royal Australasian Ornithologists Union, Canning Bridge.

Jaensch, A., Merrifield, J. and Raines, J.A. (1993). Waterbirds of south-western Australia: highest numbers counted, 1981-91. *Western Australian Bird Notes (Supplement 1)*, 68.

Jaensch, R., and Lane, J. (1993). Western Australia. Pages 10/1-10/178 in S. Usback and R. James (eds) *A directory of important wetlands in Australia*. Australian Nature Conservation Agency, Canberra.

Johnstone, R.E. and Storr, G.M. (1998). *Handbook of Western Australian Birds. Volume 1: Nonpasserines (Emu to Dollarbird)*. Western Australian Museum, Perth.

Johnstone, R.E. and Storr, G.M. (2004). *Handbook of Western Australian Birds. Volume 2: Passerines (Blue-winged Pitta to Goldfinch)*. Western Australian Museum, Perth.

Longcore, T. and Rich, C. (2001). *A review of the ecological effects of road reconfiguration and expansion on coastal wetland ecosystems*. Report to the Urban Wildlands Group, Los Angeles. URL: http://www.urbanwildlands.org/Resources/lightnoiseroads.pdf.

Maddeford, W. (2003). *North Lake Birds 1980 – 2002*. Swanyarra Pty Ltd, Applecross, Australia.

Magnus, Z. (2006) Wildlife Roadkill Mitigation Information Kit, *A Guide for Local Government and Land Managers*. Report prepared for Sustainable Living Tasmania, Hobart, Tasmania.

Marchant, S. and Higgins, P.J. eds. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks*. Oxford University Press, Melbourne, Victoria.

Marchant, S. and Higgins, P.J. eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings*. Oxford University Press, Melbourne, Victoria.

Molenaar, J.G. Sanders, M.E. and Jonkers, D. A. (2006). Road lighting and grassland birds: local influence of road lighting on a Black-tailed Godwit population. Pgs 114 – 136 in C. Rich and C. Longcore (Eds) *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington.

O'Brien Planning Consultants (1994). *Lake Coogee Environmental Management Plan*. Report to the City of Cockburn.

Parris, K. M., and Schneider, A. (2008). Impacts of traffic noise and traffic volume on birds of roadside habitats. *Ecology and Society* 14(1): 29

Paton, D.C., Ziembicki, M., Owen, P and Heddle, C. (2000). Disturbance distances for waterbirds and the management of human recreation with special reference to the Coorong region of South Australia. Final Report for the Migratory Waterbird Component of the National Wetlands Programme.

Peris, S.J. and Pescodor, M. (2004). Effects of traffic noise on passerine populations in Mediterranean wooded pastures. *Applied Acoustics* 65(4): 357-366.

Poot, H., Ens, B.J., de Vries, H., Donners, M. A. H., Wernand, M. R. and Marquenie, J. M., (2008). Green light for nocturnally migrating birds. *Ecology and Society* 13(2): 47

Raines, J. (2010). Wetlands of significance to waterbirds in relation to the Roe Highway extension. Unpublished Report to Western Wildlife.

Ramsar Convention Bureau (2000). *Strategic Framework and Guidelines for the Future Development of the List of Wetlands of International Importance*. Ramsar Convention Bureau, Gland, Switzerland.

Reijnen, R., Foppen, R. and Meeuwsen, H., (1996). The effects of traffic on the density of breeding birds in Dutch agricultural grassland. *Biological Conservation* 75: 255-260.

Sargeant, A.B., (1981). Road casualties of prairie nesting ducks. *Wildlife Society Bulletin* 9: 65-69.

Schueler, T.R. (1995). Environmental Land Planning Series: Site Planning for urban Stream Protection, Metropolitan Washington Council of Governments and the Centre for Watershed Protection.

Shwiff, S., Smith, H.T., Bard, A.M., Harbor, T.V. and Engeman, R.M. (2003). An economic analysis of a simple structural method to reduce road-kills of Royal Terns at bridges. *Caribbean Journal of Science* 39(2): 250-253.

Smith, H.T., Barry, R.M., Engeman, R.M., Shwiff, S.A. and Miller, W.J.B., (2003). Wildlife road-kills in an urban park in Florida. *Florida Field Naturalist* 31(3): 53-58.

Storey, A.W., Vervest, R.M., Pearson, G.B. and Halse, S.A. (1993). Wetlands of the Swan Coastal Plain Volume 7: Waterbird Usage of Wetlands of the Swan Coastal Plain. Environmental Protection Authority and Water Corporation, Western Australia.

Taylor, S.M., Hanson, L., and Beitia, C.. (2001). *Assessment of costs and benefits of detention for water quality enhancement*. In: American Society of Civil Engineers World Water & Environmental Resources Congress 2001, Orlando, Florida, May 20–24, 2001.

Trombulak, S.C. and Frissell, C.A. (2000). Review of the ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14 (1): 18-30.

Watkins, D (1993). *A national plan for shorebird conservation in Australia*. RAOU Report 90. Australian Wader Studies Group.

Wilcox, J. (1999). *The Birds of Kings Park and their use of the Adjacent Suburban Gardens*. Unpublished Honours Thesis, Murdoch University.

Winning, G and Murray, M. (1997). Flight Behaviour and Collision Mortality of Waterbirds Flying Across Electricity Transmission Lines Adjacent to the Shortland Wetlands, Newcastle, NSW. *Wetlands (Australia)* 17(1): 29-40.

Wong, T., Breen, P. and Lloyd, S. (2000). *Water sensitive road design – design options for improving stormwater quality of road runoff*. Technical Report 00/1. Cooperative Research Centre for Catchment Hydrology.

Appendix 1. Flyway and Important Bird Area (IBA) 1% Criteria.

