Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for a Significant Western Australian Wetland

Lake Guraga

2008

Figure 1 – A view of the riparian vegetation and the water body at Lake Guraga.

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Contents

1. Introduction

This Resource Condition Report (RCR) was prepared by the Inland Aquatic Integrity Resource Condition Monitoring (IAI RCM) project. It describes the ecological character and condition of Lake Guraga, the largest of the lakes and swamps on the Dandaragan Plateau.

Lake Guraga was selected as a study site in the current project because it is listed in the Directory of Important Wetlands in Australia (DIWA) (Environment Australia 2001). It is a good example of a large saline/brackish lake on the Swan Coastal Plain and provides significant habitat for waterbirds.

1.1. Site Code

Directory of Important Wetlands in Australia: WA079.

Register of the National Estate Place ID: 18697.

Inland Aquatic Integrity Resource Condition Monitoring Project (DEC): RCM029.

Waterfowl Counts in the South-West WA (DEC/RAOU): CALMWCSWWA_GURA.

Waterbirds in Nature Reserves of South-West WA (DEC/RAOU): CALMWNRSWA_398_1.

South West Wetlands Monitoring Program (DEC): SWWMP_GURA.

1.2. Purpose of Resource Condition Report

This RCR provides a summary of information relevant to the ecology of Lake Guraga. This information is then used to describe the drivers of, and threats to, the wetland ecosystem. The resultant 'snapshot' of ecological character will provide context for future monitoring of the lake and assist with assessing the effectiveness of management planning and actions at the site.

1.3. Relevant Legislation and Policy

The following is a summary of legislation and policy that may be relevant to the management of Lake Guraga:

International

Migratory bird bilateral agreements and conventions

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds. These are relevant to Lake Guraga due to its usage by migratory waterbirds. 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; and

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.

National legislation

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

The EPBC Act is the Australian Government's principal piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places - defined in the Act as matters of national environmental significance.

There are seven matters of national environmental significance to which the EPBC Act applies. One of these is relevant to Lake Guraga: migratory species listed under international treaties.

Australian Heritage Council Act 2003

Lake Guraga has been placed on the Register of the National Estate. The Australian Heritage Council Act protects places of National and Commonwealth significance.

Western Australian state policy

Wildlife Conservation Act 1950

This Act provides for the protection of wildlife. All fauna in Western Australia is protected under section 14 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.

Local Government Act 1995

This Act lays down the responsibilities, powers and procedures for Local Government Bodies. It allows a local government authority control and manage reserves placed under their control.

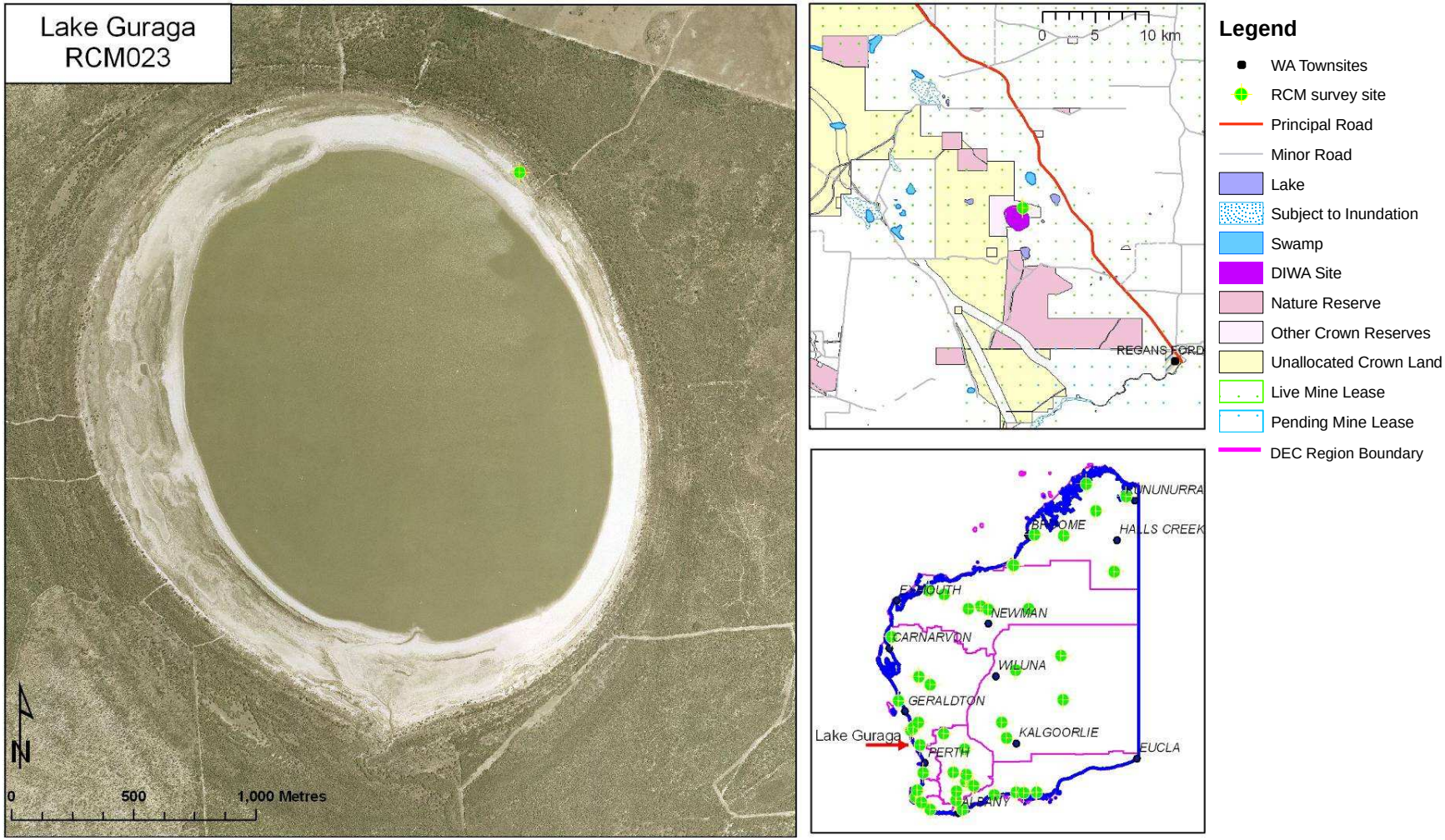

Figure 2 – Aerial photograph showing the survey location at Lake Guraga. Also, the tenure of land surrounding Lake Guraga (upper insert) and the location of all IAI RCM survey sites in Western Australia (lower insert).

2. Overview of Lake Guraga

2.1. Location and Cadastral Information

Lake Guraga lies west of the Brand Highway, approximately 14 km south of Cataby in the Shire of Dandaragan (Figure 2). It is contained within a recreation reserve vested in the Local Government Authority. That reserve is bordered by Unallocated Crown Land to the west and freehold land used for pasture grazing and cereal cropping to the east and south. Namming Nature Reserve, approximately 3 km to the south of the lake, is the largest of several conservation reserves in the vicinity.

