Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for a Significant Western Australian Wetland

Balicup Lake

2009

Figure 1 – A view across the water body at Balicup Lake.

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Contents

1. Introduction

This Resource Condition Report (RCR) was prepared by the Inland Aquatic Integrity Resource Condition Monitoring project (IAI RCM). It describes the ecological character and condition of Balicup Lake, a seasonal saline lake in the south-west of Western Australia. Balicup Lake is part of the Balicup Lake System, which comprises a wide belt of wetlands situated in lowland immediately north of the Stirling Range (Figure 2).

Balicup Lake was selected as a study site in the IAI RCM project as it is recognised as part of a nationally significant wetland system, by being listed in the *Directory of Important Wetlands in Australia* (DIWA) (Environment Australia 2001). The Balicup Lake System has also been nominated for listing under the Ramsar Convention as a Wetland of International Significance (Jaensch and Watkins 1999) because it supports more than 1% of the Australian population of Banded Stilt (*Cladorhynchus leucocephalus*). Specifically, the Balicup Lake System is a good example of a group of naturally saline, seasonal lakes in inland south Western Australia and is an important dry season refuge for waterbirds in the wheatbelt region.

1.1. Site Code

Directory of Important Wetlands in Australia: WA023.

Register of the National Estate 'Indicative' Place ID: 100074.

Inland Aquatic Integrity Resource Condition Monitoring Project (DEC): RCM037.

Transect code: RCM037-R1.

Waterbirds in Nature Reserves of South-West WA (DEC/RAOU): CALMWNRSWA_92_1.

1.2. Purpose of Resource Condition Report

The objective of this RCR is to set a benchmark against which future measures of condition can be assessed. This will allow the effectiveness of management planning and actions to be gauged. The report provides a 'snapshot' of all available ecological information relevant to the site and describes the key drivers of, and threats to, the system.

1.3. Relevant International Agreements and Legislation

This section provides a brief summary of the international agreements and legislation that are relevant to the management of Balicup Lake.

International Agreements

Migratory bird bilateral agreements and conventions

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds which may be relevant to Balicup Lake. The bilateral agreements are:

JAMBA - The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1974;

CAMBA - The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment, 1986;

ROKAMBA - The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006;

The Bonn Convention on Migratory Species (CMS) - The Bonn Convention adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

Convention on Wetlands (Ramsar) - Australia a signatory to the Ramsar Convention, a intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Balicup Lake System is proposed for listing under the Ramsar Convention so this convention may be relevant in the future.

National legislation

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. These are defined in the Act as matters of national environmental significance. There are seven matters of national environmental significance to which the EPBC Act applies, two of which are relevant to Balicup Lake:

- nationally threatened species and ecological communities; and
- migratory species listed under international treaties JAMBA, CAMBA and CMS.

As the Balicup Lake System is also a proposed Ramsar site, if this listing is achieved, the site will be further protected under the EPBC Act as a wetland of international significance.

Western Australia legislation

Wildlife Conservation Act 1950

This Act provides for the protection of wildlife. All fauna (animals native to Australia) in Western Australia is protected under section 14 and all flora (plants native to Western Australia) are protected under section 23 of the *Wildlife Conservation Act 1950*. The Act establishes licensing frameworks for the taking and possession of protected fauna, and establishes offences and penalties for interactions with fauna.

Conservation and Land Management Act 1987

This Act is administered by the State Department of Environment and Conservation (DEC) and applies to public lands. It sets the framework for the creation and management of marine and terrestrial parks, reserves and management areas in Western Australia, and deals with the protection of flora and fauna within reserve systems.

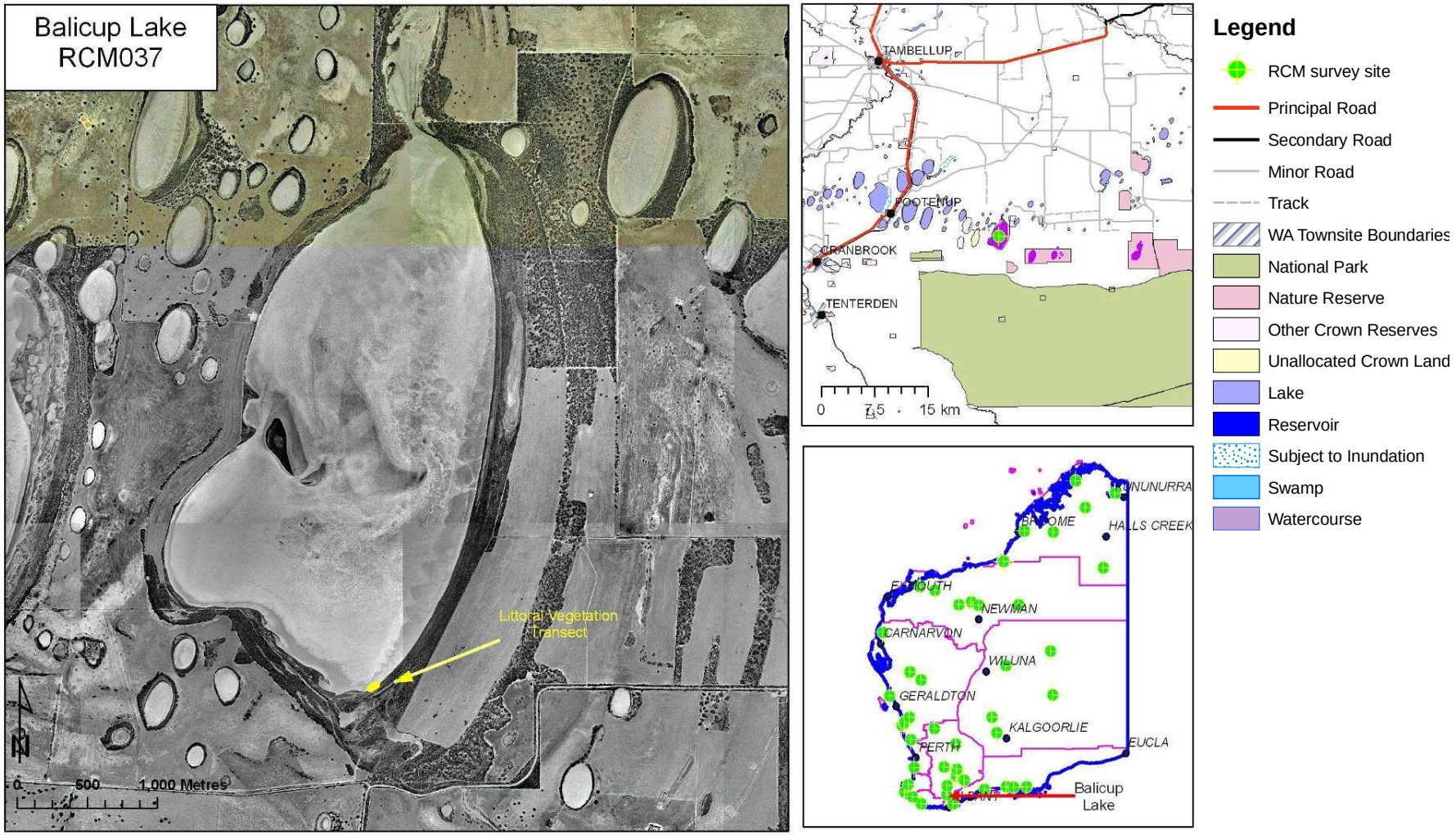

Figure 2 – Aerial photograph showing the location of the vegetation transect at Balicup Lake. Aquatic invertebrates and water quality were sampled adjacent to the transect. The upper insert shows the location of the sampling site relative to the Balicup Lake System. The lower insert shows the location of Balicup Lake in relation to other IAI RCM sites and its location in Western Australia.