Species	IBA 1% Criteria	1% Flyway Criteria (Bamford *et al.* 2008)	Species	IBA 1% Criteria	1% Flyway Criteria (Bamford *et al.* 2008)
Anatidae (ducks and swans)			**Rallidae (crakes, rails and allies)**		
Musk Duck	500	-	Eurasian Coot	100,000	-
Freckled Duck	250	-	**Recurvirostridae (stilts and avocets)**		
Black Swan	10,000	-	Black-winged Stilt	3,000	-
Australian Shelduck	5,000	-	Red-necked Avocet	1,100	-
Australian Wood Duck	10,000	-	Banded Stilt	2,100	-
Pink-eared Duck	10,000	-	**Charadriidae (plovers and dotterels)**		
Australasian Shoveler	1,500	-	Pacific Golden Plover	2,000	1,000
Grey Teal	20,000	-	Grey Plover	7000	1,250
Chestnut Teal	1,000	-	Red-capped Plover	950	-
Pacific Black Duck	6,000	-	Double-banded Plover	500	500
Hardhead	10,000	-	Black-fronted Dotterel	170	-
Blue-billed Duck	150	-	Hooded Plover	105	-
Podicipedidae (grebes)			Red-kneed Dotterel	5,000	-
Australasian Grebe	5,000	-	**Rostratulidae (snipe)**		
Hoary-headed Grebe	5,000	-	Australian Painted Snipe	5,000	-
Great Crested Grebe	12,000	-	**Scolopacidae (godwits, sandpipers & allies)**		
Anhingidae (darter)			Black-tailed Godwit	7,500	1,600
Australasian Darter	1,000	-	Bar-tailed Godwit	12,000	3,250
Phalacrocoracidae (cormorants)			Whimbrel	20,000	1,000
Little Pied Cormorant	5,000	-	Terek Sandpiper	10,000	600
Great Cormorant	17,000	-	Common Sandpiper	40,000	250
Little Black Cormorant	10,000	-	Grey-tailed Tattler	400	500
Pied Cormorant	5,000	-	Common Greenshank	14,000	600
Pelecanidae (pelicans)			Marsh Sandpiper	12,000	1000
Australian Pelican	10,000	-	Wood Sandpiper	33,000	1000
Ardeidae (bitterns, egrets and herons)			Great Knot	3,800	3750
Australasian Bittern	30	-	Red Knot	10,000	2200
Australian Little Bittern	4,000	-	Sanderling	7,000	220
White-necked Heron	500	-	Red-necked Stint	3,200	3250
Eastern Great Egret	20,000	-	Long-toed Stint	250	250
Intermediate Egret	10,000	-	Pectoral Sandpiper	1,000	-
Cattle Egret	60,000	-	Sharp-tailed Sandpiper	1,600	1600
White-faced Heron	5,000	-	Curlew Sandpiper	18,000	1800
Little Egret	20,000	-	**Laridae (gulls and terns)**		
Nankeen Night-Heron	10,000	-	Fairy Tern	90	-
Threskiornithidae (ibis and spoonbills)			Gull-billed Tern	3,400	-
Glossy Ibis	25,000	-	Caspian Tern	3,000	-
Australian White Ibis	10,000	-	Whiskered Tern	10,000	-
Straw-necked Ibis	10,000	-	White-winged Black Tern	30,000	-
Yellow-billed Spoonbill	1,000	-	Silver Gull	20,000	-

Appendix 2. Species listed on databases for the Swan Coastal Plain, but unlikely to be present on the wetlands in the study area.

Species	Status	Reason for excluding from Table 2.
Eastern Reef Egret *Egretta sacra*	CS1	Coastal species, unlikely to use near-coastal wetlands except as a vagrant.
Intermediate Egret *Ardea intermedia*	-	Occurs in northern and eastern Australia, only present on the Swan Coastal Plain as an occasional vagrant.
Black Bittern *Ixobrychus flavicollis*	CS2	Probably locally extinct on the Swan Coastal Plain
Masked Lapwing *Vanellus miles*	-	Occurs in northern and eastern Australia, only present on the Swan Coastal Plain as an occasional vagrant.
Latham's Snipe *Gallinago hardwickii*	CS1	Occurs as a non-breeding migrant to eastern Australia. Only present on the Swan Coastal Plain as an occasional vagrant.
Ruddy Turnstone *Arenaria interpres*	CS1	Coastal species that favours tidal mudflats, rocky shores and sea-weed covered beaches (Johnstone and Storr 1998). Unlikely to use near-coastal wetlands except as a vagrant.
Sanderling *Calidris alba*	CS1	Coastal species favouring sandy beaches and occasionally intertidal mudflats (Geering *et al*. 2007). Unlikely to use near-coastal wetlands except as a vagrant.
Pacific Golden Plover *Pluvialis dominicus*	CS1	Coastal species that favours intertidal sand and mudflats, coastal salt marshes and rocky beaches (Geering *et al*. 2007), Unlikely to use near-coastal wetlands except as a vagrant.
Greater Sand Plover *Charadrius leschenaultii*	CS1	Coastal species favouring sandy beaches and intertidal mudflats (Geering *et al*. 2007). Unlikely to use near-coastal wetlands except as a vagrant.
Caspian Tern *Hydroprogne caspia*	CS1	Coastal species, unlikely to use near-coastal wetlands except as a vagrant.
Common Tern *Sterna hirundo*	CS1	Coastal species, unlikely to use near-coastal wetlands except as a vagrant.
Bar-tailed Godwit *Limosa lapponica*	CS1	Coastal species favouring intertidal mudflats (Geering *et al*. 2007) and sandy beaches (Johnstone and Storr 1998). Unlikely to use near-coastal wetlands except as a vagrant.
Whimbrel *Numenius phaeopus*	CS1	Coastal species favouring intertidal mudflats, tidal reefs and sandy beaches (Johnstone and Storr 1998). Unlikely to use near-coastal wetlands except as a vagrant.
Eastern Curlew *Numenius madagascariensis*	CS1	Coastal species favouring intertidal mudflats (Geering *et al*. 2007). Unlikely to use near-coastal wetlands except as a vagrant.
Grey-tailed Tattler *Tringa brevipes*	CS1	Coastal species favouring intertidal mudflats, reefs and rocky platforms (Geering *et al*. 2007). Unlikely to use near-coastal wetlands except as a vagrant.
Terek Sandpiper *Xenus cinereus*	CS1	Coastal species favouring intertidal mudflats, estuaries and bays (Geering *et al*. 2007). Unlikely to use near-coastal wetlands except as a vagrant.
Great Knot *Calidris tenuirostris*	CS1	Coastal species favouring sandy beaches, and intertidal mudflats (Johnstone and Storr 1998). Unlikely to use near-coastal wetlands except as a vagrant.
Red Knot *Calidris canutus*	CS1	Coastal species favouring sandy beaches, and intertidal mudflats (Johnstone and Storr 1998). Unlikely to use near-coastal wetlands except as a vagrant.
Broad-billed Sandpiper *Limicola falcinellus*	CS1	Coastal species favouring estuaries, bays and mangrove-lined inlets (Geering *et al*. 2007). Unlikely to use near-coastal wetlands except as a vagrant.

Appendix 3. Habitat Preferences of Wetland and Migratory Birds.

Species	Usual Habitats*	Open water	Deep water	Shallow water	Open shore	Emergent rushes	Fringing trees	Nearby parkland	Breeding Habitat*
Anatidae (ducks and swans)									
Musk Duck	Freshwater wetlands, estuaries & salt-lakes	●	●	●					Well-vegetated freshwater wetlands
Freckled Duck	Well-vegetated freshwater or saline wetlands	●		●	●				Well-vegetated freshwater wetlands
Black Swan	Open freshwater wetlands & estuaries	●		●	●			●	Well-vegetated freshwater wetlands
Australian Shelduck	Freshwater wetlands, estuaries & salt-lakes	●		●	●		●		Well-vegetated freshwater wetlands or salt-lakes
Australian Wood Duck	Pasture and herbage alongside freshwater wetlands or farm dams.			●	●		●	●	Nests in large eucalypt hollow, sometimes at a distance from wetland.
Pink-eared Duck	Large freshwater wetlands, & salt-lakes	●		●	●				Well-vegetated fresh or brackish wetlands.
Australasian Shoveler	Deep well-vegetated freshwater wetlands & salt-lakes	●		●	●				In vegetation on freshwater wetlands
Grey Teal	Freshwater wetlands, estuaries & salt-lakes	●		●	●		●	●	Nests in large eucalypt hollow, sometimes at a distance from wetland (up to 1km).
Chestnut Teal	Freshwater wetlands, estuaries & sheltered seas.	●		●	●				In vegetation on freshwater wetlands or brackish waters.
Northern Mallard	Naturalised on Perth freshwater wetlands.	●		●	●			●	In vegetation on freshwater wetlands
Pacific Black Duck	Freshwater wetlands, estuaries & sheltered seas.	●		●	●		●	●	In vegetation on freshwater wetlands
Hardhead	Freshwater wetlands, rain-freshened salt-lakes & farm dams.	●	●	●					Well-vegetated freshwater wetlands
Blue-billed Duck	Deep freshwater wetlands	●	●	●					Well-vegetated freshwater wetlands
Muscovy Duck	Introduced on Perth wetlands.	●		●	●			●	-
Domestic Goose	Introduced on Perth wetlands.	●		●	●			●	-
Podicipedidae (grebes)									
Australasian Grebe	Open freshwater wetlands.	●	●	●		●			Floating platform of vegetation in wetlands.
Hoary-headed Grebe	Open freshwater or brackish wetlands or salt-lakes.	●	●	●		●			Floating platform of vegetation in wetlands.
Great Crested Grebe	Large, deep freshwater or brackish wetlands or salt-lakes.	●	●	●		●			Floating platform of vegetation in wetlands.
Anhingidae (darter)									
Australasian Darter	Freshwater wetlands, rivers, mangrove streams & estuaries.	●	●				●		In small colonies in trees overhanging wetlands or streams.

