Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for a Significant Western Australian Wetland

Rowles Lagoon

2009

Figure 1 – The moon rising above Rowles Lagoon.

This report was prepared by:

Anna Nowicki, Technical Officer, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Stephen Kern, Botanist, Department of Environment and Conservation, Locked Bag 104 Bentley Delivery Centre 6983

Adrian Pinder, Senior Research Scientist, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Glen Daniel, Environmental Officer, Department of Environment and Conservation, Locked Bag 104 Bentley Delivery Centre 6983

Invertebrate sorting and identification was undertaken by:

Nadine Guthrie, Research Scientist, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Ross Gordon, Technical Officer, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Prepared for:

Inland Aquatic Integrity Resource Condition Monitoring Project, Strategic Reserve Fund, Department of Environment and Conservation

July 2009

Suggested Citation

DEC (2009). *Resource Condition Report for Significant Western Australian Wetland: Rowles Lagoon.* Prepared for Inland Aquatic Integrity Resource Condition Monitoring (IAI RCM) Project. Department of Environment and Conservation. Perth, Australia.

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 Rowles Lagoon, a seasonal, freshwater lake, near Coolgardie. Rowles Lagoon is the largest and most permanent of all freshwater lakes in the Rowles Lagoon System. It is popular with day-trippers, campers and water sport enthusiasts and is the only lake in the Goldfields with a gazetted water ski and jet ski area.

Rowles Lagoon was selected as a study site in the IAI RCM project because the Rowles Lagoon System is listed in the Directory of Important Wetlands in Australia (DIWA) (Environment Australia 2001). DIWA lists the Rowles Lagoon System as a good example of a freshwater lake/swamp system of the temperate arid interior, probably the largest such system that is inundated regularly. Also, the teatree/lignum swamp community found in the area is a good example of its type and probably the largest area of such vegetation in the southwest of the arid interior. Finally, Rowles Lagoon is important because no other wetland in temperate parts of the arid interior is known to support a comparable number of waterbird species (Handley 1996).

1.1. Site Code

Directory of Important Wetlands in Australia: WA015

Register of the National Estate Indicative Place ID: 102199

Inland Aquatic Integrity Resource Condition Monitoring Project (DEC): RCM015

Transect codes: RCM015-R1

RCM015-R2

1.2. Purpose of Resource Condition Report

The objective of the RCR is to summarise all available ecological information relevant to Rowles Lagoon and describe the drivers of, and threats to, the system. This 'snapshot' of ecological character will provide context for future monitoring of the site and allow the effectiveness of management planning and actions to be assessed.

1.3. Relevant International Agreements and Legislation

The following is a summary of international agreements and legislation that are relevant to the management of Rowles Lagoon.

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 that are relevant to Rowles Lagoon. 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.

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. One of these is relevant to Rowles Lagoon, namely migratory species listed under international treaties JAMBA, CAMBA and CMS.

Australian Heritage Council Act 2003

Rowles Lagoon has been placed on the Register for National Estate (indicative place). Indicative placement on the Register for National Estate means that data has been provided to or obtained by the Australian Heritage Council or the former Australian Heritage Commission for Rowles Lagoon and has been entered into their database. However, the site is in the assessment process and a decision on whether the place should be entered in the Register has not been made. The Australian Heritage Council can no longer add places to or remove places or a part of a place from the Register of the National Estate (as of February 2007). Hence, Rowles Lagoon currently is not offered protection under the *Australian Heritage Council Act 2003*.

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.