2. Overview of Balicup Lake

2.1. Location and Cadastral Information

Balicup Lake lies approximately 12 km east of Pootenup and 20 km north-northeast of Cranbrook, north of Hamilla Road (Figure 2). The Balicup Lake System is located immediately north of the Stirling Range. The lake is contained within Balicup Nature Reserve (A18468), which was gazetted for the purpose of conservation of flora and fauna. Some of the lakes in the Balicup Lake System are contained within five other unconnected nature reserves (Salt Lake A25812, Jebarjup A26160, Camel Lake A26161, Three Swamps C26162 and Beejanup C30526). The surrounding areas are mainly freehold land used for pasture grazing, cereal cropping, recreation and very low human population.

2.2. IBRA Region

Balicup Lake lies within the western subregion (AW2) of the Avon Wheatbelt Interim Biogeographic Regionalisation of Australia (IBRA) region. This region is a dissected plateau of Tertiary laterite in the Yilgarn Craton. The western subregion comprises gently undulating rises to low hills with abrupt breakaways. The vegetation consists primarily of proteaceous scrubheaths rich in endemic species (Beecham 2003).

2.3. Climate

The nearest Bureau of Meteorology weather station to Balicup Lake is at Mt Barker, 40 km away (Bureau of Meteorology 2009). Records have been kept at Mt Barker since 1886.

Mt Barker experiences a semi-arid warm Mediterranean climate. It receives a mean annual rainfall of 732.7 mm, approximately half of that (51%) falls between May and August (Figure 3). Annual evaporation at Mt Barker is c. 1,500 mm. However, the Balicup Lake System is drier than would otherwise be expected due to the rain shadow effect of the Stirling Range. For this reason it is best categorised as a dry Mediterranean type climate, with relatively long, dry and hot summers and short, wet and cold winters (Lennard *et al.* 1991).

Balicup Lake was sampled on the 11th of November 2008. In the nine months preceding the IAI RCM survey (Feb – Oct 2008), Mt Barker received 533.5 mm of rain, with a further 19.7 mm falling in the first 11 days of November. The majority of this (337.9 mm) fell between April and July.

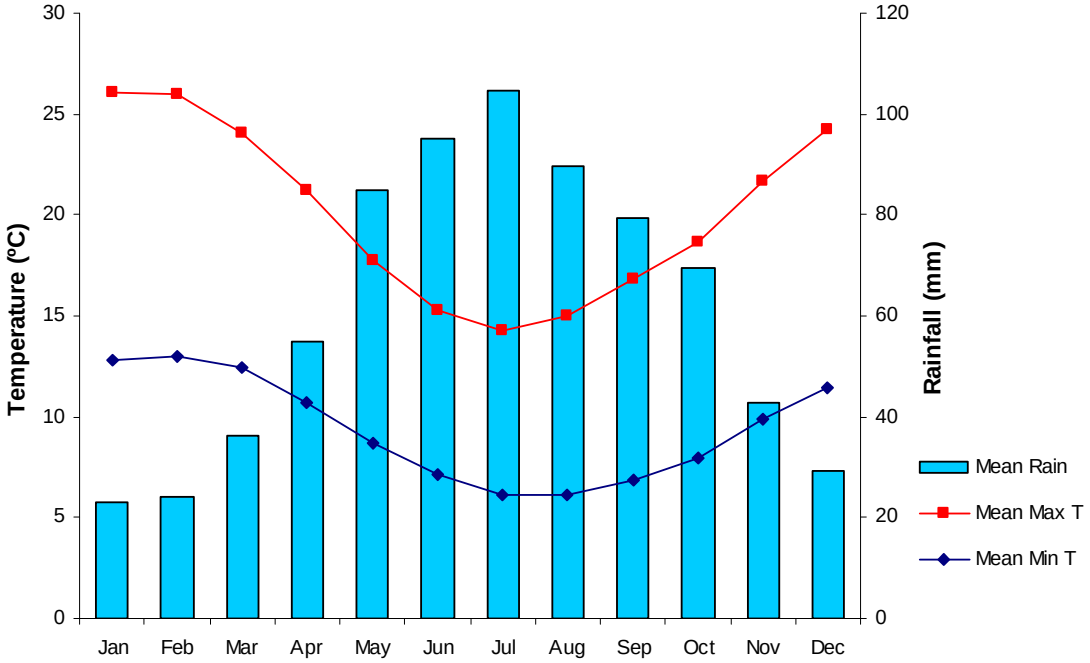

Figure 3 – Climatic averages for Mt Barker, approximately 40 km south-southwest of Balicup Lake.

2.4. Wetland Type

The *Directory of Important Wetlands in Australia* (Environment Australia 2001) describes the Balicup Lake System as comprising of 'seasonal saline marshes' (type B12) and 'seasonal/intermittent saline lakes' (type B8). Balicup Lake itself is a seasonal saline lake and is a macroscale round sumpland. Other wetlands in the system are microscale to macroscale round or elongate sumplands; microscale islets of rock or sand occur in some sumplands (Jaensch 1992).

2.5. Directory of Important Wetlands in Australia Criteria

The Balicup Lake System is designated as a wetland of national importance under criteria 1, 4 and 5 of the Directory of Important Wetlands in Australia. These criteria are as follows:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia.

   It is a good example of the naturally saline, seasonal lakes that occur in the inland of south-western Australia, especially around the Stirling Range

4. The wetland supports 1% or more of the national populations of any native plant or animal taxa.

   Balicup Lake supports more than 1% of the Australian population of Banded Stilt.

5. The wetland supports native plant or animal taxa or communities, which are considered endangered or vulnerable at the national level.

   *Balicup Lake is a significant location for the Hooded Plover (*Thinornis rubricollis*).*

2.6. Values of Balicup Lake

Values are the internal principles that guide the behaviour of an individual or group. Value systems determine the importance people place on the natural environment and how they view their place within it. Divergent values may result in people pursuing different objectives in relation

to nature conservation, having different reasons for desiring a commonly agreed outcome, or favouring different mechanisms to achieve that outcome. As such, it is important to be explicit about the values that are driving conservation activities at a wetland.