Appendix 3. (cont.)

Species	Usual Habitats*	Open water	Deep water	Shallow water	Open shore	Emergent rushes	Fringing trees	Nearby parkland	Breeding Habitat*
Phalacrocoracidae (cormorants)									
Little Pied Cormorant	Freshwater wetlands, rivers, estuaries, & sheltered seas.	●	●				●		In small colonies in trees overhanging wetlands.
Great Cormorant	Freshwater wetlands, rivers, estuaries, near-coastal salt-lakes, & sheltered seas.	●	●				●		In small colonies in trees overhanging or in wetlands.
Little Black Cormorant	Estuaries, freshwater wetlands, rivers & sheltered seas.	●	●				●		In colonies in trees overhanging wetlands or rivers.
Pied Cormorant	Sheltered seas, estuaries and near-coastal wetlands.	●	●				●		Colonially on islands
Pelecanidae (pelicans)									
Australian Pelican	Estuaries & near-coastal wetlands.	●			●				In small colonies on islands
Ardeidae (bitterns, egrets and herons)									
Australasian Bittern	Dense beds of rushes around shallow freshwater wetlands.			●		●			Dense beds of rushes around shallow freshwater wetlands.
Australian Little Bittern	Dense beds of rushes around shallow freshwater wetlands.			●		●			Dense beds of rushes around shallow freshwater wetlands.
White-necked Heron	Shallow freshwater wetlands and rain-freshened salt-lakes.			●	●		●		Nests in trees overhanging wetlands.
Eastern Great Egret	Shallow freshwater wetlands.			●	●		●		Colonially in trees in wooded wetlands.
Cattle Egret	Pastures and wetlands.			●	●			●	Not known from south-west WA.
White-faced Heron	Shallow freshwater wetlands.			●	●		●		Singly or small groups in trees fringing wetlands.
Little Egret	Shallow freshwater or saltwater wetlands.			●	●				Small colonies in trees fringing wetlands.
Nankeen Night-Heron	Shallow freshwater or saltwater wetlands.			●	●		●		Colonially in trees fringing wetlands.
Threskiornithidae (ibis and spoonbills)									
Glossy Ibis	Shallows of freshwater wetlands and river pools.			●	●				Small colonies in tall paperbarks.
Australian White Ibis	Freshwater wetlands, damp pasture and estuarine habitats.			●	●		●	●	Colonially in trees in wooded wetlands.
Straw-necked Ibis	Freshwater wetlands and damp pastures.			●	●		●	●	Colonially in trees in wooded wetlands.
Yellow-billed Spoonbill	Shallows of freshwater wetlands.			●	●		●		Singly or colonially in trees fringing wetlands.
Accipitridae (eagles, harriers, kites and allies)									
Eastern Osprey	Coastal habitats.	●					●		Usually on islands.
White-bellied Sea-Eagle	Coastal habitats, estuaries and larger river systems.	●					●		Usually on islands, sometimes in tall trees on the mainland coast.
Whistling Kite	Wetlands and open terrestrial habitats.						●		In tall eucalypt trees
Swamp Harrier	Freshwater wetlands with rushes.	●				●	●		Amongst rushes in wetlands.

Appendix 3. (cont.)

Species	Usual Habitats*	Open water	Deep water	Shallow water	Open shore	Emergent rushes	Fringing trees	Nearby parkland	Breeding Habitat*
Rallidae (crakes, rails and allies)									
Purple Swamphen	Shallows of vegetated freshwater wetlands and grassy areas.			●		●		●	Nests in vegetation such as rushes, above the water.
Buff-banded Rail	Well-vegetated margins of wetlands.			●		●			On ground up to 500m from wetland.
Baillon's Crake	Well-vegetated margins of wetlands.			●		●			In rushes on wetland margin.
Australian Spotted Crake	Well-vegetated margins of wetlands.			●		●			Nests in vegetation such as rushes, above the water.
Spotless Crake	Well-vegetated margins of wetlands.			●		●			In rushes or on ground near wetland.
Dusky Moorhen	Shallows of vegetated freshwater wetlands and grassy areas.			●		●		●	Nests in vegetation such as rushes, at water level.
Eurasian Coot	Freshwater wetlands, grassy areas.			●	●	●		●	Nests in vegetation such as rushes, at water level.
Recurvirostridae (stilts and avocets)									
Black-winged Stilt	Shallow, open freshwater or brackish wetlands.			●	●				Nests on inland salt lakes.
Red-necked Avocet	Shallow, open freshwater, brackish or saltwater wetlands.			●	●				Nests on inland salt lakes.
Banded Stilt	Salt-lakes, estuaries, also fresh and brackish wetlands.			●	●				Nests colonially on inland salt lakes.
Charadriidae (plovers and dotterels)									
Grey Plover	Intertidal beaches and mudflats, also occasionally uses drying freshwater wetlands.			●	●				Non-breeding visitor to Australia.
Little Ringed Plover				●	●				Non-breeding visitor to Australia.
Red-capped Plover	Sandy beaches, estuarine flats, salt-lakes and shores of freshwater wetlands.			●	●				On ground.
Black-fronted Dotterel	Margins of shallow freshwater or brackish wetlands.			●	●				On ground, up to 500m from water.
Hooded Plover	Beaches, salt lakes and estuaries.			●	●				On ground.
Red-kneed Dotterel	Margins of shallow freshwater or brackish wetlands.			●	●				On ground, often on islet in salt-lake.
Scolopacidae (godwits, sandpipers, stints and allies)									
Black-tailed Godwit	Freshwater and brackish wetlands, and intertidal mudflats.			●	●				Non-breeding visitor to Australia.
Common Sandpiper	Estuaries, mangrove creeks, coastal salt lakes, river pools, dams and drying wetlands.			●	●				Non-breeding visitor to Australia.
Grey-tailed Tattler	Coastal species favouring intertidal mudflats, reefs and rocky platforms.			●	●				Non-breeding visitor to Australia.

Appendix 3. (cont.)