2.2. IBRA Region

Lake Guraga lies within the Perth (SWA2) subregion of the Swan Coastal Plain Interim Bioregionalisation of Australia (IBRA) region. The Swan Coastal Plain region is a low-lying coastal plain, mainly vegetated with various woodlands. The Perth subregion comprises colluvial and aeolian sands, alluvial river flats and coastal limestone. The vegetation consists primarily of heath and/or tuart woodlands on limestone, banksia and jarrah/banksia woodlands on Quaternary marine dunes of various ages, and marri on colluvial and alluvial deposits (Mitchell *et al.* 2002).

2.3. Climate

The nearest Bureau of Meteorology weather station to Lake Guraga is at Lancelin, approximately 30 km to the southwest (Bureau of Meteorology 2009). Records have been kept at Lancelin since 1965. Lake Guraga may experience less rainfall than Lancelin with higher summer temperatures and lower winter temperatures, but these differences would not be large.

Lancelin experiences a Mediterranean climate with warm, dry summers and mild, wet winters. It receives a mean annual rainfall of 614.5 mm with approximately 70% falling between May and August (Figure 3). Annual evaporation at Lancelin is approximately 2,300 mm.

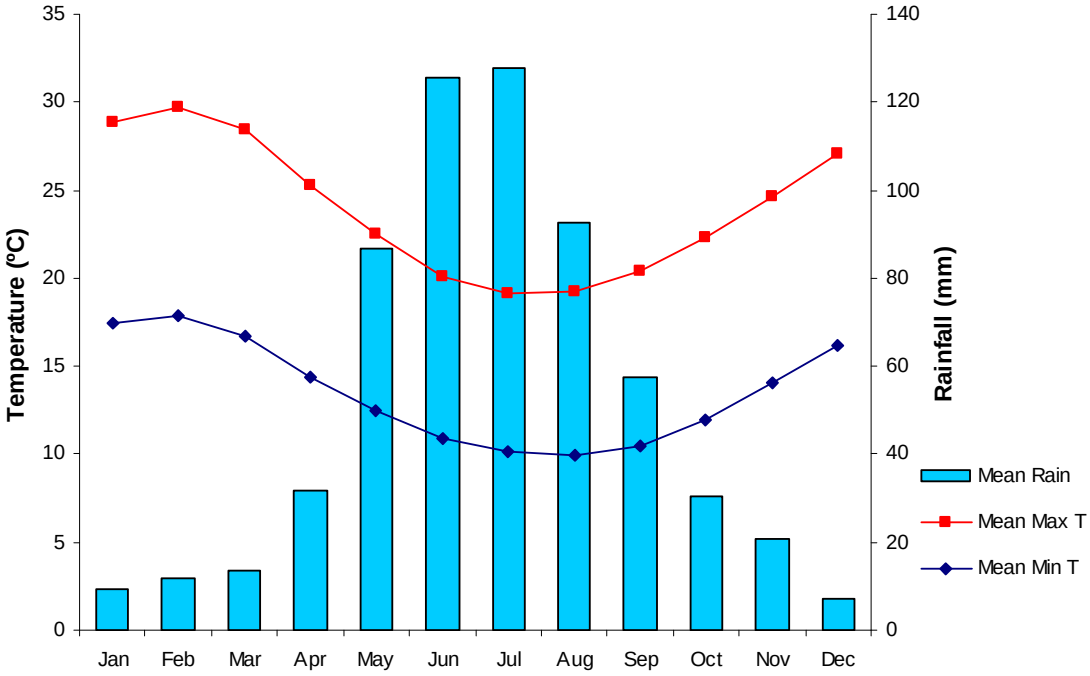

Figure 3 – Climatic averages for Lancelin, approximately 30 km southwest of Lake Guraga.

Lake Guraga was surveyed for the IAI RCM project on the 6th of October 2008. In the nine months preceding the survey, Lancelin received 661 mm of rain. The majority of this (306 mm) fell in June and July. A total of 11 mm of rain was received in the first six days of October, immediately prior to the RCM survey.

2.4. Wetland Type

Lake Guraga is a macroscale round lake that is inundated on a near-permanent basis. A low bank separates the inner basin from a fringing flat which contains numerous microscale elongate depressions (Jaensch 1992).The Directory of Important Wetlands in Australia (Environment Australia 2001) describes Lake Guraga as a 'seasonal saline marsh' (type B12) and a 'permanent saline/brackish lake' (type B7).

2.5. Directory of Important Wetlands in Australia Criteria

Lake Guraga is designated as a wetland of national importance under criteria 1, 2, 3, 4 and 6 of the Directory of Important Wetlands in Australia. These criteria are as follows:

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

  Lake Guraga is a good example of a large saline/brackish lake in the Swan Coastal Plain bioregion.

- Criterion 2: It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.

  Lake Guraga is an important part of the Caren Caren Brook system.

- Criterion 3: It is a wetland that 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.

  Lake Guraga is a major moulting area for Australian Shelduck and a breeding area for three species: Australian Shelduck, Grey Teal and Red-capped Plover. The lake is also a major drought refuge area for waterbirds.

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

  Lake Guraga is an internationally important stop-over area for fifteen waterbird species and is habitat for large populations of waterbird species, including Hoary-headed Grebe, Grey Teal, Pink-eared Duck and Musk Duck.

- Criterion 6: The wetland is of outstanding historical or cultural significance.

  Lake Guraga has been listed on the Register of the National Estate.

2.6. Values of Lake Guraga

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. Because of this, 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 Lake Guraga 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. For example, firewood may be collected and sold or exchanged for another commodity or commercial cattle may be grazed on native grasses. Lake Guraga is supports no known productive uses.

c. Ecosystem services

There are many naturally occurring phenomena that bring enormous benefit to mankind. For example, 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. Lake Guraga is a good example of a large saline/brackish lake in the Swan Coastal Plain bioregion. It is significant to the local and regional hydrology because it retains water, thus mitigating flood flows and contributing to groundwater/surface water interactions (V & C Semeniuk Research Group 1994). Lake Guraga is also a major moulting area for one species, breeding area for three species and migration stop-over for fifteen species of waterbirds listed under international treaties. These factors make it one of the more important wetlands for waterbirds in the south-western land division of WA.

d. Amenity

Amenity describes features of the natural environment that make life more pleasant for people. For example, pleasant views, shade and wind shelter from a stand of trees. Lake Guraga is valued by the local community for the amenity it provides. It is a picturesque lake in a near-natural setting. The site is popular for bird-watching and spectacular spring concentrations of waterbirds can be viewed (Jaensch 1992).

e. 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 may also be considered 'control' sites that allow us to benchmark other, altered habitats. A number of scientific studies have been conducted at Lake Guraga. The Royal Australasian Ornithologists Union (now Birds Australia) conducted waterbird surveys (forty-three in total) at the lake between 1981 and 1991 (Jaensch *et al.* 1988; Halse *et al.* 1990; Halse *et al.* 1992; Halse *et al.* 1994). Lake Guraga was also included in the South West Wetland Monitoring Program conducted by the Department of Conservation and Land Management (CALM, now DEC). The lake was monitored from 1982 until 2000 for water depth and salinity (Lane *et al.* 2004).

f. 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. Lake Guraga is used by the local community as a recreation site. It is valued by naturalists for passive recreation (V & C Semeniuk Research Group 1994). Interest has been expressed in using the lake for boating (Jaensch 1992).

g. Spiritual/philosophical values

People's spiritual and philosophical reasons for valuing the 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.

h. 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. Lake Guraga may support endemic or rare taxa. Such unique features would increase the potential for future opportunities.