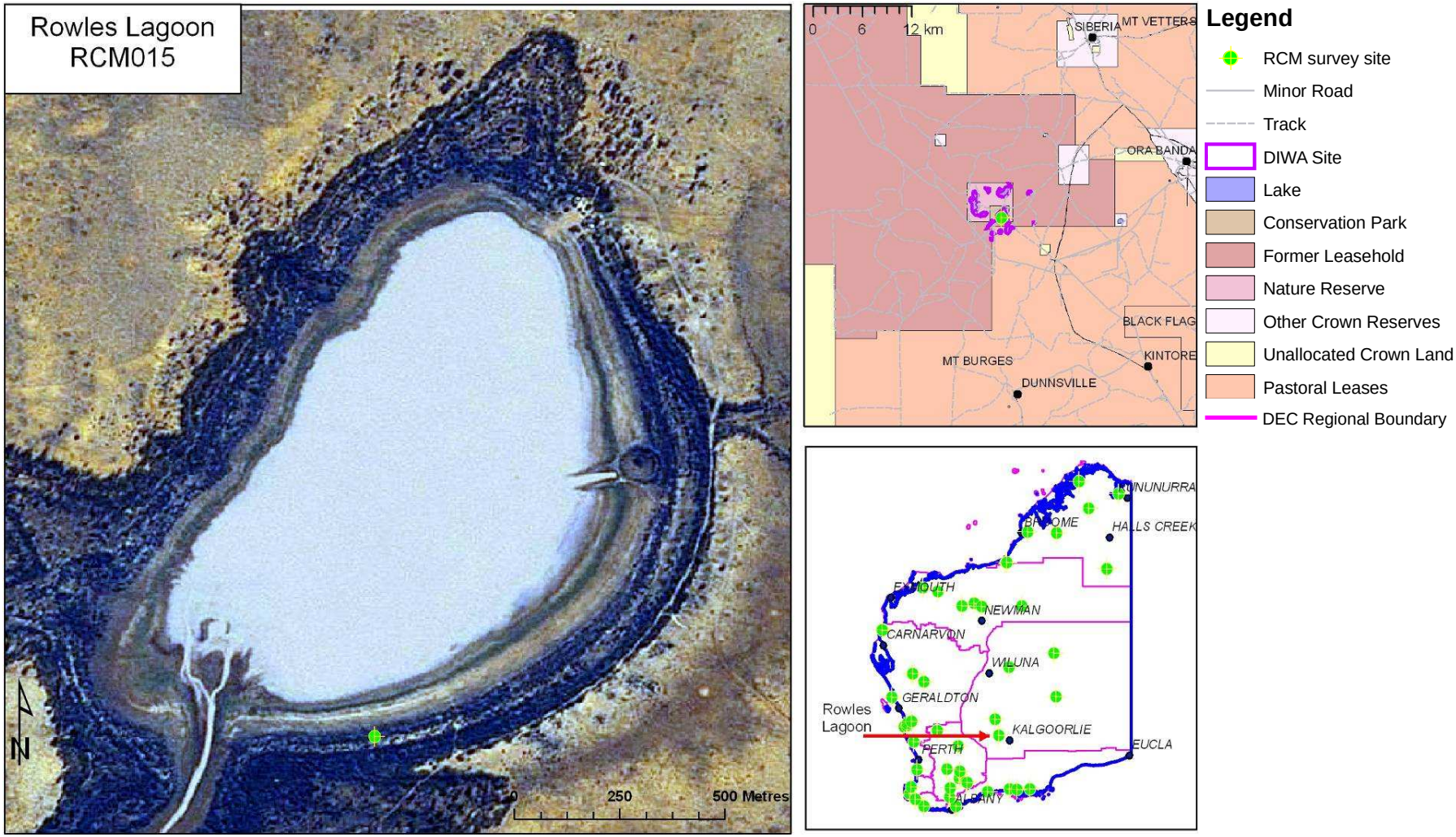

Figure 2 – Aerial photograph showing the location of the survey site at Rowles Lagoon. The upper insert shows the location Rowles Lagoon relative to the other lakes in the Rowles Lagoon System and the tenure of surrounding land. The lower insert shows the location of the Rowles Lagoon in Western Australia and in relation to other IAI RCM project sites.

2. Overview of Rowles Lagoon

2.1. Location and Cadastral Information

Rowles Lagoon lies approximately 65 km north-northwest of Coolgardie (Figure 2). The lake is contained within Rowles Lagoon Conservation Park, which is vested in the Conservation Commission and is managed by the Goldfields regional office of the Department of Environment and Conservation. The conservation park was gazetted for the purposes of fauna and flora conservation and recreation.

Most of the remainder of the Rowles Lagoon System is contained within Clear and Muddy Lakes Nature Reserve and an adjoining water reserve. The southernmost wetland (unnamed) and Canegrass Lagoon are situated within the Mt Burges pastoral lease. The predominant land use in the broader area pastoralism.