Species	Usual Habitats*	Open water	Deep water	Shallow water	Open shore	Emergent rushes	Fringing trees	Nearby parkland	Breeding Habitat*
Scolopacidae (godwits, sandpipers, stints and allies)									
Common Greenshank	Freshwater and saltwater wetlands, and intertidal mudflats.			●	●				Non-breeding visitor to Australia.
Marsh Sandpiper	Freshwater and saltwater wetlands, both near the coast and inland.			●	●				Non-breeding visitor to Australia.
Wood Sandpiper	Freshwater wetlands, occasionally intertidal mudflats.			●	●				Non-breeding visitor to Australia.
Great Knot	Coastal species favouring sandy beaches, and intertidal mudflats.			●	●				Non-breeding visitor to Australia.
Red Knot	Coastal species favouring sandy beaches, and intertidal mudflats.			●	●				Non-breeding visitor to Australia.
Red-necked Stint	Wide range of fresh and saltwater habitats, including freshwater wetlands.			●	●				Non-breeding visitor to Australia.
Long-toed Stint	Freshwater wetlands and river pools, though it can occur in other habitats.			●	●				Non-breeding visitor to Australia.
Pectoral Sandpiper	Freshwater wetlands.			●	●				Non-breeding visitor to Australia.
Sharp-tailed Sandpiper	Non-tidal freshwater or brackish wetlands.			●	●				Non-breeding visitor to Australia.
Curlew Sandpiper	Intertidal mudflats, also uses freshwater wetlands.			●	●				Non-breeding visitor to Australia.
Ruff	Freshwater wetlands.			●	●				Non-breeding visitor to Australia.
Laridae (gulls & terns)									
Fairy Tern	Sheltered seas, estuaries and near-coastal wetlands.	●			●				Colonially, usually on islands, also in Swan River Estuary.
Gull-billed Tern	Coastal and estuarine habitats, near-coastal and freshwater wetlands.	●			●				Nests on inland salt lakes.
Whiskered Tern	Freshwater wetlands, inundated salt-lakes, estuaries and river pools.	●			●				Nests on inland salt lakes.
White-winged Black Tern	Mainly freshwater wetlands when in the south-west.	●			●				Non-breeding visitor to south-west WA.
Silver Gull	Coastal and estuarine habitats, near-coastal and inland lakes.	●			●			●	Usually colonially on islands.
Acrocephalidae									
Australian Reed-Warbler	Fringing vegetation around wetlands, particularly rushes.					●			Fringing vegetation around wetlands, particularly rushes.
Megaluridae									
Little Grassbird	Fringing vegetation around wetlands, particularly rushes.					●			Fringing vegetation around wetlands, particularly rushes.

*after Johnstone *et al*. (1998), Johnstone *et al*. (2004) and Geering *et al*. (2007).

Appendix 4. Raw count data from 2009 - 2010 waterbird surveys.

Bibra Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	23	25	27	30	9	7			1			5
Black Swan	80	62	32	41	15	1	2	2	6	18	165	263
Radjah Shelduck						1	1	1				
Australian Shelduck	7	5	84	45	22	109	3	4	6	3	10	52
Australian Wood Duck	3		4	4	19	6						
Pink-eared Duck		2	2	14		744	1	12	1			
Australasian Shoveler	2		67	49	3	317	6	8	4	1	77	310
Grey Teal	7	12	9	32	263	3849	138	168	179	1309	1376	2206
Chestnut Teal										1		
Northern Mallard	5	3	3	3	3	2	4	4	4	4	4	3
Pacific Black Duck	34	39	215	233	1638	362	84	99	307	1326	1666	1396
Hardhead	577	79	39	55	21							100
Blue-billed Duck	16	7	13	5								
Domestic Goose	1	1					1		1	1	1	1
Australasian Grebe		1		1	2				3			3
Hoary-headed Grebe				7	5		2					1
Great Crested Grebe			1									
Darter			1	2					1			
Little Pied Cormorant	1		1	7		2						
Great Cormorant						1	1					
Little Black Cormorant				4	2	15						
Australian Pelican				2		53		9	5	2		
Great Egret	1		2	4		15						
White-faced Heron			2		3	9	6	4	4	29	7	1
Glossy Ibis						23						
Australian White Ibis			4	4	15	7		1		511	26	26
Straw-necked Ibis					5	4	8		4	179	35	
Yellow-billed Spoonbill					1	10			2			
White-bellied Sea-Eagle	1											
Swamp Harrier			1		1	1				1	1	1
Purple Swamphen		2	2	2	12	17		7	2	4		5
Spotless Crake									1			
Dusky Moorhen	1	2	1	1	4	2	1	3	3	3	4	
Eurasian Coot	906	479	1376	875	258	7	8	1	2	32	85	555
Black-winged Stilt			3	5	34	2513	100	71	2	130	848	398
Banded Stilt					1	4					1	
Red-necked Avocet					20	1329	3	2		28	49	69
Red-capped Plover							1272					
Common Greenshank						39	1	2				
Marsh Sandpiper						1						
Sharp-tailed Sandpiper						2						
Whiskered Tern						4						
Silver Gull	22	53	46	85	198	491	188	117	16	3	10	15
Australian Reed-Warbler	1	4	2		2							1
Little Grassbird	1											
Total:	**1689**	**776**	**1937**	**1510**	**2556**	**9947**	**1830**	**515**	**554**	**3585**	**4365**	**5411**

Appendix 4. (cont.)

Kogolup Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	6	6	3	9	2	5						2
Black Swan	14	4	2	1	1	2	5	7	84	157	138	25
Australian Shelduck						1			2	8		2
Australian Wood Duck				1								
Pink-eared Duck		10						6				
Australasian Shoveler	4	8			8	74	5	7		14	48	48
Grey Teal				4	17	185	289	65	2	44	21	12
Chestnut Teal							1					
Pacific Black Duck	44	3	16	26	11	94	73	22	13	118	326	106
Hardhead	24	12	4	17	2							4
Blue-billed Duck	8	3	7	7	5	7	12	6				
Australasian Grebe	4				2	1	24	10	4			4
Hoary-headed Grebe	4	19	14	49	38	21	21	15				
Little Pied Cormorant	3	3		3	4	2						
Little Black Cormorant				1	1							
Australian Pelican				1	5			1				
Great Egret					1		1					
White-faced Heron			1	3	1	7	8	2			3	
Little Egret			1	1								
Australian White Ibis	10	1	33	19	13	30	4				2	
Straw-necked Ibis			2			6	1					
Yellow-billed Spoonbill			1			2	9					
White-bellied Sea-Eagle							1					
Whistling Kite	1	3	4	1	2	8					2	1
Swamp Harrier	2		2	1			2	1		2	2	
Purple Swamphen	29	23	44	35	2	43	85	68	68	70	36	7
Spotless Crake	4	1				1						
Dusky Moorhen	2					1	3	10				
Eurasian Coot	25	31	16	13	15	34	35	48				
Black-winged Stilt							73	46	3	5		
Banded Stilt								4				
Red-necked Avocet							9					
Red-capped Plover								21				
Common Sandpiper							1					
Common Greenshank							3	2				
Marsh Sandpiper								1				
Wood Sandpiper								1				
Sharp-tailed Sandpiper							5	2				
Australian Reed-Warbler	8	8	10	2	3	6					3	2
Little Grassbird	2	2	1								2	3
Total:	**194**	**137**	**161**	**194**	**133**	**530**	**670**	**345**	**176**	**418**	**583**	**216**

Appendix 4. (cont.)