The intent of nature conservation is usually to maintain the ecosystem services, scientific and educational uses and opportunity value at a given site. Doing so is likely to have positive effects on the amenity, recreational potential 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 Lake Guraga

The objective of the Lake Guraga RCR is to compile information relevant to the ecology of the wetland's ecosystem. By doing so, it is possible to identify the critical components and drivers of the wetlands. These components and processes determine the site's ecological character and are the variables that should be assessed 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 its hydrological regime. Position and hydrology, in turn, exert a strong influence on the physiochemical properties of the water column and the biota that utilise it.

A summary of Lake Guraga's critical ecosystem components is presented in Table 1. This is followed by a description of the results of the IAI RCM 2008 survey. Some data from previous studies of the site are also presented.

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

Component	Summary description
Geomorphology	Macroscale round lake situated in the Perth Basin on the Bassendean Dunes system
Hydrology	Near-permanent; inflow from Caren Caren Brook system; catchment partly cleared
Water Quality	Hyposaline (secondarily), poikilohaline (35.2 mS/cm); highly nutrient enriched
Benthic Plants	None
Littoral Vegetation	Grassland and herbland fringing the inner basin; low open-woodland and open-scrub in surrounding areas; natural/impacted condition
Invertebrates	Low diversity of widespread halotolerant species
Fish	None seen
Waterbirds	49 waterbird species have been recorded, including 15 species listed in the schedule to at least one of the migratory bird bilateral agreements.

3.1. Geology and Soils

Lake Guraga is situated in the Perth Basin – an elongate trough covering an area of approximately 172,000 km between Geraldton and Augusta (Jaensch 1992; Cadman *et al.* 1994; Geoscience Australia 2008). This sedimentary basin formed during the separation of Australia and Greater India in the Permian to Early Cretaceous period (Geoscience Australia 2008).

The Lake lies on the Bassendean Dunes System, which consists of marine/continental sandstone/siltstone overlain with sand. The fringing flat includes clay-like deposits (Jaensch 1992). Soils at the site are predominately white sand.

3.2. Hydrology

Lake Guraga is part of the Guraga Suite in the neighbourhood of Caro Brook in the Bassendean Dunes Unit. Water is supplied from the Caren Caren Brook system, which originates 25 km to the northeast. It enters Lake Guraga via Namming Lake and a connecting stream which may not flow in drier years (Jaensch 1992). Water is maintained in the lake through ponding of precipitation (V & C Semeniuk Research Group 1994). Lake Guraga is situated within the Minyulo Caren Caren catchment, which is moderately disturbed due to partial clearing (Jaensch 1992).

Lake Guraga is nearly permanently inundated. It was dry for several months in autumn of 1991 and 1992, and again briefly in the autumns of 1986 and 1990 (Jaensch 1992). The water depth of Lake Guraga varied between 0.25 m and 2.5 m over the three years between 1982 and 1985 (Australian Government 1995). The lake has attained a maximum water depth of 2.47 m in September 1983 and has a September mean water depth of 1.44 m (Jaensch 1992; Lane et al. 2004).

3.3. Water Quality

Lake Guraga has previously been described as hyposaline and poikilohaline[1] with generally low salinity in spring (5 ppt), moderate salinity in autumn (14 ppt) and sometimes very high salinity when water levels are low in summer (Jaensch 1992; Australian Government 1995). A maximum salinity of 223 ppt was recorded in November 1990 and a minimum of 3.3 ppt in September 1986 (Jaensch 1992; Lane *et al.* 2004).

The water of Lake Guraga is basic, with recorded pH ranging from 7.3 to 10.2 (Jaensch 1992; Lane *et al.* 2004). The water is clear and light penetration good (Jaensch 1992; Lane *et al.* 2004).

The physio-chemical characteristics of Lake Guraga were measured by the IAI RCM project on 6 October 2008 (Table 2). At that time, salinity was moderately high (40 g/L) and the wetland was highly nutrient enriched. The concentration of nitrogen and phosphorous in the water exceeded ANZECC/ARMCANZ (2000) guidelines for south-west wetlands by an order of magnitude. Turbidity was also elevated, probably as a result of wind disturbance of the clay sediments. The high pH is typical of salinised wetlands that are not affected by acidification.

[1] The terms *hyposaline* and *poikilohaline* respectively refer to salinity in the water body being relatively low, but variable throughout the year.

Table 2 – Water chemistry parameters at Lake Guraga.

pH	9.32
Alkalinity (mg/L)	640
TDS (g/L)	40
Turbidity (NTU)	290
Colour (TCU)	54
Total nitrogen (µg/L)	13,000
Total phosphorus (µg/L)	1,400
Total soluble nitrogen (µg/L)	8,400
Total soluble phosphorus (µg/L)	30
Chlorophyll (µg/L)	2
Na (mg/L)	14,300
Mg (mg/L)	711
Ca (mg/L)	93
K (mg/L)	44
Cl (mg/L)	23,300
SO_4 (mg/L)	2.1
HCO_3 (mg/L)	781
CO_3 (mg/L)	0.5

3.4. Benthic Plants

Lake Guraga has been described as having an abundance of aquatic plant growth (Australian Government 1995). However, there were no aquatic plants observed at the time of the IAI RCM survey. This warrants further investigation as the presence of dense aquatic vegetation has been identified as highly important to the site's avifauna (Australian Government 1995).

3.5. Littoral Vegetation

The vegetation of Lake Guraga consists of herbland and grassland in bacataform arrangement (Jaensch 1992). This fringing belt is composed of samphire species (predominantly *Agrostis avenacea*, *Sporobolus virginicus* and *Wilsonia backhousei*) covering a series of shallow winter wet depressions on the western side and the adjacent low rolling dunes (Jaensch 1992; Australian Government 1995). The surrounding areas support low open banksia woodland and open-scrub/heathland, and damplands containing scattered Flooded Gum (*Eucalyptus rudis*) (Jaensch 1992; Australian Government 1995). The surrounding areas of undisturbed vegetation form corridors, providing an uninterrupted succession of dryland to wetland habitats. This provides habitat for a diversity of plants (V & C Semeniuk Research Group 1994).

Three 30 m long vegetation transects were established as part of the IAI RCM survey within the vegetation fringing the northern side of Lake Guraga (Table 3).

Table 3 – Site attributes of the Lake Guraga vegetation transects.

Transect		R1	R2	R3
Datum		WGS84	WGS84	WGS84
Zone		50	50	50
Easting		363391	363406	363434
Northing		6585443	6585478	6585497
Length		30 m	30 m	30 m
Bearing		300	300	300
Wetland state		Drying	Drying	Drying
Soil state (%)	Dry	0	0	100
	Waterlogged	100	100	0
	Inundated	0	0	0
Substrate (%)	Bare	10	40	30
	Rock	0	0	0
	Cryptogam	0	0	0
	Litter	0	0	10
	Trash	0	0	10
	Logs	0	0	5
Time since last fire		fire unlikely here	fire unlikely here	<5 years
Community condition		Natural	Natural/Impacted	Natural/Impacted
Upper Stratum	Cover (%)	-	-	-
	Height (m)	-	-	-
Mid Stratum	Cover (%)	9.63	<1	32.2
	Height (m)	0.4	0.4	<3
Ground Cover	Cover (%)	51.8	49.5	10
	Height (m)	0.1	0.1	<0.2

Transect RCM023-R1

This transect was established within 50 m of the water's edge on the lake's northern margin (Figure 4). The soil was waterlogged at the time of survey. Vegetation consisted of *Tecticornia pergranulata* subsp. *pergranulata* low sparse chenopod shrubland (9.6% cover, 0.4 m tall) over *Wilsonia backhousei*, *Lawrencia glomerata*, *Triglochin mucronata* low herbland (51.8% cover, 0.1 m tall). Table 4 provides a complete list of taxa recorded along the transect RCM023-R1.