2.2. IBRA Region

Rowles Lagoon lies in the northwest of the Eastern Goldfields subregion (COO3) of the Coolgardie Interim Biogeographic Regionalisation of Australia (IBRA) region. This subregion lies on the Yilgarn Craton's 'Eastern Goldfields Terrains'. The relief is subdued and comprises gently undulating plains interrupted in the west with low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. The underlying geology is of gneisses and granites eroded into a flat plane covered with tertiary soils and with scattered exposures of bedrock. Calcareous earths are the dominant soil group and cover much of the plains and greenstone areas. A series of large playa lakes in the western half are the remnants of an ancient major drainage line. The vegetation consists primarily of mallees, acacia thickets and shrub heaths on sandplains. The area is rich in endemic acacias (Cowan 2001).

2.3. Climate

The nearest Bureau of Meteorology weather station to Rowles Lagoon is at Coolgardie (Bureau of Meteorology 2009), which is 65 km south-southeast of Rowles Lagoon. Records have been kept at Coolgardie since 1893. Weather conditions at Rowles Lagoon would not differ appreciably from those at Coolgardie.

Coolgardie experiences a semi-arid, Mediterranean influenced climate. It receives a mean annual rainfall of 270.3 mm with the highest rainfall occurring in May and June (approximately 29 mm each) (Figure 3). Rainfall is not strongly seasonal but significant rainfall events, which recharge the wetland, are often associated with rain-bearing depressions generated by decaying tropical cyclones (Chapman 2000). Annual evaporation at Coolgardie is approximately 2,700 mm, which is ten times the annual rainfall. Temperatures peak in January with a mean daily minimum/maximum of 17 ºC/33.3 ºC and fall to 5.2 ºC/16.1 ºC in July.

Rowles Lagoon was surveyed by the IAI RCM project on the 18th of August 2008. In the six months preceding the survey, the area received approximately 150 mm of rain. The majority of this (80 mm) fell in February. No rain fell in the first eighteen days of August.

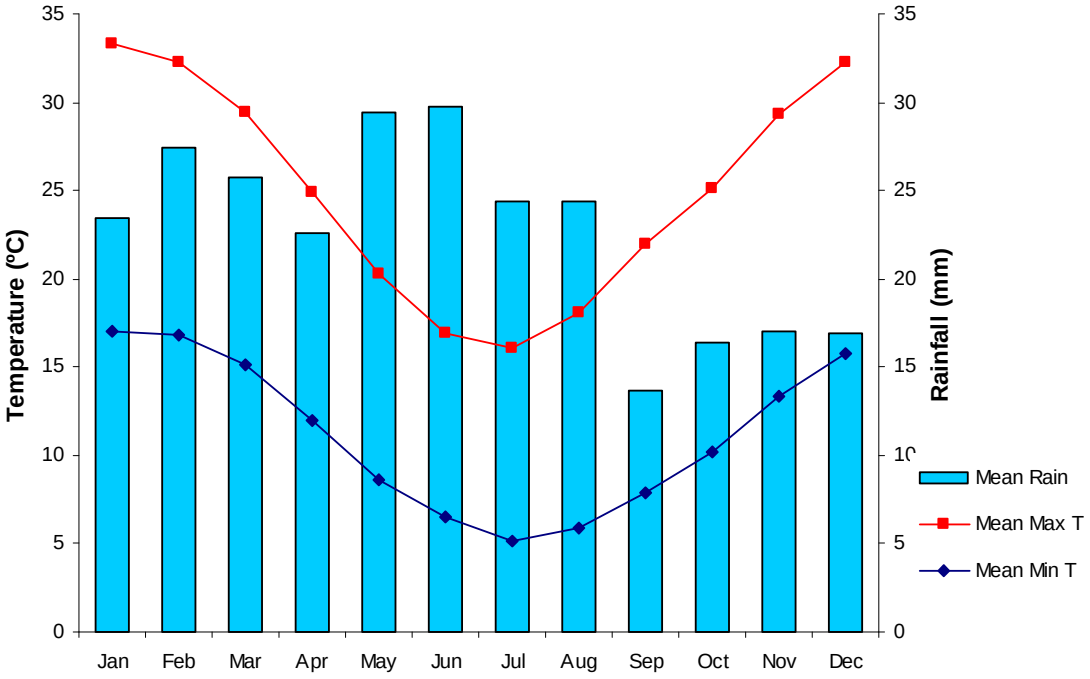

Figure 3 – Climatic averages for Coolgardie.