The Conceptual Framework for Managing Natural Biodiversity in the Western Australian Wheatbelt (Wallace 2003) identified eight reasons that humans value natural biodiversity:

a. Consumptive use

Consumptive use is gaining benefit from products derived from the natural environment, without these products going through a market place, for example, the collection and personal use of firewood or 'bushtucker'. While Balicup Lake is likely to have been used historically by local Aboriginal people, the lake supports no known consumptive use values in the present day.

b. Productive use

Productive use values are derived from market transactions involving products derived from the natural environment. The same firewood that is collected for personal use may be exchanged for money, or another commodity. While Balicup Lake is likely to have been used historically by local Aboriginal people, the lake supports no known productive use values in the present day.

c. Opportunities for future use

Not all uses of the natural environment may be apparent at present. The potential for future benefit from the natural environment is maximised by maintaining the greatest possible biodiversity. Every lost taxa or ecosystem represents lost opportunities. Balicup Lake may support endemic or rare taxa. Such unique features would increase the potential for future opportunities to present.

d. Ecosystem services

There are many naturally occurring phenomena that bring enormous benefit to mankind. For instance, plants generate oxygen, insects pollinate food crops and wetlands mitigate floods by regulating water flows. The term 'ecosystem services', is used as a broad umbrella to cover the myriad of benefits delivered, directly or indirectly, to humankind by healthy ecosystems. The Balicup Lake System is a good example of a group of naturally saline, seasonal lakes in inland south WA. The most notable ecosystem service of the Balicup Lake System is its contribution and role as habitat for native fauna. The wetland system supports more than 1% of the Australian population of Banded Stilt. Balicup Lake is also a major drought refuge area for waterbirds in the wheatbelt region.

e. Amenity

Amenity describes features of the natural environment that make life more pleasant for people. For instance, pleasant views and shade or wind shelter from a stand of trees. It is difficult to quantify the amenity value of a site such as Balicup Lake, but it is certainly valued by the local community for the amenity it provides. Balicup Lake offers a pleasant view of water with a backdrop of the Stirling Range (Figure 1).

f. Scientific and educational uses

Parts of the natural environment that remain relatively unmodified by human activity represent great educational opportunities. Such sites allow us to learn about the changes that have occurred to the natural world. They can also be considered 'control' sites that allow us to benchmark other, altered habitats. Balicup Lake has been surveyed for waterbirds as part of the Waterbirds in Nature Reserves of South-Western Australia project conducted by the Department of Conservation Land Management (now DEC) and the Royal Australasian Ornithologists Union (RAOU, now Birds Australia). Balicup Lake has been recommended for recognition as a conservation category wetland (V & C Semenuik Research Group 1999).

g. Recreation

Many recreational activities rely on the natural environment (bird watching, canoeing, wildflower tourism, etc.) or are greatly enhanced by it (hiking, cycling, horse riding, photography, etc.). Recreation may deliver economic benefit derived from tourism and also delivers spiritual and physical health benefits to the recreator. Balicup Lake is used by the local community and tourists as a passive recreation site.

h. Spiritual/philosophical values

People's spiritual and philosophical reasons for valuing natural environment are numerous and diverse. One commonly cited is the 'sense of place' that people derive from elements of their environment. This is evident in many Aboriginal and rural Australians, who strongly identify themselves with their natural environment. Many people also believe that nature has inherent value or a right to exist that is independent of any benefit delivered to humans. A sense of spiritual well-being may be derived from the knowledge of healthy environments, even if the individual has no contact with them.

The intent of nature conservation is usually to maintain the ecosystem service values, opportunity values and scientific and educational values at a given site. Doing so is likely to have positive effects on the amenity values, recreational values and spiritual/philosophical values to which the site's natural environment contributes. Consumptive and productive uses of the natural environment are not usually considered, as these are often incompatible with nature conservation.

3. Critical Components and Processes of the Ecology of Balicup Lake

The primary objective of the Balicup Lake Resource Condition Report (RCR) is to identify, describe and quantify the critical components and drivers of the wetland's natural environment. These components and processes determine the site's ecological character and are the variables that should be addressed in any ongoing monitoring.

Climate and geomorphology are the most important drivers of wetland ecosystems. Between them, these factors determine the position of a wetland in the landscape and the type and hydrological regime of that wetland. In turn, a wetland's position, type and hydrology exert a strong influence on its biota and biochemical properties and processes.

A summary of Balicup Lake's critical ecosystem components is presented in Table 1, followed by a detailed description of the results of the Inland Aquatic Integrity Resource Condition Monitoring (IAI RCM) 2008 survey as well as of any previous studies conducted on the wetland.

Table 1 – Summary of critical ecosystem components at Balicup Lake.

Component	Summary description
Geomorphology	Macroscale round sumpland situated in the Yilgarn Craton, at the foot of the Stirling Range
Hydrology	Inflow primarily via ephemeral creeks; catchments undisturbed but creeks flow through cleared land
Water Quality	Saline (21.2 mS/m); pH 8.23
Benthic Plants	None
Littoral Vegetation	Dominated by tall grassland with sparse shrubs, fringed with *Melaleuca*; impacted condition
Invertebrates	One species found (*Parartemia* sp.)
Fish	None
Waterbirds	None; 8 species previously recorded, including 3 protected by

	international migratory agreements
Terrestrial Vertebrates	Emu and dog tracks observed during survey. Several reptiles and five species of frog previously recorded

3.1. Geology and Soils

Balicup Lake is situated on a Tertiary plateau in the Yilgarn Craton in alluvial and lacustrine valley-fill deposits (Jaensch 1992; Beecham 2003). The lake is located at the northern foot of the Stirling Range, which rises to 600 m near the site (Jaensch 1992). The area of land north of the Stirling Range is predominantly flat with scattered dune ridges and salt lakes (Lennard et al. 1991).

The Stirling Range Formation unconformably overlies Archaean granite. Archaean basement rocks crop out to the north and Proterozoic ones to the south (Lennard et al. 1991). The greatest depth to basement occurs in the vicinity of Balicup Lake where drilling has found fresh Archaean granite at up to 50 m depth (Ellis 1984). This tendency of basement depths to increase in this locale and diminish to the north, south, east and west has led to the area being informally termed the Tambellup Sub-basin (Ellis 1984). The Sub-basin comprises friable, poorly consolidated sediments of the Plantagenet Group, which overly bedrock unconformably and are overlain by superficial Quaternary units. The Plantagenet Group consists of the Werillup Formation, on which Balicup Lake lies, and the Pallinup Siltstone (Lennard et al. 1991). Quaternary deposits unconformably overly the Plantagenet Group and consist of alluvium, colluvium and saline and/or gypsiferous lake material. Sand dunes marginal to the scattered salt lakes of the Balicup Lake System are surrounded by sands, silts and clays derived from alluvium and lake deposits. These dunes may also be gypsiferous (Lennard et al. 1991).