Scattered plants of the weed *Arctotheca calendula* were recorded on the transect. The overall community condition was considered 'natural' (Table 12 in Appendix 1).

Figure 4 – Lake Guraga vegetation transect RCM023-R1.

Table 4 – Plant taxa recorded on Lake Guraga vegetation transect RCM023-R1.

Genus	Species	Height (m)	Stratum[1]	Form
Tecticornia	*pergranulata* subsp. *pergranulata*	0.4	G1	Chenopod
Wilsonia	*backhousei*	0.1	G2	Forb
Lawrencia	*? glomerata*	0.2	G2	Forb
Triglochin	*mucronata*	0.1	G2	Forb
** Arctotheca*	*calendula*	0.2	G2	Forb
Puccinellia	*stricta*	0.2	G2	Grass

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.
? Limited confidence in identification.

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

G1+ ^*Tecticornia pergranulata* subsp. *pergranulata*\samphire shrub\1\r; G2 ^*Wilsonia backhousei*, *Lawrencia ?glomerata*, *Triglochin mucronata*, **Arctotheca calendula*, *Puccinellia stricta*\forb, tussock grass\1\c.

Transect RCM023-R2

The second transect was established approximately 100 m from the water's edge on the northern margin of the lake (Figure 5). Soil was moist at the time of survey. Isolated plants of *Tecticornia pergranulata* subsp. *pergranulata* and *T. indica* subsp. *bidens* low chenopod shrubs formed the upper vegetative layer over a mixture of open low herbs, grasses and sedges (49.5% cover, 0.1 m tall). Table 5 provides a complete list of taxa recorded along the transect RCM023-R2.

Six species of weeds were recorded on the transect. As such, the community condition was considered somewhat impacted' (Table 12 in Appendix 1).

Figure 5 – Lake Guraga vegetation transect RCM023-R2.

Table 5 – Plant taxa recorded on vegetation transect RCM023-R2 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Tecticornia	*pergranulata* subsp. *pergranulata*	0.4	G1	Chenopod
Tecticornia	*indica* subsp. *Bidens*	0.4	G1	Chenopod
Cotula	*cotuloides*	0.1	G2	Forb
* *Cotula*	*coronopifolia*	0.1	G2	Forb
Sporobolus	*virginicus*	0.05	G2	Grass
Wilsonia	*backhousei*	0.1	G2	Forb
* *Cuscuta*	*epithymum*	0.1	G2	Vine
* *Monopsis*	*debilis*	0.1	G2	Forb
* *Crassula*	*glomerata*	0.1	G2	Forb
Isolepis	*cernua* var. *setiformis*	0.05	G2	Sedge
* *Arctotheca*	*calendula*	0.2	G2	Forb
* *Anagallis*	*arvensis*	0.1	G2	Forb
Triglochin	*mucronata*	0.1	G2	Forb
Lawrencia	*? glomerata*	0.2	G2	Forb
* *Polypogon*	*monspeliensis*	0.2	G2	Grass

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.
? Limited confidence in identification.

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

G1 ^*Tecticornia pergranulata*, *T. indica* subsp. *bidens*\samphire shrub\1\bi; G2+ ^*Cotula cotuloides*, ^**Cotula coronopifolia*, *Sporobolus virginicus*, *Wilsonia backhousei*, **Cuscuta epithymum*\forb, grass\1\i.

Transect RCM023-R3

Transect R3 was established approximately 120 m from the water's edge (Figure 6). The sandy soils were dry at the time of survey. Vegetation was dominated by *Melaleuca viminea*, *Acacia saligna*, *Jacksonia furcellata* tall open shrubland (32.2% cover, <3 m tall) over various low open herbs, sedges and rushes (10% cover, <0.2 m tall). Table 6 provides a complete list of taxa recorded on transect RCM023-R3.

The vegetation on this transect has been burnt in the last five years and consequently heavy recruitment of *Melaleuca viminea* subsp. *viminea* is evident. Seven species of weeds were recorded contributing to a substantial proportion of the ground cover. Weed cover was probably elevated due to the recent disturbance by fire. The overall community condition was considered impacted' (Table 12 in Appendix 1).

Table 6 – Plant taxa recorded on vegetation transect RCM023-R3 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Melaleuca	*viminea* subsp. *viminea*	3	M1	Shrub
Acacia	*saligna*	2	M1	Shrub
Jacksonia	*furcellata*	2	M1	Shrub
Triglochin	*minutissima*	0.05	G1	Forb
Isotropis	*cuneifolia* subsp. *cuneifolia*	0.1	G1	Forb
* *Ursinia*	*anthemoides*	0.2	G1	Forb
* *Isolepis*	*marginata*	0.05	G1	Sedge
* *Juncus*	*capitatus*	0.05	G1	Rush
* *Crassula*	*glomerata*	0.1	G1	Forb
? *Sporobolus*	*virginicus*	0.1	G1	Grass
* *Lotus*	*subbiflorus*	0.1	G1	Forb
* *Vulpia*	*fasciculata*	0.3	G1	Grass
Drosera	sp.	0.1	G1	Forb
* *Briza*	*minor*	0.2	G1	Grass
Microtis	*media*	0.2	G1	Forb
Caladenia	*reptans* subsp. *reptans*	0.2	G1	Forb
Cotula	*cotuloides*	0.1	G1	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.
? Limited confidence in identification.

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

M1+ ^*Melaleuca viminea* subsp. *viminea*, *Acacia saligna*, *Jacksonia furcellata*\shrub\4\i; G1 ^*Triglochin minutissima*, ^*Isotropis cuneifolia* subsp. *cuneifolia*, **Ursinia anthemoides*, *Isolepis marginata*, **Juncus capitatus*\forb, sedge, rush\1\i.

Figure 6 – Lake Guraga vegetation transect RCM023-R3.

3.6. Aquatic Invertebrates

Three aquatic macroinvertebrate samples were collected, all in bare, open mud habitat with no macrophyte cover (Table 7). Lake Guraga is a secondarily saline wetland and this was reflected in the very low diversity of very widely distributed halotolerant species. A total of nine species of invertebrates were collected, belonging to six families. This richness represents a small proportion of what would have inhabited the wetland prior to alteration of the system's hydrology.

Table 7 – Invertebrates collected from Lake Guraga.