2.4. Wetland Type

The Directory of Important Wetlands in Australia (Environment Australia 2001) describes the Rowles Lagoon System as including:

- seasonal/intermittent freshwater lakes (>8 ha) and floodplain lakes (type B6);
- shrub swamps, shrub-dominated freshwater marsh, shrub carr, or alder thicket on inorganic soils (type B13); and
- seasonal/intermittent freshwater ponds or marshes on inorganic soils, including sloughs, potholes, seasonally flooded meadows and sedge marshes (type B10).

Rowles Lagoon itself has been described as a seasonal (possibly near-permanent) freshwater lake (Handley 1996) and is a macroscale irregular sumpland surrounded by five other mesoscale-macroscale irregular sumplands and five microscale round sumplands (Jaensch 1993).

2.5. Directory of Important Wetlands in Australia Criteria

Rowles Lagoon is designated as a wetland of national importance under criteria 1, 2 and 6 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 an important part a good example of a freshwater lake/swamp system of the temperate arid interior and probably the largest such system that is inundated regularly. It supports a teatree/lignum swamp community, which is a good example of its type and probably the largest area in the southwest of the arid interior.
2. *It is a wetland that plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex*.
6. *The wetland is of outstanding historical or cultural significance*. Its cultural significance has been recognised by being nominated for inclusion in the Register of the National Estate. The

wetland has values for passive and active recreation, nature appreciation and inspiration, as well as an historical and cultural dimension (Chapman 2000).

In addition to these criteria, Rowles Lagoon is also a drought refuge area and, after major flooding, a significant breeding area for waterbirds in the southwest of the arid interior.

2.6. Values of Rowles Lagoon

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'. It is likely that Rowles Lagoon was used by local Aboriginal people as well as European pastoralists historically for water, particularly as the Lagoon is a freshwater resource in an arid area. However, 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. Rowles Lagoon has a European historical association with the pastoral and mining industries. This includes the establishment of a boiler and steam driven pump over a well on the lakebed to pump water to the battery at Carbine mining centre, and the creation of a dam on the edge of the Lagoon for pastoral use. Fresh water from Rowles Lagoon was used to water stock (Chapman 2000). However, these are historical uses of the site and no productive use is made of it 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. Rowles Lagoon has been recognised as supporting a rich assemblage of aquatic invertebrates and waterbirds. It may also 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 Rowles Lagoon System is an ecologically important wetland of the temperate part of the arid interior. It is a good example of a freshwater lake/swamp system of the temperate arid interior. No other wetland in temperate parts of the arid interior is known to support a comparable number of species of waterbird (Handley 1996). Rowles Lagoon is a drought refuge area, and after major flooding a significant breeding area, for waterbirds in the south-west of the arid interior (Jaensch 1992).

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 Rowles Lagoon, but it is certainly valued for the amenity it provides by the local community and tourists alike. The red soils, characteristic of the arid interior, colour the waters of Rowles Lagoon red, providing spectacular views.

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 are also 'control' sites that allow us to benchmark other, altered habitats. Rowles Lagoon has potential for education of visitors and Kalgoorlie-Boulder students in aspects of wetland ecology.

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. Rowles Lagoon is used as a recreation site for water sports when the water level is adequate. It is popular with day-trippers, campers and water sport enthusiasts and is the only lake with a gazetted water ski and jet ski area in the Goldfields region. Rowles Lagoon is also a popular picnic site and lends itself well to passive recreation activities such as bird watching and bushwalking. There are good camping facilities at Rowles Lagoon, including picnic tables, toilets and designated camping sites with walk paths.

h. Spiritual/philosophical values

People's spiritual and philosophical reasons for valuing natural environments 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. It is unknown to what extent Rowles Lagoon was significant to the local Aboriginal people. There are no registered Aboriginal cultural sites within the Rowles Lagoon System. However, wetlands elsewhere in the Goldfields show signs of past traditional use (Chapman 2000).

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 Rowles Lagoon

The objective of the Rowles Lagoon 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 Rowles Lagoon'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 Rowles Lagoon.