Lake Coogee												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	4	2	1	9	7	3	2	2		2	7	10
Black Swan	3	1			1		2		11	2	6	3
Australian Shelduck	4				10	1	2		6	5	4	
Australasian Shoveler					1				2		7	
Grey Teal	6	9			47				4		2	
Pacific Black Duck	6	10	1		4				5	27	8	5
Blue-billed Duck									1			
Hoary-headed Grebe	13								7		6	26
Darter					1							
Little Pied Cormorant	1		7	36	44	24	4	4	14	17	13	
Great Cormorant	1											
Little Black Cormorant			24	26	27	16						
Australian Pelican	1		1				2		2			
Great Egret	2	1			1				2			
White-faced Heron	3	1	2	2	1	2	1	4	5		2	3
Little Egret										1	2	
Australian White Ibis	3		2	6	1	30	306	458	237			
Straw-necked Ibis									5	11		
Yellow-billed Spoonbill			1		5						1	1
Whistling Kite						1						
Spotless Crake									2			
Dusky Moorhen											2	
Eurasian Coot		2	2							6	6	22
Black-winged Stilt			6	12	2	74	60	72	86			
Banded Stilt							10	9	1			
Red-necked Avocet							25	49	8			
Black-fronted Dotterel							1		11			
Marsh Sandpiper							1					
Red-necked Stint									1			
Silver Gull	80	14	56	63	382	26	211	194	61	68	6	42
Little Grassbird				1								
Total:	**127**	**40**	**103**	**155**	**534**	**177**	**627**	**792**	**471**	**139**	**72**	**112**

Appendix 4. (cont.)

Fawcett Rd Wetland												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	1	2										
Black Swan	2	2	1							2	2	1
Australian Shelduck	3			10	33						2	2
Grey Teal	4	2		1	10							2
Pacific Black Duck		2		4	3						2	2
White-faced Heron				1	1							
Nankeen Night Heron				1								
Australian White Ibis					4							
Straw-necked Ibis				1		5		1				
Yellow-billed Spoonbill					1							
Dusky Moorhen		1										
Eurasian Coot	23	9	2	6								
Black-winged Stilt				2	17		2			82		
Banded Stilt										1		
Red-necked Avocet										10		
Red-capped Plover								2				
Black-fronted Dotterel								1				
Silver Gull	15	18	1	1						4	16	1
Total:	**48**	**36**	**4**	**27**	**69**	**5**	**2**	**4**	**0**	**99**	**22**	**8**

Manning Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck		3		1								
Black Swan			3		1				2	1	4	2
Australian Shelduck		2		7	11				1	2	2	2
Pink-eared Duck	1		1	9	2							
Australasian Shoveler	1	2							1	14	20	
Grey Teal	4	3	12	52	10		6	18	53	35	8	5
Northern Mallard		1		2			2	2				
Pacific Black Duck	2	2	10	11	1		11	17	7	13	8	8
Hardhead										2		
Blue-billed Duck	1											
Australasian Grebe		1								1		
White-faced Heron						1			1			
Australian White Ibis				1	2			1				
Straw-necked Ibis									18			
Purple Swamphen	2		4	2	1							1
Dusky Moorhen	1											1
Eurasian Coot	80	49	31	48	42					91	16	334
Black-winged Stilt				28	87		3	2	36	4		
Banded Stilt										1		
Silver Gull	50	146	116	53	165				19	31		26
Total:	**142**	**209**	**177**	**214**	**322**	**1**	**22**	**40**	**138**	**195**	**58**	**379**

Appendix 4. (cont.)

Little Rush Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	5	6	4	3	5	4						
Black Swan	2	2	1							2	2	2
Australian Shelduck				1		36	3			2	2	
Pink-eared Duck					4							
Australasian Shoveler			2				10	2				
Grey Teal		2	7	4	7	26	213	182				
Pacific Black Duck	2	6	35	2	7	31	11	1		2		1
Hardhead			1	7		1						
Hoary-headed Grebe		4	13	19	43							
Darter	1				1							
Little Pied Cormorant			1									
Little Black Cormorant		1	2			11						
Australian Pelican							1					
Great Egret						1						
Intermediate Egret						1						
White-faced Heron							1			1	1	1
Little Egret								1				
Australian White Ibis			22		1	44						
Yellow-billed Spoonbill						12						
Swamp Harrier			1	1		1						
Purple Swamphen	2	1		1	1	1				7	3	3
Dusky Moorhen	3			1				1				
Eurasian Coot	12	12	17	4	9							
Black-winged Stilt							22	40	34			
Banded Stilt							1	2				
Red-necked Avocet							35	9	10			
Black-fronted Dotterel						1						
Common Greenshank							2	1				
Marsh Sandpiper							1					
Wood Sandpiper								8				
Total:	**27**	**34**	**106**	**43**	**78**	**170**	**300**	**247**	**44**	**14**	**8**	**7**

Appendix 4. (cont.)

Market Garden Swamp												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	3	4	2									1
Black Swan	2	2								2		1
Australian Shelduck	2	2	2		4	18			9	4	6	1
Pink-eared Duck	12	7	17	3	2						4	2
Australasian Shoveler	2				1						5	5
Grey Teal	32	27	14	19	101				40	14	17	12
Northern Mallard	1											
Pacific Black Duck	16	21	13	18	4					10	24	18
Hardhead			5	23								
Australasian Grebe	3											
Hoary-headed Grebe	16	9	7	8								
Little Pied Cormorant	1	4	4		1							
Little Black Cormorant				1	7							
Australian Pelican				1								
Great Egret				1	1							
White-faced Heron	1			2	1	3				1	1	
Little Egret			1									
Australian White Ibis		1	1	14	13	18			10			1
Straw-necked Ibis				3	2				2			
Yellow-billed Spoonbill				1	6							
Swamp Harrier			1						1			
Purple Swamphen	3	3	2	1								
Dusky Moorhen	2	1	1		1							1
Eurasian Coot	32	16	15	14	4						9	37
Black-winged Stilt			5	11	14			2	26			
Black-fronted Dotterel									4			
Silver Gull	1	6			1				1		1	
Total:	**129**	**103**	**90**	**120**	**163**	**39**	**0**	**2**	**93**	**31**	**67**	**79**

Appendix 4. (cont.)

North Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck			1									
Black Swan	148	31	14	17					7	155	148	31
Australian Shelduck	3	2		32	160				2	23	3	2
Pink-eared Duck				1	2							
Australasian Shoveler	2	1	1	34	35						2	1
Grey Teal	2		13	163	444						2	
Pacific Black Duck	119	21	77	302	392					31	119	21
Australasian Grebe	2	2	2								2	2
Little Pied Cormorant		1	2	4								1
White-necked Heron			1	1								
Great Egret			1		1							
Cattle Egret										1		
White-faced Heron	2	1		1	3	7	2		26	10	2	1
Glossy Ibis				28	20							
Australian White Ibis	1			11	37	51			41	7	1	
Straw-necked Ibis				1	3	3						
Yellow-billed Spoonbill				1								
Swamp Harrier	1										1	
Purple Swamphen	1	1	1	3	6		1	2	6	1	1	1
Dusky Moorhen		1			3							1
Eurasian Coot		29	11		2							29
Black-winged Stilt		1		150	227					7		1
Red-necked Avocet					20							
Common Greenshank					2							
Silver Gull				1								
Australian Reed-Warbler			2	2			1					
Total:	**281**	**91**	**126**	**752**	**1357**	**61**	**4**	**2**	**82**	**235**	**281**	**91**

Roe Swamp												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Australian Shelduck	2	8										2
Pacific Black Duck	22	5	5									
Australasian Grebe		2										
Little Pied Cormorant			2									
Great Egret			1									
White-faced Heron				2								
Nankeen Night Heron				4								
Australian White Ibis	2	1		13								
Straw-necked Ibis				2								
Dusky Moorhen	2		1									
Eurasian Coot		10	1									
Total:	**28**	**26**	**10**	**21**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**

Appendix 4. (cont.)

South Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	5	5	6	3	4							
Freckled Duck				1								
Black Swan	1	1			2	1				131	18	94
Radjah Shelduck										1		
Australian Shelduck	6				3	33				19	1	
Pink-eared Duck			2	34	106	15						
Australasian Shoveler				2	1	6						
Grey Teal			11	13	37	305	4					
Pacific Black Duck	3	4	17	24	2	12						86
Hardhead	17	34		46		2						
Blue-billed Duck			1									
Australasian Grebe	4	3			2	3						
Hoary-headed Grebe	2		40	28	56	14						
Darter			1									
Little Pied Cormorant	1	2	1	2		1						3
Great Cormorant		1										
Little Black Cormorant				17								
White-faced Heron			3				1		2	2	1	4
Australian White Ibis	62	117	196	102	68	36						57
Swamp Harrier				1	1				1			
Dusky Moorhen		2										
Eurasian Coot	14	14	7	3								
Black-winged Stilt				1			98					
Banded Stilt							3					
Red-necked Avocet							6					
Black-fronted Dotterel						1	19					
Red-kneed Dotterel						1						
Common Greenshank							2					
Total:	**115**	**183**	**285**	**277**	**282**	**430**	**133**	**0**	**3**	**153**	**20**	**244**

Appendix 4. (cont.)

Thomsons Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	14	8	11	4								
Black Swan	214	212	184	67	81	51				1	78	282
Australian Shelduck	14	24	11	85	236	132				35	78	42
Australian Wood Duck	1											
Australasian Shoveler	6	15	53	2	155	320						1
Grey Teal	10	20		11	116	850						6
Pacific Black Duck	111	39	15	536	142	810						5
Hardhead				4								
Blue-billed Duck	9	61	23	29								
Australasian Grebe				1	2							
Hoary-headed Grebe		26	129	55	8							
Little Pied Cormorant	2	1	10	19	7							
Great Cormorant	1											
Australian Pelican			1	14	7	17						
White-necked Heron			1	9	19							
Great Egret		1	5	3	11	6						
White-faced Heron	5	6	14	8	16	152	3			1	16	25
Little Egret				2								
Nankeen Night Heron				1								
Glossy Ibis				18	36	44						
Australian White Ibis	3	1	14	61	194	294						
Straw-necked Ibis		1	5	21	54	4						
Yellow-billed Spoonbill		1	9	7	5	10						1
White-bellied Sea-Eagle	1											
Whistling Kite	4	1	3	3	5	18					2	2
Swamp Harrier	1	2	2	2	2	2					2	1
Purple Swamphen	7	3	3	4	5	37				11	26	14
Baillon's Crake					1							
Spotless Crake	10	8	1	1	4							2
Eurasian Coot				3								
Black-winged Stilt			9	331	600	1500						51
Red-capped Plover						120	209	144	14			5
Black-fronted Dotterel					1							
Black-tailed Godwit						1						
Common Greenshank					4	6						
Marsh Sandpiper					2	4						
Wood Sandpiper					1	8						
Red-necked Stint							2				1	
Long-toed Stint					1							
Sharp-tailed Sandpiper		3				6						
Silver Gull						300						
Australian Reed-Warbler	7	7	9	9	9	3						5
Little Grassbird	9	2	4	2		1					1	6
Total:	**429**	**442**	**516**	**1312**	**1724**	**4696**	**214**	**144**	**14**	**48**	**204**	**448**

Appendix 4. (cont.)

Yangebup Lake												
Species	**30/08/09**	**27/09/09**	**1/11/09**	**1/12/09**	**24/12/09**	**22/01/10**	**25/02/10**	**18/03/10**	**18/04/10**	**30/05/10**	**20/06/10**	**18/07/10**
Musk Duck	12	6	6	8	8	41	37	38	35	6	10	9
Black Swan		7	36	43	67	15	6	5	3	2	7	5
Radjah Shelduck							1					
Australian Shelduck	2	14	418	656	268	97	20		24	2	3	2
Australian Wood Duck	3	2										8
Pink-eared Duck		2	14	2	54	345	985	699	36	121	316	451
Australasian Shoveler	5	11	13			21	51	28	10	54	69	14
Grey Teal	11	13	10	9	9	69	51	30	172	256	368	27
Northern Mallard											1	
Pacific Black Duck	26	41	24	14	10	21	15	12	162	318	210	49
Hardhead	7	18	44	35	44	34		3	4	39	27	384
Blue-billed Duck	270	133	47	99	353	393	168	277	319	142	223	118
Domestic Goose	1		2	3	3	2	2	2	2	2	1	1
Australasian Grebe	4		1	1					2			
Hoary-headed Grebe	14	99	85	170	121	441	48	6	17	12	2	15
Little Pied Cormorant		2		1								
Great Cormorant			2	3		4						
Little Black Cormorant		1		2	5	2	1			1		
Australian Pelican		2	2	5	14	19	21	4	2	2		
Great Egret		1		1		2	1	1	1			
White-faced Heron	1		2		3	1	3	2	1	3		2
Australian White Ibis	1	3	14	7	11	12	2	1			3	1
Straw-necked Ibis			2	19		16						
Yellow-billed Spoonbill						3	1	1		3		1
Whistling Kite					1	1		2		1		1
Swamp Harrier								1				1
Purple Swamphen	7	2		1		5	7	1		1	2	3
Buff-banded Rail						1						
Australian Spotted Crake						1						
Spotless Crake						1						
Dusky Moorhen	1						1					
Eurasian Coot	11	33	220	413	94	200	88	31	65	35	17	6
Black-winged Stilt		5				6	10		2	2	2	
Banded Stilt								5				
Red-necked Avocet						2					1	
Red-capped Plover								4				
Black-fronted Dotterel							19	46		20	25	24
Masked Lapwing								1				
Common Sandpiper		1				1	1					
Common Greenshank								1				
Silver Gull							8					1
Australian Reed-Warbler	1	1	1	1	1	1		1		1	1	1
Little Grassbird	1		1	1	1	1					1	
Total:	**378**	**397**	**944**	**1494**	**1067**	**1758**	**1547**	**1202**	**857**	**1023**	**1289**	**1124**

Appendix 5. High counts of conservation significant species

Note: Counts given are the highest single count of the species on the wetland in the dataset indicated. Not all wetlands were surveyed in each study.