Class	Order	Family	Lowest ID	Sample[1]
Gastropoda	Neotaeniglossa	Pomatiopsidae	*Coxiella* sp.	3
Insecta	Coleoptera	Hydrophilidae	*Berosus* sp.	1, 2, 3
	Diptera	Ceratopogonidae	*Culicoides* sp.	2, 3
		Chironomidae	*Procladius paludicola*	1, 2, 3
			Tanytarsus fuscithorax/semibarbitarsus	1, 2, 3
			Cladopelma curtivalva	3
		Dolichopodidae	Dolichopodidae	1, 2, 3
		Muscidae	Muscidae	3

1 Samples 1, 2 and 3 denote the three replicate sub-samples as above.

A previous survey, conducted between March and September 1979, found the faunal assemblages of Lake Guraga were dominated by crustaceans. Five species of Crustacea (including one copepod) were recorded as well as one insect species (Halse 1981). However, the 2008 IAI RCM survey found Lake Guraga was dominated by insects. This may be due, in part, to the use of different survey methods in the two projects. The IAI RCM project did not identify microinvertebrates, whereas Halse (1981) identified all aquatic invertebrates. This would explain the lack of microcrustacea (copepods and ostracods) in the 2008 samples.

Another source of variation between the 1979 and 2008 results is the difference in climatic conditions in the lead up to those surveys. The year 1979 was an exceptionally dry year in WA. Coorow (113 km northeast of Lake Guraga) received only 181 mm of rain from March to September 1979 (Halse 1981). More rain fell in Lancelin in July 2008 alone (241.4 mm) with a

total of 628.1 mm from March to October (6th). This resulted in water levels in the lake falling throughout the 1979 winter, while salinity rose to 44 ppt (Halse 1981), much higher than the 21.3 ppt recorded in 2008. Lower salinity generally favours insect species and may offer an explanation on the shift from crustacean dominance to an insect dominated wetland.

3.7. Fish

No fish have been recorded in Lake Guraga and none were seen during the IAI RCM survey in 2008.

3.8. Waterbirds

Lake Guraga is one of the more important wetlands for waterbirds in the southwest of WA. It supports a diverse and abundant bird life and is an important drought refuge area for waterbirds (Australian Government 1995). Previous waterbird surveys have been conducted at Lake Guraga by DEC and RAOU (Royal Australasian Ornithologists Union, now Birds WA) under the projects 'Waterfowl Counts in the South-West WA' (WCSW) and 'Waterbirds in Nature Reserves of South-West WA' (WNRSW). All of the waterbirds observed during the IAI RCM survey have previously been recorded at Lake Guraga (Table 8).

A total of forty-nine species of waterbirds have been recorded at Lake Guraga, including fifteen species listed in the schedule to at least one of the migratory bird bilateral agreements and conventions (Table 8). Species known to occur at Lake Guraga include Freckled Duck, which is gazetted 'rare and endangered' under the Western Australian Wildlife Conservation Act (Creagh 2003).

Lake Guraga sometimes supports very large numbers of waterbirds. The highest number of waterbirds counted in a single survey was 27,697 birds of twenty-two species in October 1985. This figure is exceeded in southwestern Australia only by the Vasse Estuary, Dumbleyung Lake and Peel Inlet (Australian Government 1995). Lake Guraga is one of the top three wetlands in southwestern Australia for Hoary-headed Grebe, Grey Teal, Pink-eared Duck and Musk Duck. Other species that have been particularly common at various times include Black Swan, Great Cormorant, Red-necked Avocet and Eurasian Coot. A variety of wader species have been recorded at Lake Guraga, the most numerous of which are Red-capped Plover and Red-necked Stint (Jaensch et al. 1988; Halse et al. 1990; Jaensch 1992; Australian Government 1995).

Three species have been observed using Lake Guraga as a breeding site: Australian Shelduck, Grey Teal and Red-necked Stint (Jaensch 1992). Lake Guraga is a moulting site for Australian Shelduck populations within WA. Some 6,000 to 8,000 of these ducks migrate to the lake to moult in late spring.

Table 8 – Waterbirds observed at Lake Guraga.

Organisation/Project Duration of project		**DEC/RAOU WNRSW 1981 - 1988**	**DEC/RAOU WCSW 1988 - 1991**	**DEC RCM 06/10/2008**
Common name	**Latin name**			
* American Golden Plover	*Pluvialis dominica*	✓		
Australasian Shoveler	*Anas rhynchotis*	✓	✓	
Australian Pelican	*Pelecanus conspicillatus*	✓		
Australian Shelduck	*Tadorna tadornoides*	✓	✓	✓
Australian White Ibis	*Threskiornis molucca*	✓		
Australian Wood Duck	*Chenonetta jubata*	✓	✓	
Banded Stilt	*Cladorhynchus leucocephalus*	✓		✓
* Bar-tailed Godwit	*Limosa lapponica*	✓		
* Black-tailed Godwit	*Limosa limosa*	✓		
Black-winged Stilt	*Himantopus himantopus*	✓		✓

Organisation/Project Duration of project		DEC/RAOU WNRSW 1981 - 1988	DEC/RAOU WCSW 1988 - 1991	DEC RCM 06/10/2008
Common name	**Latin name**			
Black Swan	*Cygnus atratus*	✓	✓	✓
Blue-billed Duck	*Oxyura australis*	✓		
* Broad-billed Sandpiper	*Limicola falcinellus*	✓		
* Common Greenshank	*Tringa nebularia*	✓		
Common Sandpiper	*Tringa hypoleucos*	✓		
* Curlew Sandpiper	*Calidris ferruginea*	✓		
Darter	*Anhinga melanogaster*	✓		
Double-banded Plover	*Charadrius bicinctus*	✓		
Eurasian Coot	*Fulica atra*	✓	✓	
Freckled Duck	*Stictonetta naevosa*	✓		
Great Cormorant	*Phalacrocorax carbo*	✓		
Great Crested Grebe	*Podiceps cristatus*	✓		
* Great Egret	*Ardea alba*	✓		
* Great Knot	*Calidris tenuirostris*	✓		
* Grey Plover	*Pluvialis squatarola*	✓		
Grey Teal	*Anas gracilis*	✓	✓	
Hardhead	*Aytha australis*	✓	✓	
Hoary-headed Grebe	*Poliocephalus poliocephalus*	✓		
Little Black Cormorant	*Phalacrocorax sulcirostris*	✓		
Little Pied Cormorant	*Phalacrocorax melanoleucos*	✓		
* Long-toed Stint	*Calidris subminuta*	✓		
* Marsh Sandpiper	*Tringa stagnatilis*	✓		
Musk Duck	*Biziura lobata*	✓	✓	
Pacific Black Duck	*Anas superciliosa*	✓	✓	
* Pectoral Sandpiper	*Calidris melanotos*	✓		
Pink-eared Duck	*Malacorhynchus membranaceus*	✓	✓	
Red-capped Plover	*Charadrius ruficapillus*	✓		✓
Red-kneed Dotterel	*Erythrogonys cinctus*	✓		
Red-necked Avocet	*Recurvirostra novaehollandiae*	✓		
* Red-necked Stint	*Calidris ruficollis*	✓		
* Sharp-tailed Sandpiper	*Calidris acuminata*	✓		
Silver Gull	*Larus novaehollandiae*	✓		
Straw-necked Ibis	*Threskiornis spinicollis*	✓		
Swamp Harrier	*Circus approximans*	✓		
Unidentified Duck		✓		
Unidentified Grebe		✓		
Unidentified Small Waders		✓		
Unidentified Stilt-type		✓		
Whiskered Tern	*Sterna hybrida*	✓		
* White-bellied Sea-eagle	*Haliaeetus leucogaster*	✓		
White-faced Heron	*Egretta novaehollandiae*	✓		
White-necked Heron	*Ardea pacifica*	✓		
Yellow-billed Spoonbill	*Platalea flavipes*	✓		

* Listed under Migratory Bird Agreements JAMBA, CAMBA and/or ROKAMBA.