3.2. Hydrology

The Balicup Lake System is located east of the Gordon River (Handley 1996) and is situated in the Beaufort Inlet-Pallinup River Catchment within the Albany Coast Basin. The upper catchments are undisturbed but middle sections of some creeks pass through cleared land (Jaensch 1992). The Balicup Lake group of wetlands are remnants of an ancient watercourse believed to be a former channel of the Pallinup River. Rising sea levels filled the valley with marine sediments and created the chain of basins found today (South Coast Rivercare).

Surface drainage of the wetland system is poorly defined. During periods of substantial rain, runoff occurs via ephemeral streams (originating 6-9 km south in the Stirling Range) to the larger salt lakes and other low points in the topography (Lennard *et al.* 1991; Jaensch 1992). The chain of salt lakes are discharge areas for groundwater, which is recharged on the higher land of the Stirling Range (Lennard *et al.* 1991).

Balicup Lake is a seasonal basin wetland (sumpland). Water depth data is limited for the wetland but the lake is expected to be similar to nearby Camel Lake, which has a maximum recorded water depth of 0.73 m and a September mean of 0.37 m (Jaensch 1992).

3.3. Water Quality

Balicup Lake is naturally saline. The nitrogen concentration recorded in the IAI RCM survey was quite high (Table 2), but this is often the case for salt lakes and is not necessarily a cause for concern, although there is little buffer between the lake and surrounding agricultural land. The chlorophyll concentration is not excessive, which confirms that the high concentration of nitrogen is not causing eutrophication. The lake has very low alkalinity which means that it would have little buffering capacity against acidification, should this be an issue.

Table 2 – Water chemistry parameters at Balicup Lake.

pH	8.23
Alkalinity (mg/L)	95
TDS (g/L)	190
Turbidity (NTU)	0.25
Colour (TCU)	9
Total nitrogen (µg/L)	3,200
Total phosphorus (µg/L)	5
Total soluble nitrogen (µg/L)	2,300
Total soluble phosphorus (µg/L)	5
Chlorophyll (µg/L)	9.5
Na (mg/L)	68,600
Mg (mg/L)	4,860
Ca (mg/L)	1,210
K (mg/L)	1,280
Cl (mg/L)	113,000
SO_4 (mg/L)	10,400
HCO_3 (mg/L)	116
CO_3 (mg/L)	0.5

3.4. Benthic Plants

No benthic vegetation was recorded during the IAI RCM 2008 survey.

3.5. Littoral Vegetation

Balicup Lake has a buffer of native vegetation 0.5-1 km wide around most of the wetland area. A single vegetation transect was established on the south-eastern margin of Balicup Lake (Table 3).

Table 3 – Site attributes of the Balicup Lake vegetation transect (RCM037-R1).

Datum		WGS84
Zone		50
Easting		572429
Northing		6206547
Length		30 m
Bearing		270
Wetland state		Drying
Soil state (%)	Dry	100
	Waterlogged	0
	Inundated	0
Substrate (%)	Bare	30
	Rock	0
	Cryptogam	5
	Litter	2

	Trash	0
	Logs	0
Time since last fire		no evidence
Community condition		Impacted
Upper Stratum	Cover (%)	-
	Height (m)	-
Mid Stratum	Cover (%)	57.6
	Height (m)	<1.5
Ground Cover	Cover (%)	11.96667
	Height (m)	<0.3

Transect RCM037-R1

The transect was established on a low dune within 5 m of the lake edge (Figure 4). The soil was dry at the time of survey. Vegetation was dominated by *Austrostipa juncifolia* tall grassland with *Lawrencia squamata* mid-high sparse shrubs (57.6% cover, <1.5 m tall). The groundcover consisted of a mixture of low sparse shrubs, forbs and grasses (12% cover, <0.3 m tall). Table 4 provides a complete list of taxa recorded along the transect RCM037-R1.

Thirteen of the nineteen species recorded on the transect were weeds. As such, the overall community condition was considered 'impacted' (Table 10in Appendix 1).

Further from the edge of the lake a narrow band of vegetation dominated by *Melaleuca cuticularis* trees surrounds the *Austrostipa juncifolia* grassland (Figure 5). Samphire-dominated vegetation occurs directly adjacent to the lakes edge and within drainage depressions nearby.

Figure 4 – Balicup Lake vegetation transect RCM037-R1.

Figure 5 – Looking away from the lake edge with samphire-dominated vegetation in the foreground, *Austrostipa juncifolia* grassland, and *Melaleuca cuticularis* in the background.

Table 4 – Plant taxa recorded along vegetation transect RCM037-R1 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Austrostipa	*juncifolia*	1.5	G1	Grass
Lawrencia	*squamata*	0.8	G1	Shrub
**Avena*	*barbata*	1.5	G1	Grass
Tecticornia	*pergranulata* subsp. *pergranulata*	0.3	G2	Chenopod
Frankenia	*tetrapetala*	0.2	G2	Shrub
**Trifolium*	*campestre* var. *campestre*	0.1	G2	Forb
**Erodium*	*botrys*	0.1	G2	Forb
**Erodium*	*cicutarium*	0.1	G2	Forb
**Sonchus*	*oleraceus*	0.5	G2	Forb
**Lagurus*	*ovatus*	0.3	G2	Grass
**Bromus*	*hordeaceus*	0.3	G2	Grass
**Bromus*	*diandrus*	0.5	G2	Grass
**Moraea*	*setifolia*	0.2	G2	Forb
**Hypochaeris*	*radicata*	0.4	G2	Forb
Disphyma	*crassifolium*	0.1	G2	Forb
**Parapholis*	*incurva*	0.1	G2	Grass
**Lolium*	*rigidum*	0.4	G2	Grass
Triglochin	*mucronata*	0.1	G2	Forb
**Centaurium*	*erythraea*	0.2	G2	Forb

1 In an NVIS description, 'U' denotes the upper storey, 'M' the mid storey and 'G' the under storey (ground cover). Numerals to denote substrata from tallest (ESCAVI 2003).

* Introduced species.

According to the National Vegetation Information System (NVIS), the vegetation community may be described as (ESCAVI 2003):

G1+ ^*Austrostipa juncifolia*, *Lawrencia squamata*, **Avena barbata*\tussock grass, shrub\3\c; G2 ^*Tecticornia pergranulata* subsp. *pergranulata*, *Frankenia tetrapetala*, **Trifolium campestre* subsp. *campestre*, **Erodium botrys*, **Erodium cicutarium* \samphire shrub, shrub, forb\1\r.