Component	Summary description
Geomorphology	Macroscale irregular sumpland situated in the Yilgarn Craton; sandy clay lakebed
Hydrology	Inflow from creeks to southwest, highly reliant on tropical cyclones; catchment is moderately disturbed
Water Quality	Fresh (~500 µS/m); alkaline pH ~8.5
Benthic Plants	Nil
Littoral Vegetation	Teatree dominated open-scrub or open-heathland in periform arrangement; natural/impacted condition; special community: a good and large example of the tea- tree/lignum swamp community
Invertebrates	10 macroinvertebrate families recorded
Fish	Nil
Waterbirds	At least 41 species, including 8 under treaties; drought refuge and breeding area; threatened species Freckled Duck recorded here
Terrestrial Vertebrates	21 species of reptile, 1 species of frog and 5 species of native mammals

3.1. Geology and Soils

Rowles Lagoon is situated on greenstone belt bounded to the west and north by granitoid rocks and to the northeast by an extensively mineralised area, the Ora Banda Domain. Greenstone rock forms are known to be prospective for minerals such as gold and nickel. A localised granitoid sequence, the Rowles Lagoon Monzogranite is southwest of the reserves, slightly intruding into Clear and Muddy Lakes Reserve (Chapman 2000).

The lakebed is composed of lacustrine deposits of silt and clay. Sands, silts and clay occupied by fringing woodland surround Rowles Lagoon. Further from the lakebed, and occupying much of the catchment, are shallow brown alluvial loams over clay. A subdued dune line of gypseous sands is located on the east side of Rowles Lagoon. The soil there is very fragile and is a favoured warren site for rabbits (Chapman 2000).

3.2. Hydrology

Rowles Lagoon is located in the Raeside-Ponton basin, which is moderately disturbed (Jaensch 1993). As a sumpland, the lagoon's lakebed level is above the groundwater table (Chapman 2000). Surface inflow to Rowles Lagoon is from several creeks to the southwest (Jaensch 1993; Handley 1996). The lagoon is highly reliant on tropical cyclone events to sustain water levels (ABC 2004). Rowles Lagoon is described as seasonally inundated and few dry years have been recorded. The lagoon was dry in 2004 for the first time in twelve years (Jaensch 1993; Handley 1996; ABC 2004). Inundation may persist through at least one summer following episodic flooding brought by summer-autumn rain events of tropical origin, as in 1992 (Jaensch 1992).

Rowles Lagoon is the largest and deepest of all freshwater lakes in the Rowles Lagoon System. Its depth is usually less than 1 m (e.g. August 1979) but has been reported to be up to 7 m deep at times (Jaensch 1993).

3.3. Water Quality

Rowles Lagoon was moderately alkaline and fresh when sampled (Table 2). Nutrients and chlorophyll concentrations were low, indicating good water quality. The slightly elevated turbidity would have resulted from wind induced waves stirring up the clay/sand sediments. Sediments were over 91% sand and clay, with these fractions about equal. Water depth was over 70 cm.

Table 2 – Water quality parameters at Rowles Lagoon as sampled by the RCM survey.

pH	8.31
Alkalinity (mg/L)	195
TDS (g/L)	0.31
Turbidity (NTU)	220
Colour (TCU)	9
Total nitrogen (µg/L)	840
Total phosphorus (µg/L)	40
Total soluble nitrogen (µg/L)	300
Total soluble phosphorus (µg/L)	5
Chlorophyll (µg/L)	4.5
Na (mg/L)	81
Mg (mg/L)	4.2
Ca (mg/L)	11.7
K (mg/L)	5.2
Cl (mg/L)	30
SO_4 (mg/L)	16
HCO_3 (mg/L)	238
CO_3 (mg/L)	0.5

3.4. Benthic Plants

There were no benthic plants at Rowles Lagoon at the time of the IAI RCM survey in 2008. The only emergent vegetation consisted of *Melaleuca* saplings. Some algae were seen on submerged twigs. Previous records suggest the lakebed is largely devoid of vegetation when dry (Chapman 2000).

3.5. Littoral Vegetation

The vegetation fringing Rowles Lagoon is mainly teatree (*Melaleuca* sp.) dominated open-scrub or open-heathland in periform arrangement. The surrounding areas support low open-forest or open-woodland, with low shrubland or low open-woodland on the outskirts. The low-shrublands consist of lignum (*Muehlenbeckia cunninghamii*) with canegrass (*Eragrostis australasica*). This teatree/lignum swamp community is a good example of its type and is probably the largest area of this association in the southwest of the arid interior (Jaensch 1993). The ridge of gypseous sandy loam to the east of Rowles Lagoon is vegetated by characteristic grassland/herbfield with abundant annuals following good rainfall as well as grasses *Aristida contorta*, *Bromus rubens* and *Stipa scrabra* (Chapman 2000). One Priority 2 species, *Rumex crystallinus*, is known to occur in moist soil within the *Melaleuca* thicket at Rowles Lagoon, and a Priority 1 species, *Goodenia pusilliflora*, may be present, as it was recorded nearby (Chapman 2000). This species is known to occur in drier areas where water lies after rain (National Herbarium of New South Wales 2009).