3.9. Terrestrial Vertebrates

No evidence of frogs or other terrestrial vertebrates was found during the IAI RCM 2008 survey. However, two frog species and three reptile species are known to occur in the area (Table 9).

Table 9 – Western Australian Museum records for fauna collected within 5 km of Lake Guraga (WA Museum 2009).

Accession ID/s	Common Name	Latin name	Year
R141596	Common Dwarf Skink	*Menetia greyii*	2000
R104386	Moaning Frog	*Heleioporus eyrei*	1990
R40097	Guenther's Toadlet	*Pseudophryne guentheri*	1971
R26809	Yellow-faced Whip Snake	*Demansia psammophis*	1966
R31080 R31081 R31082	Western Spiny-tailed Gecko	*Strophurus spinigerus*	1965

4. Interactions between Ecological Components at Lake Guraga

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. This justification may also be extended to nomination for the Directory of Important Wetlands in Australia, as the criteria are very similar. Accordingly, the primary determinants of ecological character at Lake Guraga are:

- The characteristics that make the site a good example of a wetland type occurring within a biogeographic region in Australia.
- The contribution the site makes to the ecological or hydrological functioning of the wetland system/complex.
- The animal taxa that utilise the site as habitat at a vulnerable stage in their life cycles, or as a refuge when adverse conditions such as drought prevail; and the characteristics of the site that allow it support these populations.
- The plant or animal taxa that have more than 1% of their national populations supported by the site.
- The site's outstanding historical and cultural significance.

Table 10 summarises the interactions between key components and processes at Lake Guraga that give rise to the site's ecological character. 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.

Table 10 – The relationship between the services and benefits delivered by Lake Guraga and the key components and processes that support them.

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Ecosystem Service Value A good example of a wetland type occurring within a biogeographic region in Australia	Large saline/brackish lake on the Swan Coastal Plain bioregion.	Vegetation communities	Water regime Water quality Soils and sediments	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion
Ecosystem Service Value Plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex	Geomorphology and hydrology	None	Climate	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Sedimentation
Ecosystem Service Value Provides habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail	Australian Shelduck (moulting and breeding area) Grey Teal and Red-capped Plover (breeding area) 15 species of waterbird that use the lake for a migration stop-over for Other waterbirds that utilise the site as a drought refuge	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Hydrological regime Water quality Habitat extent and distribution Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Ecosystem Service Value Supports 1% or more of the national populations of any native plant or animal taxa	Hoary-headed Grebe Grey Teal Pink-eared Duck Musk Duck	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Water regime Water quality Habitat extent and distribution Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)
Amenity Value Aesthetics	Landscape amenity Waterbird populations Vegetation communities	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Hydrological regime Water quality Habitat extent and distribution Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)
Scientific/Educational Value Research opportunities	Waterbird populations Aquatic invertebrate communities Vegetation communities Hydrology and water quality	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Hydrological regime Water quality Habitat extent and distribution Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Recreational Value Bird watching Picnicking Boating Bush walking Photography Wildflower tourism	Landscape amenity Waterbird populations Vegetation communities Significant flora Significant fauna	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Hydrological regime Water quality Habitat extent and distribution Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)
Spiritual Value The wetland is of outstanding historical or cultural significance	Landscape amenity Waterbird populations Vegetation communities Significant flora Significant fauna	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Hydrological regime Water quality Habitat extent and distribution Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Weeds Erosion Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)
Opportunity Value Potential future use of unique flora and fauna	Endemic flora Endemic fauna	Pollinators Food sources	Habitat extent and distribution Hydrological regime Fire regime Water quality Soils	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Inappropriate fire regimes Weeds Grazing by livestock or pest animals Predation by introduced fauna Inappropriate recreation (e.g. four-wheel driving)

5. Threats to the Ecology of Lake Guraga

The ambition for management at Lake Guraga is to maintain those elements of the ecology that resulted in its nomination as a DIWA site. The critical components of the ecology are the geomorphologic, hydrologic and water quality factors that make the lake a good example of a saline lake on the Swan Coastal Plain, suitable stopover for migratory birds and refuge site for domestic 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. Also of importance are the elements of the system that contribute to its cultural and scientific value.

Threats to Lake Guraga 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 11. In summary, failure to achieve the management goal for Lake Guraga is most likely to result due to salinisation of surface and groundwater, eutrophication and pollution, and weeds. Recreation, mining and climate change are also significant threats.

Altered Hydrology

Changes to the hydrology of Lake Guraga have been identified as a major threat to the site (Jaensch 1992; NAIMS 2000; Comer et al. 2002; Mitchell et al. 2002; NACC 2005). Surface water inflows to Lake Guraga have been decreased significantly by flood control works on Caren Caren Brook and the diversion of water for irrigation. As a result, the proportion of inflow from groundwater has increased (Australian Government 1995). The associated lowered levels of water in Lake Guraga could potentially affect the riparian vegetation (Mitchell et al. 2002).

Salinisation of surface and groundwater has been commonly identified as a threat affecting Lake Guraga (NAIMS 2000; Comer *et al.* 2002; Mitchell *et al.* 2002). Salinisation occurs when the water table rises in response to increased water infiltration and reduced evapotranspiration following the clearing of native vegetation. Rising groundwater dissolves salt that was previously stored in the soil above the water table and transports it to the soil surface. The combination of soil waterlogging and high concentrations of salt cause a number of impacts, including the death of vegetation and disruption of soil structure (Mulcahy 1978; Ruprecht and Schofield 1991; George *et al.* 1995; Halse *et al.* 2003).

Nutrient Enrichment and Water Pollution

Lake Guraga has been identified as vulnerable to nutrient enrichment and pollution (Jaensch 1992; NAIMS 2000; Comer *et al.* 2002; Mitchell *et al.* 2002). Elevated nutrients can cause algal blooms in wetlands, which impact on flora and fauna. The IAI RCM survey found very high nutrient levels in Lake Guraga. A turf farm that operates to the east of Lake Guraga could be contributing to this via run-off containing fertilisers. If this is occurring, runoff may also be transporting herbicides into the lake.

Recreational usage of the area

A number of four wheel drive tracks were observed on the northern, western and southern sides of Lake Guraga (Australian Government 1995). Four wheel driving kills vegetation and degrades soil structure (Figure 7). This increases the likelihood of soil erosion provides opportunities for colonisation by weed species.

Figure 7 – Evidence of four wheel drive tracks affecting the riparian vegetation of Lake Guraga.

There have been proposals to use Lake Guraga for recreational activities, particularly boating (Jaensch 1992; NAIMS 2000). Use of the lake for recreational boating could be a threat to the wetland, specifically due to bird disturbance, introduction of pollutants and increased access to the site.

Impacts from mining

Two mineral sands mining operations are occurring in the vicinity of Lake Guraga. Iluka's Cataby Mineral Sands Project is located approximately 20 km to the north-northwest of the lake and Tiwest Joint Venture's Cooljaroo Mine is immediately north of this.