3.6. Aquatic Invertebrates

A single macroinvertebrate species was collected from Balicup Lake (Table 5). At 190 g/L, very few macroinvertebrate species would be expected, but the average macroinvertebrate richness for salt lakes with salinity ≥ 90 g/L is four species and lakes with salinity < 50 g/L normally have at least two species. The single species recorded in Balicup Lake is therefore quite low, especially for an alkaline lake. However, the lake was drying so salinity had probably increased rapidly in the weeks prior to sampling and other, less salt tolerant species may have already disappeared from the lake. The brine shrimp collected is almost certainly *Parartemia longicaudata* based on the location of the lake. To separate this from *Parartemia* n. sp. 'c' requires female specimens (only one male was collected) but the latter species has previously only been found in the northern Wheatbelt and Murchison regions.

Table 5 – Aquatic invertebrates collected from Balicup Lake.

Class	Order	Family	Lowest ID
Crustacea	Anostraca	Branchiopodidae	*Parartemia ?longicaudata*

? = identification not confirmed

Some nearby salt lakes were sampled in the Biological Survey of the South-west Agricultural Zone in September 1998 by Pinder *et al*. (2004). Anderson Lake, east of Balicup Lake, had a salinity of 130 g/L in September 1998 and had seventeen macroinvertebrate species, including *P. longicaudata*. One of the lakes in Three Swamps Nature Reserve, also north of the Stirling Range, had a salinity of 31 g/L and seventeen macroinvertebrates and a lake in Mailalup Nature Reserve, east of the Stirling Range, had salinity 63 g/L and twelve species.

3.7. Fish

No fish were observed during the 2008 IAI RCM survey. Fish have not been recorded previously.

3.8. Waterbirds

No waterbirds were recorded at Balicup Lake during the 2008 IAI RCM survey. The wetland was previously surveyed by the Department of Conservation and Land Management (CALM, now DEC) and the Royal Australasian Ornithologists Union (RAOU, now Birds Australia) as part of the Waterbirds in Nature reserves of South-West Western Australia (WNRSSWA) project in October 1984 (Jaensch *et al.* 1988). Eight species were recorded during this survey (Table 6); including three species protected by international migratory agreements (see section 1.3). The eight species included seven species of waders and one duck. During the survey, Bar-tailed Godwit was recorded at six wetlands. Balicup Lake was the only non-coastal wetland of these six.

Across the Balicup Lake System, fourteen species have been identified, four of which are listed under international migratory agreements (Jaensch 1992; Handley 1996). Four species have been found breeding within the system, including Hooded Plover, which is a nationally vulnerable species (Jaensch *et al.* 1988; Jaensch and Watkins 1999). At least 4,096 waterbirds were counted across the lake system in October 1984, the most abundant of which were Banded Stilt, with 2,824 individuals present at Balicup Lake (Jaensch *et al.* 1988; Jaensch 1992). Balicup Lake was in the top 10% of wetlands of importance for numbers of waterbirds compared to 602 other wetlands surveyed in the south-west of Western Australia (Jaensch et al. 1988; Handley 1996). The Balicup Wetland System has historically been an important dry season refuge for waterbirds in the wheatbelt region (Handley 1996).

Table 6 – Waterbirds observed at Balicup Lake during the WNRSWWA project.

Common Name	Latin Name	Number
Australian Shelduck	*Tadorna tadornoides*	120
Banded Stilt	*Cladorhynchus leucocephalus*	2,824
* Bar-tailed Godwit	*Limosa lapponica*	2
Hooded Plover	*Thinornis rubricollis*	3
Red-capped Plover	*Charadrius ruficapillus*	86
Red-necked Avocet	*Recurvirostra novaehollandiae*	227
* Red-necked Stint	*Calidris ruficollis*	78
* Sharp-tailed Sandpiper	*Calidris acuminata*	10

* Listed under Migratory Bird Agreements JAMBA, CAMBA and ROKAMBA (Section 1.3)

3.9. Terrestrial Vertebrates

Emu (*Dromaius novaehollandiae*) and dog (*Canis lupus familiaris*) tracks were observed at Balicup Lake during the 2008 IAI RCM survey (Figure 6). Several reptiles and five species of frogs have previously been recorded in the vicinity of Balicup Lake (Table 11), meaning that Balicup Lake is potentially a significant wetland for frogs.

Figure 6 – Salt-encrusted Emu tracks present at Balicup Lake.

Table 7 – Western Australian Museum (2009) records for fauna collected within 5 km of Balicup Lake.

Common Name	Latin Name	Year/s
Frogs		
False Western Froglet	*Crinia pseudinsignifera*	1953
Glauert's Froglet	*Crinia glauerti*	1953
Gunther's Toadlet	*Pseudophryne guentheri*	1953
Tschudi's Froglet	*Crinia georgiana*	1953
Turtle Frog	*Myobatrachus gouldii*	1984
Snakes		
Bardick	*Echiopsis curta*	1984
Crowned Snake	*Elapognathus coronatus*	1953
Gould's Hooded Snake	*Parasuta gouldii*	
Southern Blind Snake	*Ramphotyphlops australis*	1970, 1971
Pygopods		
Common Scaly-foot	*Pygopus lepidopodus*	
Pretty Worm-lizard	*Aprasia pulchella*	1974
Skinks		
Common Dwarf Skink	*Menetia greyii*	1984
South-western Orange-tailed Slider	*Lerista distinguenda*	1984
Geckos		
Marbled Gecko	*Christinus marmoratus*	
Thick-tailed Gecko	*Underwoodisaurus milii*	
Goannas		
Heath Monitor	*Varanus rosenbergi*	

4. Interactions between Ecological Components at Balicup Lake

An appreciation of the interactions between the elements of a wetland ecosystem is essential to understanding the condition of the system. Although components of a wetland are often monitored and managed as discrete entities, they exist as nodes in a complex ecological web. Documenting the full extent of the interactions that occur at a wetland would be impractical. However, it is essential to identify key interactions that define the system's ecological character.

Hale and Butcher (2007) justified the equivalence of Ramsar nomination criteria and primary determinants of ecological character. Accordingly, the primary determinants of ecological character at Balicup Lake are:

- The characteristics that make the site a good example of a wetland type occurring within a biogeographic region in Australia.
- The plant or animal taxa that have >1% of their national populations supported by the site.
- The native plant or animal taxa or communities, which are considered endangered or vulnerable at the national level and are supported by the wetland.

Table 8 summarises the interactions between key components and processes at Balicup Lake. The table lists the components that are directly responsible for the provision of each service or benefit of the wetland and the biotic and abiotic factors that support or impact these components. Also listed are the key threats that may affect the components or processes. This information assists in the identification of the primary determinants of ecological character.

Table 8 – The relationship between the services and benefits delivered by Balicup Lake and the key components and processes that support them.