Two vegetation transects were established as part of the IAI RCM survey at Rowles Lagoon on the 18th August 2008 (Table 3). Transect RCM015-R1 was located in a zone that receives

periodic inundation, whilst transect RCM015-R2 was located approximately 100 m from the water's edge in permanent fringing vegetation. The vegetation of these transects is described below. Further from the wetland, *Eucalyptus* woodland dominated the vegetation, followed by a sharp change into low saltbush-dominated plains.

The *Melaleuca* observed during the IAI RCM survey was identified as *Melaleuca phoidophylla* and this ID was confirmed by the Western Australian Herbarium (pers.comm. R. Davis). The *Melaleuca* present at Rowles Lagoon has previously been described as *Melaleuca xerophila* (Jaensch 1993). It is possible that the *Melaleuca* was originally misidentified. However, lignum (*Muehlenbeckia cunninghamii*) was not seen during the IAI RCM survey. Therefore, it is also possible that the *Melaleuca* that occurs in association with lignum is in fact *M. xerophila* and that a second species of teatree, *M. phoidophylla*, occurs elsewhere around the lake. Further investigation into this issue is required.

Table 3 – Site attributes of the vegetation transects at Rowles Lagoon.

Transect			**RCM015-R1**	**RCM015-R2**
Datum			WGS84	WGS84
Zone			51	51
Easting			294426	294425
Northing			6630791	6630697
Length			50 m	50 m
Bearing			240	255
Wetland state			Drying	Drying
Soil state (%)		dry	100	100
		waterlogged	0	0
		inundated	0	0
Substrate (%)	Observed	bare	30	50
		rock	0	0
		cryptogam	0	0
		litter	10	40
		trash	0	10
		logs	0	0
	Expected	bare	30	50
		rock	0	0
		cryptogam	0	0
		litter	20	40
		trash	10	10
		logs	0	0
Time since last fire			no evidence	no evidence
Community condition			Impacted	Natural
Upper Stratum		Cover (%)	2.12	33.98
		Height (m)	1.5	5
Mid Stratum		Cover (%)	<10	<1
		Height (m)	0.5	<0.5
Ground Cover		Cover (%)	62.56	-
		Height (m)	<0.3	-

Transect RCM015-R1

Transect RCM015-R1 was established adjacent to the water's edge in a zone that receives periodic inundation (Figure 4). The soil surface was dry at the time of survey. Vegetation was dominated by *Melaleuca phoidophylla* tall sparse shrubland (2.1% cover, 1.5 m tall) over *Glycyrrhiza acanthocarpa* low sparse shrubs (<10% cover, 0.5 m tall) over *Trigonella suavissima*, *Pterochaeta paniculata*, *Cucumis myriocarpus* low herbs (62.6% cover, <0.2 m tall).

All *M. phoidophylla* plants along the transect were young with no evidence of stumps or stags to suggest previous survival of mature plants, though large plants dominated the vegetation further from the lake edge (Transect RCM015-R2). Most *G. acanthocarpa* plants in the mid-stratum were dead at the time of survey.

Four species of weeds were recorded along transect RCM015-R1 (Table 4). Stock trampling was evident in some parts of this vegetation zone. The overall community condition was considered 'impacted' (Table 10 in Appendix 1).

Figure 4 – Rowles Lagoon vegetation transect RCM015-R1.

Table 4 – Plant taxa recorded along vegetation transect RCM015-R1 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Melaleuca	*phoidophylla*	2	U1	Shrub
Glycyrrhiza	*acanthocarpa*	0.5	M1	Shrub
? Pterochaeta	*paniculata*	0.05	G1	Forb
Trigonella	*suavissima*	0.03	G1	Forb
** Cucumis*	*myriocarpus*	0.05	G1	Forb
** Salvia*	*verbenaca*	0.2	G1	Forb
** Carrichtera*	*annua*	0.4	G1	Forb
Swainsona	*canescens*	0.1	G1	Forb
Eragrostis	*dielsii*	0.02	G1	Grass
** Erodium*	*cicutarium*	0.02	G1	Forb

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):

U1+ ^*Melaleuca phoidophylla*\^shrub\3\r; M1 *Glycyrrhiza acanthocarpa*\shrub\1\r; ^*Trigonella suavissima*, ?*Pterochaeta paniculata, *Cucumis myriocarpus*,**Salvia verbenaca*, **Carrichtera annua*, *Swainsona canescens*\forb\1\c.