Lake Guraga has been identified as a groundwater dependent ecosystem, at risk from altered groundwater levels due to mining activity (Froend and Loomes 2004). Modelling was undertaken to gauge the potential cumulative impacts of the Cooljarloo and Cataby operations on groundwater dependent ecosystems. No effect on the groundwater levels at Lake Guraga was predicted. Wetland vegetation was deemed not at risk of impact from changes to groundwater. The accuracy of this modelling should be monitored throughout the life of the minesites.

Impacts of weeds, fire and herbivory on vegetation

In 1995, the vegetation of Lake Guraga was described as being in 'very good condition' with few human impacts evident other than a number of four wheel drive tracks (Australian Government 1995). However, by 2008, the condition of the vegetation was considered 'impacted' (Table 12 in Appendix 1) due to the presence of considerable populations of weed species. The IAI RCM survey recorded severe weed infestations both in the riparian zone and further from the lake's edge (Figure 8).

Several mounds of soil, presumably spoil from track construction, were dumped at the northern end of the lake. The dumped soil appeared to be a vector for weed propagules, as the area surrounding the mounds were heavily weed infested. More appropriate methods of disposing of spoil need to be implemented and these disturbed areas should be treated to remove weeds.

Figure 8 – Weeds present on disturbed soils to the north of Lake Guraga.

At the time of the IAI RCM survey, the impacts of fire were evident at Lake Guraga. Much of the bushland around the southern and eastern sides of the lake had been burnt in December 2007. This appears to have facilitated the establishment of weeds in the burnt area.

Grazing also appeared to be impacting the vegetation of Lake Guraga. The presence of a large number of kangaroos was recorded, as was cow faeces.

Climate change

Climate change may be expected to affect Lake Guraga. Climate change modelling conducted by the CSIRO predicts that rainfall received by the southwest of WA will decline by as much as 20% by 2030 and 60% by 2070, relative to 1990 figures (EPA 2007). The impacts of this on the ecology and geomorphology of Lake Guraga are difficult to predict and should be monitored. It is likely that climate change may lead to alteration in wetland extent, water quality and vegetation.

Table 11 – Threat assessment for Lake Guraga.

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 Lake Guraga, 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	0.3	0.25	Lake Guraga is a secondarily salinised wetland and its ecology has already changed accordingly. Further salinisation could affect the riparian vegetation and make the wetland less suitable for waterbirds.
	Carbon cycle and climate change	0.05	0.05	A significant decline in rainfall is predicted for the southwest region of WA (EPA 2007). This may lead to alteration in wetland extent, water quality and vegetation. Climate change may have positive effects if it reverses the trend in water table rise.
Impacts of introduced plants and animals	Environmental weeds	0.3	0.15	Weeds are one of the primary threats to the ecology of Lake Guraga with severe infestations evident. Alteration to natural fire regimes may facilitate the establishment of weed species in the area.
	Herbivory, wallowing and trampling by introduced species	0.1	0.0	Evidence of cattle. Cattle wallowing around the lake margins kill vegetation and make soil susceptible to erosion. Over-grazing has similar impacts. Fencing to exclude cattle is required.
Impacts of problem native species	Overgrazing by native species.	0.05	0.0	No impacts evident. Potential threat, as large numbers of kangaroos are present.
Impacts of disease	Plant pathogens	0.0	0.0	No impacts evident.
Detrimental regimes of physical disturbance events	Fire regimes	0.2	0.1	Evidence of recent fire was observed. Fire facilitates the establishment of exotic grasses and other weeds. Fire also create the potential for erosion of soils with the next rainfall event. Fire management may be necessary.

Threat category	Management issue	Probability that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
	Drought	0.05	0.05	The hydrology of Lake Guraga is dependent on a combination of inflow from an ephemeral creek and rainfall. Increased periods of drought associated with climate change could potentially change the near-permanent nature of the lake.
	Flood	0	0	Flooding is unlikely in the area.
Impacts of pollution	Herbicide, pesticide or fertiliser use and direct impacts	0.3	0.1	Lake Guraga is highly nutrient enriched and pollution has been identified as a threatening process occurring at the wetland. Eutrophication may be attributed to agricultural run-off.
Impacts of competing land uses	Recreation management	0.1	0.0	Four wheel drive tracks evident. Uncontrolled, four wheel driving at Lake Guraga could cause further loss of riparian vegetation and soil erosion, and may facilitate weed invasion.
	Nutrient enrichment of water body.	0.4	0.1	Lake Guraga has extremely high nutrient levels suggesting eutrophication is a dominant threat to its ecology. This is possibly a result of agricultural run-off. It is also likely that cattle accessing the lake will result in nutrient enrichment of the water body.
	Urban and industrial development	0.2	0.0	Continuing land clearing and impacts on small fragmented remnants which predominate in the central and southern zone of the Swan Coastal Plain IBRA subregion have been identified as processes threatening the ecology of Lake Guraga (Mitchell et al. 2002).
	Consumptive uses	0.0	0.0	There was no evidence of consumptive use of Lake Guraga.
	Illegal activities	0.1	0.0	Soil appears to have been illegally dumped at the site, assisting the spread of weed species.
	Mines and quarries	0.01	0.0	Mineral sands mining operations occur 20 km north of Lake Guraga. Mining may cause groundwater drawdown potentially impacting the vegetation in the east of the reserve within which Lake Guraga is contained. Mining is not expected to affect the actual lake or its vegetation.

Threat category	Management issue	Probability that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	0.01	0.01	Lake Guraga is well-connected to areas of native vegetation, some of which is contained within nature reserves. Populations are likely to be self-supporting in this setting. Off-site impacts on migratory birds could potentially reduce their population size to unsustainable levels, but this could not be addressed at a site level.

6. Knowledge Gaps and Recommendations

Lake Guraga is situated on the Bassendean Dune System, the vegetation of which has been identified as poorly represented in conservation reserves in the region (Beard 1981; CALM/Dept. Ag. 1996; Creagh 2003), particularly in regards to wetland vegetation (Creagh 2003). The relatively small amount of land currently set aside for conservation, coupled with the high degree of floristic variation and complexity of vegetation types, means that many vegetation types are likely to be under-represented in reserves. Despite being a DIWA listed wetland, Lake Guraga is not within a conservation reserve. Although the condition of the vegetation surrounding Lake Guraga has been impacted by weeds, it is still amenable to recovery to a natural state with management intervention. Consideration should be given to inclusion of Lake Guraga in the conservation reserve system.

Recreational activities, such as four wheel driving, and illegal activities, such as soil dumping, should be closely controlled to prevent further deterioration of the riparian vegetation surrounding Lake Guraga.

Weed management may have to be employed to mitigate the impacts of the current weed infestation.

The riparian vegetation of Lake Guraga may also need to be fenced to exclude livestock and pest native species with the aim of reducing grazing pressures. This may also serve to reduce nutrient enrichment of the waterbody.

Some investigation of the source of nutrients entering the lake is also required. A management strategy could then be developed to reduce the nutrient runoff from neighbouring properties.

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Appendix 1 – Vegetation Condition

Table 12 – Overall Vegetation Community Condition Rating as adapted from Thackway and Lesslie (2005). Shading indicates the condition of Lake Guraga.