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Opportunity Value Potential future use of unique flora and fauna	Endemic flora Endemic fauna	Pollinators Food sources	Habitat extent and distribution Hydrological regime Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Nutrient enrichment from surrounding agriculture Waterlogging Introduced fauna (overgrazing and predation) Weeds Erosion
Ecosystem Service Value It is a good example of a wetland type occurring within a biogeographic region in Australia	Naturally saline, seasonal lake in the inland of south-western Australia	Vegetation communities	Hydrological regime Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Nutrient enrichment from surrounding agriculture Waterlogging Introduced fauna (overgrazing) Weeds Erosion
Ecosystem Service Value It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail	Hooded Plover Waterbirds that utilise the site as a drought refuge	Aquatic invertebrate populations (food source) Vegetation communities (habitat)	Hydrological regime Water quality Habitat extent and distribution	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Nutrient enrichment from surrounding agriculture Waterlogging Introduced fauna (overgrazing and predation) Weeds Erosion Loss of migratory bird populations due to offsite factors

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Ecosystem Service Value The wetland supports 1% or more of the national populations of any native plant or animal taxa	Banded Stilt	Aquatic invertebrate populations (food source) Vegetation communities (habitat)	Hydrological regime Water quality Habitat extent and distribution	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Nutrient enrichment from surrounding agriculture Waterlogging Introduced fauna (overgrazing and predation) Weeds Erosion
Recreational Value Bird watching Picnicking Bush walking Photography	Landscape amenity Waterbird populations Vegetation communities Significant flora Significant fauna	Aquatic invertebrates Vegetation communities	Hydrological regime Water quality Habitat extent and distribution Soils and sediments	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Nutrient enrichment from surrounding agriculture Waterlogging Introduced fauna (overgrazing and predation) Weeds Erosion Loss of migratory bird populations due to offsite factors

5. Threats to the Ecology of Balicup Lake

The ambition for management at Balicup Lake is to maintain those elements of the ecology that resulted in its nomination as a *Directory of Important Wetlands in Australia* (DIWA) site. The critical components of the ecology are the geomorphologic, hydrologic and water quality factors that make the lake a suitable stopover for migratory birds and refuge site for resident waterbirds. These factors are the primary determinants of the lake's ecological character. They are influenced by and exert an influence on the vegetation communities that surround the water body, the aquatic invertebrate and benthic vegetation communities that inhabit it and the threatening processes that face all of these.

Threats to Balicup Lake must be considered in relation to their likelihood of causing failure of the above management goal for the lake. An assessment is made of the probability that goal failure will result due to the impacts of each threatening process identified at the site, or potentially acting there. The results of this assessment are presented in Table 9. In summary, failure to achieve the management goal for Balicup Lake is most likely to result due to secondary salinisation caused by excessive clearing of native vegetation. The effects of weeds and eutrophication resulting from excessive nutrient input from surrounding agricultural land may also affect the wetland in the future. The impacts of erosion and waterlogging, and of climate change should also be considered.

Balicup Lake has been identified as a wetland at risk, and has been recommended for recognition as a conservation category wetland (Jaensch 1992; V & C Semenuik Research Group 1999). Some of the threatening processes identified for the wetland include broad-scale vegetation clearing, changed hydrology (salinity, altered inundation regime), weeds, and other agricultural activities (Comer et al. 2002). Despite this, the condition of the wetland has been described as 'good' (with recovery requiring little intervention) (Comer et al. 2002). During the IAI RCM survey, no evidence of grazing, physical disturbance by animals (e.g. pugging, digging, worn access tracks or bank erosion), or nutrient enrichment was sighted in the immediate area of wetland. However, dog tracks were sighted at the lake's shore, unaccompanied by human foot-prints. This indicates the fauna of Balicup Lake may be at threat from predation.

Salinisation

The Balicup Lake System lies within the Wheatbelt, a region broadly defined by the area of cleared vegetation and roughly delineated by the 300 mm and 600 mm rainfall isohyets (Halse *et al.* 2003a). The land surrounding the wetland system is used for cereal cropping and pastoralism (stock grazing) (Jaensch 1992). Most of the lakes have retained only a degraded narrow fringe (0.5 m – 1 m) of remnant bush (South Coast Rivercare; Jaensch 1992). As a result, the region is now subject to secondary salinisation, the primary threat affecting wetlands of the Wheatbelt region (George *et al.* 1995; Williams 1999; Halse *et al.* 2003b). Secondary salinisation involves rising water tables as a result of clearing of native perennial vegetation. Salt that was previously stored in the soils above the water table is dissolved into groundwater. As the saline groundwater rises to the surface, a combination of waterlogging and salinity causes vegetation death (Mulcahy 1978; Ruprecht and Schofield 1991; George *et al.* 1995; Halse *et al.* 2003a). Unfortunately, measures to control secondary salinisation, including drainage and the disposal of drainage water, often bring with them their on management issues and can adversely affect wetland biodiversity (Cale et al. 2004).

Preliminary drilling conducted by Lennard et al. (1991) has demonstrated the severity of the salinity problem within the North Stirlings Land Conservation District (NSLCD), which includes land within the Shires of Cranbrook and Tambellup and encompasses Balicup Lake. The drilling has shown that groundwater levels in places are within a few metres or less of the surface and have Total Dissolved Solids (TDS) values greater than seawater. Low hydraulic gradients and low hydraulic conductivities have been measured and there is an upward vertical potential gradient by which deep saline water travels towards the surface. Groundwater tables are rising, as indicated by the steadily expanding salt patches. Farmers also reported that water levels in bores were once much lower than at present. Salt storage profiles are evidence of the huge reserves of salt

in the area. Lennard et al. (1991) suggest well researched, long-term initiatives be put into effect to avoid soil salinity becoming a very severe problem limiting production in the area and killing native vegetation.

Weeds

Thirteen species of weeds were identified during the 2008 IAI RCM survey. As a result, the overall condition of the vegetation was considered 'impacted' (Table 10 in Appendix 1). Agricultural weeds have been identified as a threatening process affecting Balicup Lake by the Biodiversity Audit of WA (Comer *et al.* 2002). Given the proximity of agricultural land to the lake and associated high rate of encroachment and recolonisation, long-term weed management would be difficult.

Erosion and waterlogging

The loose, sandy soils present at Balicup Lake are very susceptible to wind erosion, especially when vegetation has been lost due to waterlogging and/or elevated soil salinities (Lennard et al. 1991). The soils are also highly prone to waterlogging (Lennard et al. 1991), which may result in tree death.

Eutrophication

Potential threats to the ecology of Balicup Lake may involve changes to its water quality such as eutrophication. Although Balicup Lake itself is contained within a nature reserve, land use of the surrounding area includes cereal cropping and pasture grazing. The lake has only a narrow buffer of native vegetation. Eutrophication of the lake is therefore a possibility (Jaensch 1992; Comer *et al.* 2002) although results from this RCM survey indicate this is not currently an issue of concern. Runoff containing agricultural fertilisers and herbicides may increase the nutrient content of the lake. The consequences of eutrophication include algae blooms, a reduction in diversity of aquatic invertebrates and a loss of amenity values (Harper 1992).