Species of Conservation Significance 1

CS1 Species	Wetland												
	Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
RAOU Waterbird Usage Surveys 1981 - 1988													
Australasian Bittern					-			-				2	
Eastern Great Egret	4	23			-		1	-	4			15	2
Cattle Egret					-			-			1		
Glossy Ibis		2			-			-				24	
Eastern Osprey					-			-				1	
White-bellied Sea-Eagle					-			-				1	
Pacific Golden Plover					-			-					
Grey Plover					-			-					
Little Ringed Plover					-			-					
Black-tailed Godwit	4				-			-				15	
Bar-tailed Godwit					-			-				1	
Common Sandpiper	1				-		1	-					1
Grey-tailed Tattler				1	-			-					
Common Greenshank	1	7		5	-			-		3	2	40	1
Marsh Sandpiper		3			-			-				30	
Wood Sandpiper	1	3	1		-			-				21	5
Great Knot					-			-				1	
Red Knot					-			-				2	
Red-necked Stint	1			3	-			-				2500	1500
Long-toed Stint	1				-			-				11	15
Pectoral Sandpiper					-			-				3	
Sharp-tailed Sandpiper		8			-			-				1000	80
Curlew Sandpiper	6	2		1	-			-				2500	200
Ruff (Reeve)					-			-				1	1
White-winged Black Tern					-			-				60	
ScopeWest Waterbird Surveys 1990 - 1992													
Australasian Bittern				-	-	-	-	-			-	1	
Eastern Great Egret	7	8	1	-	-	-	-	-	1	2	-	5	2
Cattle Egret				-	-	-	-	-			-		
Glossy Ibis		1		-	-	-	-	-			-		
Eastern Osprey				-	-	-	-	-			-		
White-bellied Sea-Eagle				-	-	-	-	-			-		
Pacific Golden Plover				-	-	-	-	-			-		
Grey Plover				-	-	-	-	-			-		
Little Ringed Plover				-	-	-	-	-			-		
Black-tailed Godwit				-	-	-	-	-			-	6	
Bar-tailed Godwit				-	-	-	-	-			-		
Common Sandpiper				-	-	-	-	-			-		
Grey-tailed Tattler				-	-	-	-	-			-		

Appendix 5. (cont.)

CS1 Species	Wetland												
	Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
ScopeWest Waterbird Surveys 1990 - 1992													
Common Greenshank				-	-	-	-	-			-	8	
Marsh Sandpiper				-	-	-	-	-			-	4	
Wood Sandpiper		2		-	-	-	-	-			-	45	6
Great Knot				-	-	-	-	-			-		
Red Knot				-	-	-	-	-			-		
Red-necked Stint		63		-	-	-	-	-			-		
Long-toed Stint		13		-	-	-	-	-			-	3	2
Pectoral Sandpiper		1		-	-	-	-	-			-		1
Sharp-tailed Sandpiper		1		-	-	-	-	-			-	375	1
Curlew Sandpiper				-	-	-	-	-			-	240	9
Ruff (Reeve)				-	-	-	-	-			-		
White-winged Black Tern				-	-	-	-	-			-	66	
Birds Australia Atlas Database 1998 - 2010													
Australasian Bittern													
Eastern Great Egret	19	9		1		1			2			9	2
Cattle Egret													
Glossy Ibis	31	17							8			63	
Eastern Osprey	2												
White-bellied Sea-Eagle													
Pacific Golden Plover													
Grey Plover									9				
Little Ringed Plover													
Black-tailed Godwit											2	2	
Bar-tailed Godwit													
Common Sandpiper													2
Grey-tailed Tattler													
Common Greenshank	1	19				3					14	29	1
Marsh Sandpiper		1											
Wood Sandpiper		7											
Great Knot													
Red Knot													
Red-necked Stint		6										600	15
Long-toed Stint		1										2	
Pectoral Sandpiper													
Sharp-tailed Sandpiper		22										100	
Curlew Sandpiper											30	150	1
Ruff (Reeve)													
White-winged Black Tern												1	
Unpublished Data from Bamford Consulting Ecologists 1999 - 2009													
Australasian Bittern			-	-	-	-	-	-	-	-	-		
Eastern Great Egret	20	8	-	-	-	-	-	-	-	-	-		2
Cattle Egret			-	-	-	-	-	-	-	-	-	6	
Glossy Ibis		3	-	-	-	-	-	-	-	-	-	40	
Eastern Osprey			-	-	-	-	-	-	-	-	-	1	
White-bellied Sea-Eagle			-	-	-	-	-	-	-	-	-		
Pacific Golden Plover			-	-	-	-	-	-	-	-	-		

Appendix 5. (cont.)

CS1 Species	Wetland												
	Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
Unpublished Data from Bamford Consulting Ecologists 1999 - 2009													
Grey Plover			-	-	-	-	-	-	-	-	-		
Little Ringed Plover			-	-	-	-	-	-	-	-	-		
Black-tailed Godwit			-	-	-	-	-	-	-	-	-		
Bar-tailed Godwit			-	-	-	-	-	-	-	-	-		
Common Sandpiper		1	-	-	-	-	-	-	-	-	-		
Grey-tailed Tattler			-	-	-	-	-	-	-	-	-		
Common Greenshank	20	2	-	-	-	-	-	-	-	-	-	15	
Marsh Sandpiper			-	-	-	-	-	-	-	-	-		
Wood Sandpiper	1		-	-	-	-	-	-	-	-	-		
Great Knot			-	-	-	-	-	-	-	-	-		
Red Knot			-	-	-	-	-	-	-	-	-		
Red-necked Stint	30		-	-	-	-	-	-	-	-	-		
Long-toed Stint			-	-	-	-	-	-	-	-	-		
Pectoral Sandpiper			-	-	-	-	-	-	-	-	-		
Sharp-tailed Sandpiper	20	2	-	-	-	-	-	-	-	-	-		
Curlew Sandpiper			-	-	-	-	-	-	-	-	-		
Ruff (Reeve)			-	-	-	-	-	-	-	-	-		
White-winged Black Tern			-	-	-	-	-	-	-	-	-		

Appendix 5. (cont.)

Species of Conservation Significance 2

CS2 Species	Wetland												
	Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
RAOU Waterbird Usage Surveys 1981 - 1988													
Australian Little Bittern	0	3	0	0	-	0	0	-	0	0	0	2	0
Hooded Plover	0	0	0	0	-	0	0	-	0	0	0	0	0
Fairy Tern	0	0	0	0	-	0	0	-	0	0	0	0	0
ScopeWest Waterbird Surveys 1990 - 1992													
Australian Little Bittern	0	0	0	-	-	-	-	-	0	0	-	0	0
Hooded Plover	0	0	0	-	-	-	-	-	0	0	-	0	0
Fairy Tern	0	0	0	-	-	-	-	-	0	0	-	0	0
Birds Australia Atlas Database 1998 - 2010													
Australian Little Bittern	-	-	-	-	-	-	-	-	-	-	-	1	-
Hooded Plover	-	-	-	-	-	-	-	-	-	-	-	1	-
Fairy Tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Unpublished Data from Bamford Consulting Ecologists 1999 - 2009													
Australian Little Bittern	0	0	-	-	-	-	-	-	-	-	-	0	0
Hooded Plover	0	0	-	-	-	-	-	-	-	-	-	0	0
Fairy Tern	0	0	-	-	-	-	-	-	-	-	-	0	0

Species of Conservation Significance 3

CS3 Species	Wetland												
	Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
DEC Waterfowl Counts 1988 - 1992													
Musk Duck	269	22	-	-	-	-	2	-	49	-	-	58	130
Freckled Duck	0	0	-	-	-	-	0	-	0	-	-	0	0
Pink-eared Duck	654	100	-	-	-	-	22	-	9	-	-	303	279
Australasian Shoveler	79	222	-	-	-	-	0	-	2	-	-	272	78
Hardhead	87	10	-	-	-	-	0	-	173	-	-	68	32
Blue-billed Duck	58	20	-	-	-	-	0	-	27	-	-	367	388

Appendix 5. (cont.)