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 – Herbarium Plant Records

Table 13 – Herbarium Records for Lake Guraga.

Search Coordinates: NW corner: 30.8393°S, 115.5384°E; SE corner: 30.9499°S, 115.6749°E

Family	Species	Alien	Cons. Status
Anthericaceae	*Laxmannia ramosa* subsp*. ramosa*		
Anthericaceae	*Thysanotus multiflorus*		
Apiaceae	*Trachymene pilosa*		
Apiaceae	*Xanthosia huegelii*		
Asteraceae	*Pterochaeta paniculata*		
Asteraceae	*Quinetia urvillei*		
Asteraceae	*Waitzia podolepis*		
Boryaceae	*Borya sphaerocephala.*		
Brassicaceae	*Heliophila pusilla*	Y	
Centrolepidaceae	*Centrolepis aristata*		
Centrolepidaceae	*Centrolepis drummondiana*		
Centrolepidaceae	*Centrolepis inconspicua*		
Chloanthaceae	*Pityrodia uncinata*		
Colchicaceae	*Burchardia congesta*		
Colchicaceae	*Wurmbea dioica* subsp. *alba*		
Cyperaceae	*Isolepis stellata*		
Cyperaceae	*Lepidosperma* sp.		
Cyperaceae	*Tricostularia neesii* var. *neesii*		
Dasypogonaceae	*Dasypogon obliquifolius*		
Dilleniaceae	*Hibbertia acerosa*		
Dilleniaceae	*Hibbertia crassifolia*		
Dilleniaceae	*Hibbertia huegelii*		
Dilleniaceae	*Hibbertia hypericoides*		
Dilleniaceae	*Hibbertia spicata* subsp. *spicata*		
Dilleniaceae	*Hibbertia subvaginata*		
Epacridaceae	*Conostephium minus*		
Epacridaceae	*Leucopogon oliganthus*		
Epacridaceae	*Leucopogon polymorphus*		
Epacridaceae	*Leucopogon* sp. Moore River (M. Hislop 1695)		
Epacridaceae	*Leucopogon sprengelioides*		
Euphorbiaceae	*Monotaxis grandiflora* var. *grandiflora*		
Goodeniaceae	*Dampiera linearis*		
Goodeniaceae	*Lechenaultia floribunda*		
Gyrostemonaceae	*Gyrostemon racemiger*		
Haemodoraceae	*Anigozanthos humilis* subsp. *humilis*		
Haemodoraceae	*Blancoa canescens*		
Haemodoraceae	*Conostylis aculeata* subsp. *spinuligera*		
Haemodoraceae	*Conostylis juncea*		
Haemodoraceae	*Conostylis latens*		
Haemodoraceae	*Haemodorum spicatum*		
Haemodoraceae	*Haemodorum venosum*		
Haemodoraceae	*Phlebocarya ciliata*		
Haemodoraceae	*Phlebocarya filifolia*		
Haemodoraceae	*Tribonanthes australis*		
Juncaceae	*Juncus bufonius*	Y	
Lentibulariaceae	*Utricularia multifida*		

Family	Species	Alien	Cons. Status
Lentibulariaceae	*Utricularia tenella*		
Loganiaceae	*Logania campanulata*		
Loganiaceae	*Logania spermacocea*		
Lycopodiaceae	*Phylloglossum drummondii*		
Mimosaceae	*Acacia barbinervis* subsp. *borealis*		
Mimosaceae	*Acacia blakelyi*		
Mimosaceae	*Acacia pyrifolia*		
Mimosaceae	*Acacia* sp.		
Mimosaceae	*Vachellia farnesiana*	Y	
Myrtaceae	*Baeckea grandiflora*		
Myrtaceae	*Baeckea* sp. Mingenew (M.E. Trudgen 12029)		
Myrtaceae	*Calothamnus quadrifidus*		
Myrtaceae	*Calytrix sapphirina*		
Myrtaceae	*Chamelaucium uncinatum*		
Myrtaceae	*Conothamnus trinervis*		
Myrtaceae	*Darwinia neildiana*		
Myrtaceae	*Darwinia pinifolia*		
Myrtaceae	*Eremaea asterocarpa* subsp. *asterocarpa*		
Myrtaceae	*Eremaea fimbriata*		
Myrtaceae	*Eremaea pauciflora* var. *calyptra*		
Myrtaceae	*Eremaea pauciflora* var. *lonchophylla*		
Myrtaceae	*Eucalyptus pluricaulis*		
Myrtaceae	*Hypocalymma xanthopetalum*		
Myrtaceae	*Kunzea micrantha Schauer*		
Myrtaceae	*Malleostemon* sp. Cooljarloo (B. Backhouse)		P1
Myrtaceae	*Melaleuca ciliosa*		
Myrtaceae	*Melaleuca clavifolia*		P1
Myrtaceae	*Melaleuca preissiana*		
Myrtaceae	*Melaleuca teretifolia*		
Myrtaceae	*Scholtzia involucrata*		
Myrtaceae	*Verticordia nitens*		
Orchidaceae	*Drakaea elastica*		R
Orchidaceae	*Elythranthera brunonis*		
Orchidaceae	*Paracaleana nigrita*		
Orchidaceae	*Thelymitra antennifera*		
Orchidaceae	*Thelymitra campanulata*		
Papilionaceae	*Aotus procumbens*		
Papilionaceae	*Bossiaea eriocarpa*		
Papilionaceae	*Daviesia nudiflora* subsp. *hirtella*		
Papilionaceae	*Daviesia nudiflora* subsp. *nudiflora*		
Papilionaceae	*Gompholobium pungens*		
Papilionaceae	*Gompholobium tomentosum*		
Papilionaceae	*Isotropis cuneifolia* subsp. *cuneifolia*		
Papilionaceae	*Ptychosema pusillum*		R
Philydraceae	*Philydrella pygmaea* subsp. *pygmaea*		
Poaceae	*Amphipogon turbinatus*		
Proteaceae	*Adenanthos drummondii*		
Proteaceae	*Banksia candolleana*		
Proteaceae	*Banksia hewardiana*		
Proteaceae	*Banksia sessilis* var. *sessilis*		
Proteaceae	*Banksia shuttleworthiana*		
Proteaceae	*Conospermum nervosum*		

Family	Species	Alien	Cons. Status
Proteaceae	*Conospermum stoechadis* subsp. *stoechadis*		
Proteaceae	*Grevillea rudis*		P4
Proteaceae	*Isopogon linearis*		
Proteaceae	*Petrophile brevifolia*		
Proteaceae	*Strangea cynanchicarpa*		
Proteaceae	*Synaphea spinulosa* subsp. *spinulosa*		
Restionaceae	*Hypolaena exsulca*		
Restionaceae	*Lyginia barbata*		
Rhamnaceae	*Polianthion wichurae*		
Rutaceae	*Boronia ramosa* subsp. *anethifolia*		
Rutaceae	*Boronia scabra* subsp. *scabra*		
Sterculiaceae	*Guichenotia sarotes*		
Stylidiaceae	*Stylidium calcaratum*		
Stylidiaceae	*Stylidium crossocephalum*		
Stylidiaceae	*Stylidium schoenoides*		
Stylidiaceae	*Stylidium spiciforme*		