Climate Change

Climate change modelling conducted by the CSIRO predicts that rainfall received by the south-west of WA will decline by as much as 20% by 2030 and 60% by 2070, relative to 1990 figures (EPA 2007). The hydrology of Balicup Lake is highly reliant of rainfall patterns as it receives inflow from ephemeral creeks. A reduction in rainfall could therefore result in changes to the overall hydrology and ecology of the lake. If this should occur, management of the wetland would be difficult and engineering solutions, which carry their own threats, may have to be considered.

Table 9 – Threat assessment for Balicup Lake.

An estimate is provided of the perceived likelihood of goal failure resulting from the impacts of each identified threat category.

Goal: To maintain the geomorphology and hydrology of Balicup Lake, thus ensuring it remains a suitable drought refuge and migratory stopover for waterbirds and retains its cultural and scientific values.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Altered biogeochemical processes	Hydrological processes, particularly salinity	40	20	Balicup Lake is located within the Wheatbelt, an area highly affected by salinisation. The land surrounding the wetland system has been extensively cleared and is used for cereal cropping and pastoralism (stock grazing). Balicup Lake has been affected by secondary salinisation and the severity of this problem has been demonstrated by drilling to test groundwater.
	Carbon cycle and climate change	1	1	Climate change modelling predicts rainfall will decline by up to 20% by 2030 and 60% by 2070, relative to 1990 figures (EPA 2007). The hydrology of Balicup Lake is highly reliant on rainfall. As such, changes in climate could result in dramatic changes to the ecology of the lake.
Impacts of introduced plants and animals	Environmental weeds	10	5	Thirteen species of weeds were identified during the IAI RCM survey. Agricultural weeds have previously been described as a threatening process. Alteration to natural fire regimes may further facilitate the establishment of weed species in the area.
	Herbivory, wallowing and trampling by introduced species	0	0	Despite being surrounded by agricultural land, no evidence of disturbance by stock or introduced animals was observed at Balicup Lake.
Impacts of problem native species	Overgrazing by native species.	0.0	0.0	No impacts evident.
Impacts of disease	Plant pathogens	0	0	No impacts evident.
Detrimental regimes of physical disturbance events	Fire regimes	5	1	There was no evidence of fire at Balicup Lake. However, the vegetation present is susceptible to fire. An inappropriate fire regime may hinder recruitment, thereby affecting the vegetation communities.
	Drought	1	1	A reduction in rainfall and prolonged periods of drought associated with climate change could potentially change the hydrology of this shallow seasonal lake.
	Flood	1	1	There is no evidence of risk of excessive flooding in the area. However, the soild are prone to waterlogging which may cause tree deaths.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Impacts of pollution	Herbicide, pesticide or fertiliser use and direct impacts	5	1	Balicup Lake is surrounded by agricultural land used for cereal cropping and pastoralism. Agricultural chemicals may enter the wetland via runoff.
Impacts of competing land uses	Recreation management	1	0	Recreational usage of Balicup Lake low impact and unlikely to have any deleterious impacts.
	Nutrient enrichment of water body.	0	0	There is no evidence of stock using Balicup Lake.
	Urban and industrial development	0	0	The land surrounding Balicup Lake has already been extensively cleared for agricultural use. Further development is unlikely.
	Consumptive uses	0	0	There are no known consumptive uses of Balicup Lake.
	Illegal activities	0	0	No evidence of any threat.
	Mines and quarries	0	0	No mineral potential.
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	2	1	The area surrounding Balicup Lake has been extensively cleared. However, Stirling Range National Park, an extensive area of natural or near natural environment, is located south of the lake. Populations are likely to self-supporting in this setting.

6. Knowledge Gaps and Recommendations for Future Monitoring

Waterbirds have only been recorded at Balicup Lake on one occasion to date (in 1984). Considering the wetland's status as a DIWA listed and Ramsar nominated wetland, there is a clear need for further data on waterbird usage at the wetland. The Ramsar Criterion that applies to the wetland states: "where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl". Banded Stilt has been recorded at Balicup Lake with 2,824 individuals counted (Jaensch *et al.* 1988), exceeding 1% of the Australian population (2,100). Water and salinity data and the considerable area of suitable habitat suggest that regular use by Banded Silt does occur (Jaensch and Watkins 1999). However, repeated surveys are required to determine if the wetland is visited by such large numbers on a regular basis. It is possible that Balicup Lake also provides significant habitat and a breeding area for the Hooded Plover, a nationally vulnerable species (Jaensch et al. 1988; Jaensch and Watkins 1999). It is likely that further waterbird surveys would reveal that the wetland supports higher numbers of waterbirds, a greater diversity and/or more breeding species than currently on record (Handley 1996).

Greater investigation is required into the hydrology and drainage of the Balicup Lake System. As noted by Lennard et al. (1991), more investigation is needed to determine if the Tambellup Sub-basin, underlying the wetland system, is wholly closed or is open to the west. Do salts slowly build up within the basin or are they periodically flushed to the nearby Frankland River system and thence to the Southern Ocean? Some anomalies are evident with this scenario. For example, the surface of Camel Lake, to the east, is at a lower elevation than that of Balicup Lake, to the west, by 5-10 m and this seems inconsistent with flooding to the west. Further research is required to address these uncertainties.

The salinity problems within the Wheatbelt are attributed to the clearing of native vegetation causing a rise in the saline water table and a subsequent accumulation of soluble salts at the soil surface. One management recommendation has been to revegetate saline areas with halophytes (Malcolm 1983). Before treatments can be effectively implemented, an accurate picture of the sub-surface hydrogeology must be obtained. Preliminary groundwater studies were initiated by the Department of Agriculture and Food and a series of boreholes drilled in a badly salt affected area west of Camel Lake (Lennard et al. 1991). Future effort should be concentrated on continuing these studies.

References

Beecham, B. (2003) Avon Wheatbelt 2 (AW2 - Re-juvenated Drainage subregion). In *A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002*. (McKenzie, N. L., May, J. E., and McKenna, S., eds). Department of Environment and Conservation, Perth, Australia.

Bureau of Meteorology. (2009) Climate Statistics for Australian Locations. Bureau of Meteorology. <http://www.bom.gov.au/climate/averages/> Accessed on 5 January 2009.

Cale, D. J., Halse, S. A., and Walker, C. D. (2004) Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* **5**: 20-135.

Comer, S., Gilfillan, S., Grant, M., Barrett, S., and Anderson, L. (2002) Esperance 1 (ESP1 – Fitzgerald subregion). In *A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002*. (McKenzie, N. L., May, J. E., and McKenna, S., eds). Department of Environment and Conservation, Perth, Australia.

Ellis, C. J. (1984) *Final Report on the Tambellup Lignite Prospect (Exploration Licence Application 70/134) Mt Barker, W.A.* . CRAE Report No. 12577 (unpubl.).

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

EPA. (2007) *State of Environment Report Western Australia 2007*. Environmental Protection Authority, Perth.

ESCAVI. (2003) *National Vegetation Information System: Australian Vegetation Attribute Manual*. Department of Environment and Heritage, Canberra, Australia. August 2003.