CS3 Species	Wetland												
	Bibra Lake	Kogolup Lake	Horse Paddock Swamp	Lake Coogee	Fawcett Rd Wetland	Little Rush Lake	Manning Lake	Market Garden Swamp	North Lake	Lower Swamp	South Lake	Thomsons Lake	Yangebup Lake
RAOU Waterbird Usage Surveys 1981 - 1988													
Musk Duck	330	9	2	0	-	2	1	-	56	2	7	68	221
Freckled Duck	0	0	0	0	-	0	0	-	0	0	0	0	0
Pink-eared Duck	600	5	19	0	-	0	2	-	670	0	0	500	2200
Australasian Shoveler	370	20	25	0	-	4	59	-	7	7	1	2000	400
Hardhead	26	6	18	0	-	0	0	-	62	11	7	320	100
Blue-billed Duck	338	20	4	0	-	0	3	-	147	5	6	300	865
Nankeen Night-Heron	3	8	0	0	-	1	0	-	0	0	0	6	2
Whistling Kite	-	-	-	-	-	-	-	-	-	-	-	-	-
Dusky Moorhen	60	1	0	0	-	1	7	-	42	10	11	7	7
Red-kneed Dotterel	10	0	0	0	-	0	0	-	0	0	0	3	11
ScopeWest Waterbird Surveys 1990 - 1992													
Musk Duck	360	30	1	-	-	-	-	-	26	2	-	110	170
Freckled Duck	0	0	0	-	-	-	-	-	0	0	-	0	0
Pink-eared Duck	100	423	31	-	-	-	-	-	0	0	-	473	450
Australasian Shoveler	105	200	10	-	-	-	-	-	3	8	-	473	45
Hardhead	89	12	5	-	-	-	-	-	24	16	-	28	32
Blue-billed Duck	412	7	0	-	-	-	-	-	49	0	-	363	162
Nankeen Night-Heron	1	60	0	-	-	-	-	-	0	2	-	0	1
Whistling Kite	-	-	-	-	-	-	-	-	-	-	-	-	-
Dusky Moorhen	179	6	0	-	-	-	-	-	27	19	-	4	1
Red-kneed Dotterel	0	3	0	-	-	-	-	-	0	0	-	4	1
Birds Australia Atlas Database 1998 - 2010													
Musk Duck	6	8	-	-	-	7	3	-	4	-	4	4	340
Freckled Duck	-	-	-	-	-	-	-	-	-	-	-	-	-
Pink-eared Duck	-	8	-	-	-	4	-	-	-	-	65	-	300
Australasian Shoveler	100	270	-	-	-	82	-	-	10	-	30	25	30
Hardhead	300	390	-	-	-	17	-	-	-	-	-	86	277
Blue-billed Duck	3	16	-	-	-	-	-	-	-	-	-	75	360
Nankeen Night-Heron	3	10	-	-	-	-	-	-	-	-	-	1	-
Whistling Kite	1	4	-	-	-	-	-	-	-	-	1	4	1
Dusky Moorhen	63	8	-	-	-	2	2	-	-	-	4	1	2
Red-kneed Dotterel	-	2	-	-	-	-	-	-	-	-	2	6	-
Unpublished Data from Bamford Consulting Ecologists 1999 - 2009													
Musk Duck	187	10	-	-	-	-	-	-	-	-	-	10	400
Freckled Duck	2	0	-	-	-	-	-	-	-	-	-	0	0
Pink-eared Duck	20	5	-	-	-	-	-	-	-	-	-	0	500
Australasian Shoveler	55	122	-	-	-	-	-	-	-	-	-	150	130
Hardhead	330	275	-	-	-	-	-	-	-	-	-	10	395
Blue-billed Duck	24	10	-	-	-	-	-	-	-	-	-	8	809
Nankeen Night-Heron	0	0	-	-	-	-	-	-	-	-	-	0	0
Whistling Kite	1	1	-	-	-	-	-	-	-	-	-	2	1
Dusky Moorhen	10	6	-	-	-	-	-	-	-	-	-	0	0
Red-kneed Dotterel	0	0	-	-	-	-	-	-	-	-	-	0	0

Appendix 6. Waterbird count data for North Lake.

Species	Highest count between 1980 and 2002 (Month and year of highest count)*	Breeding Recorded
Musk Duck	50 (Jul 1996)	Yes
Black Swan	450 (Jan 1998)	Yes
Australian Shelduck	200 (Jan 1998)	Yes
Australian Wood Duck	10 (May 2002)	
Pink-eared Duck	500 (May 1996)	
Australasian Shoveler	250 (May 1998)	Yes
Grey Teal	1000 (Dec 1997 & Jan 1998)	Yes
Pacific Black Duck	300 (May 2002)	Yes
Hardhead	100 (Nov 2001)	Yes
Blue-billed Duck	450 (Apr 1982), 40 (Feb 1994) Species declining	
Australasian Grebe	30 (Jan 2000)	Yes
Hoary-headed Grebe	1250 (Jan 1998)	
Great Crested Grebe	Present singly	
Australasian Darter	Present singly	
Little Pied Cormorant	Present singly	
Great Cormorant	Present singly	
Little Black Cormorant	Present singly	
Australian Pelican	45 (Apr 1996)	
White-necked Heron	11 (Aug 2002)	
Eastern Great Egret	4 (Jan 2000)	
White-faced Heron	12 (Dec 1982)	Yes
Little Egret	Present singly	
Nankeen Night-Heron	Present singly	
Glossy Ibis	4 (Jun 2000)	
Australian White Ibis	2,200 (Mar 2002) Species increasing	
Straw-necked Ibis	60 (Apr 2002)	
Yellow-billed Spoonbill	8 (Feb 1994)	
White-bellied Sea-Eagle	1 (Aug 1998), immature bird	
Whistling Kite	Present singly	
Swamp Harrier	Present singly	
Purple Swamphen	13 (Mar 2002)	Yes
Buff-banded Rail	2 (Oct 2002)	Yes
Australian Spotted Crake	2 (Feb 2003)	
Spotless Crake	3 (Mar 2002)	
Dusky Moorhen	7 (Jun 1989)	Yes
Eurasian Coot	600 (Mar 1982)	Yes
Black-winged Stilt	200 (Jan 1998 & Apr 2002)	
Red-necked Avocet	250 (Jan 1998)	
Banded Stilt	15 (Apr 2002)	
Black-fronted Dotterel	31 (May 1996 & Apr 2002)	
Red-kneed Dotterel	2 (Apr 1991)	
Masked Lapwing	1 (Apr 1978)	
Black-tailed Godwit	4 (Apr 1996)	
Common Sandpiper	1 (Jan 1983)	
Common Greenshank	11 (Feb 2002)	
Red-necked Stint	30 (Apr 1996)	
Sharp-tailed Sandpiper	1 (Apr 1982)	
Whiskered Tern	25 (Oct 1982)	
Silver Gull	1,500 (Mar 1991)	
Australian Reed-Warbler	4 (Jan 1981)	
Little Grassbird	1 (Mar 2002)	
Rainbow Bee-eater	20 (Feb 1981)	Last nest 1998

* From Maddeford (2003).

Appendix 7. Rainfall data from Jandakot Airport.

This graph has been produced using data available from the Australian Bureau of Meteorology.