George, R. J., McFarlane, D. J., and Speed, R. J. (1995) The consequences of a changing hydrologic environment for native vegetation in southwestern Australia. In *Nature conservation 4: the role of networks*. (Saunders, D. A., Craig, J. L., and Mattiske, E. M., eds). Pages 9-22. Surrey Beatty & Sons, Sydney, Australia.

Hale, J., and Butcher, R. (2007) *Ecological Character Description for the Peel-Yalgorup Ramsar Site*. Department of Environment and Conservation and the Peel-Harvey Catchment Council, Perth, Australia.

Halse, S. A., Ruprecht, J. K., and Pinder, A. M. (2003a) Salinisation and prospects for biodiversity in rivers and wetlands of south-west Western Australia. *Australian Journal of Botany* **51**: 673-688.

Halse, S. A., Ruprecht, J. K., and Pinder, A. M. (2003b) Salinization and prospects for biodiversity in rivers and wetlands of south-west Western Australia. *Australian Journal of Botany* **51**.

Handley, M. (1996) *Australian Wetlands Conservation Project: final report*. prepared for the Australian Heritage Commission, Canberra, Australia.

Harper, D. (1992) *Eutrophication of freshwaters. Principles, problems and restoration.* Chapman and Hall, New York, USA.

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

Jaensch, R. P. (1992) Balicup Lake System - WA023. In *Australian Wetlands Database*. Department of Environment, Heritage and the Arts. Accessed on 4 March 2009.

Jaensch, R. P., and Watkins, D. (1999) *Nomination of additional Ramsar wetlands in Western Australia: final report to the Western Australian Department of Conservation and Land Management*. Department of Conservation and Land Management.

Lennard, R., Nulsen, R. A., and Southwell, C. E. (1991) *Climate, Physiography Geology, Hydrology and Land Use in the North Stirlings Area - A Precursory Report*. Resource Management Technical Report No.126. Department of Agriculture, Perth, Australia. October 1991.

Malcolm, C. V. (1983) *Wheatbelt Salinity. A review of the salt land problem in South-Western Australia*. Technical Bulletin No. 52. Department of Agriculture.

Mulcahy, M. J. (1978) Salinisation in the southwest of Western Australia. *Search* **9**: 269-272.

Pinder, A. M., Halse, S. A., McRae, J. M., and Shiel, R. J. (2004) Aquatic invertebrate assemblages of wetlands and rivers in the wheatbelt region of Western Australia. *Records of the Western Australian Museum* **Supplement No. 67**: 7-37.

Ruprecht, J. R., and Schofield, N. J. (1991) Effects of partial deforestation on hydrology and salinity in high salt storage landscapes. I. Extensive block clearing. *Journal of Hydrology* **129**: 19-38.

South Coast Rivercare. *Pallinup River*.

Thackway, R., and Lesslie, R. (2005) *Vegetation Assests, States, and Transitions (VAST): accounting for vegetation condition in the Australian landscape*. Technical Report. Bureau of Rural Sciences, Canberra, Australia.

V & C Semenuik Research Group. (1999) *Preliminary Delineation of Consanguineous Wetland Suites in the Pallinup North Stirling Region, Southwestern Australia.* . Unpublished report to the Water and Rivers Commission, Albany, Australia.

WA Museum. (2009) FaunaBase. Western Australian Museum.

Wallace, K. J., B.C. Beecham., B.H. Bone. (2003) *Managing Natural Biodiversity in the Western Australian Wheatbelt: a conceptual framework*. Department of Conservation and Land Management, Perth, W.A.

Williams, W. D. (1999) Salinisation: a major threat to water resources in the arid and semi-arid regions of the world. *Lakes & Reservoirs: Research and Management* **4**: 85-91.

Appendix 1

Table 10 – Overall Vegetation Community Condition Rating as adapted from Thackway and Lesslie (2005). Shading indicates the condition of Balicup Lake.

Overall Community Condition Rating					
	0 ◆ – – –	1 – – –	2 – – –	3 – – –	4 – – – ◆
	RESIDUAL BARE	**NATURAL**	**IMPACTED**	**DEGRADED**	**REMOVED/REPLACED**
Community Condition Class	Areas where native vegetation does not naturally persist	Native vegetation community structure, composition and regenerative capacity intact - no significant perturbation from land management practices	Native vegetation community structure, composition and regenerative capacity intact but perturbed by land management practices	Native vegetation community structure, composition and regenerative capacity significantly altered by land management practices	Species present are alien to the locality and either spontaneous in occurrence or cultivated. Alternatively, vegetation may have been removed entirely
Regenerative Capacity	Natural regenerative capacity unmodified - ephemerals and lower plants	Regenerative capacity intact. All species expected to show regeneration are doing so	Natural regenerative capacity somewhat reduced, but endures under current/past land management practices	Natural regenerative capacity limited and at risk due to land management practices. Rehabilitation and restoration possible through removal of threats	Regenerative potential of native vegetation has been suppressed by ongoing disturbances. There is little potential for restoration
Vegetation Structure	Nil or minimal	Structural integrity of native vegetation is very high. All expected strata, growth forms and age classes are present	Structure is altered but persists, i.e. some elements of a stratum are missing	Structure of native vegetation is significantly altered, i.e. one or more strata are missing entirely	All structural elements of native vegetation are missing or highly degraded
Vegetation Composition	Nil or minimal	Compositional integrity of native vegetation is very high. All species expected at the site are present	Composition of native vegetation is altered. All major species are present, although proportions may have changed. Some minor species may be missing	Significant species are missing from the site and may have been replaced by opportunistic species. Loss of species affects structure of vegetation	Native vegetation removed entirely +/- replaced with introduced species

Appendix 2

Plant specimens submitted to the WA Herbarium:
Triglochin mucronata (RCM037-R1-12)

Table 11 – Herbarium Records for Balicup Lake.

Search Coordinates: NW corner 34.2063°S, 117.7191° E; SE corner 34.2926°S, 117.8166°E

Family	*Species*	Alien	Cons. Status
Dilleniaceae	*Hibbertia subvaginata*		
Epacridaceae	*Andersonia* aff. *caerulea*		
Epacridaceae	*Andersonia simplex*		
Goodeniaceae	*Dampiera ? loranthifolia*		
Haemodoraceae	*Conostylis aculeata* subsp. *aculeata*		
Myrtaceae	*Eucalyptus decipiens* subsp. *chalara*		
Myrtaceae	*Regelia inops*		
Myrtaceae	*Verticordia lindleyi* subsp. *purpurea*		
Papilionaceae	*Gastrolobium reticulatum*		
Papilionaceae	*Jacksonia grevilleoides*		
Papilionaceae	*Jacksonia racemosa*		
Proteaceae	*Banksia repens*		
Proteaceae	*Petrophile ericifolia* subsp. *ericifolia*		
Proteaceae	*Petrophile filifolia* subsp. *filifolia*		
Restionaceae	*Hypolaena fastigiata*		