Transect RCM015-R2

Transect RCM015-R2 was established approximately 100 m from the water's edge (Figure 5). The vegetation of transect RCM015-R2 was dominated by *Melaleuca phoidophylla* very tall open shrubland (34% cover, 4-5 m tall). *Maireana* sp. low isolated plants comprised the understorey (Table 5).

This vegetation community was long undisturbed with no evidence of recent fire or significant flooding event. Occasional stock tracks were the only observed disruption to the community. Most of the *M*. *phoidophylla* plants were mature, though young plants were scattered throughout the community as evidence of ongoing recruitment for this species. Overall community condition was considered 'natural' (Table 10 in Appendix 1).

Figure 5 – Rowles Lagoon vegetation transect RCM015-R2.

Table 5 – Plant taxa recorded along Rowles Lagoon vegetation transect RCM015-R2 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Melaleuca	*phoidophylla*	5	U1	Shrub
Maireana	sp.	0.3	G1	Chenopod

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).

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

U1+ ^*Melaleuca phoidophylla*\^shrub\4\i; *Maireana* sp.\chenopod shrub\1\bi.

3.6. Aquatic Invertebrates

No previous aquatic invertebrate sampling has been conducted at Rowles Lagoon (Chapman 2000). The IAI RCM survey sampled three habitats within Rowles Lagoon in August 2008:

1. *Melaleuca* saplings
2. Bare Sediment
3. Bare Sediment

A total of twenty macroinvertebrate species (Table 6), belonging to eleven families, was collected by the survey. There has been little aquatic biodiversity survey work undertaken in the Goldfields against which to compare the richness and composition of the aquatic invertebrates from this wetland. However, the twenty species collected is close to the average (twenty-two species) collected from freshwater basins in the Carnarvon Basin by Halse *et al*. (2000).

There were no annelids, molluscs, water mites or representatives from several insect families (including mayflies), but most of these groups tend to be particularly intolerant of drying and have poor dispersal abilities. Some molluscs would have been expected. If the wetland becomes saline as it dries, this would also eliminate these groups. The fairy shrimp *Branchinella simplex* (which is tolerant of mild salinity) has not been collected frequently and there are only eight other records from Western Australia, mostly in the Goldfields but also two from the Wheatbelt. Other species are common and widespread and mostly southern fauna.

Table 6 – Aquatic macroinvertebrates recorded from Rowles Lagoon in August 2008.

Class	Order	Family	Lowest ID	Sample*
Crustacea	Anostraca	Thamnocephalidae	*Branchinella simplex*	1,2,3
	Conchostraca	Cyzicidae	*Caenestheriella packardi*	1
Insecta	Coleoptera	Haliplidae	*Haliplus* sp.	2
		Dytiscidae	*Allodessus bistrigatus*	1
			Sternopriscus multimaculatus	1,2
			Dytiscidae	3
		Hydrophilidae	*Berosus macumbensis*	2,3
			Berosus nutans	1
			Enochrus elongatus	1
			Limnoxenus zelandicus	1
	Diptera	Ceratopogonidae	*Bezzia* sp.	1,2,3
			Culicoides sp.	1,3
			Nilobezzia sp.	3
	Hemiptera	Corixidae	*Sigara* sp.	1
			Agraptocorixa parvipunctata	1,3
			Agraptocorixa sp.	2
			Micronecta robusta	1
			Micronecta gracilis	1,2,3
		Notonectidae	*Anisops hyperion*	1,2,3
			Notonectidae sp.	2
	Odonata	Lestidae	*Austrolestes annulosus*	2,3
		Hemicorduliidae	*Hemicordulia tau*	3
			Zygoptera	2
	Trichoptera	Leptoceridae	*Oecetis* sp.	2,3

* Numerals indicate habitats sampled as listed above.

3.7. Fish

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

3.8. Waterbirds

The Rowles Lagoon System is considered a 'conservation island' because it provides a freshwater refuge in an otherwise arid region. The lakes are a drought refuge and, after flooding, provide a significant breeding area for waterbirds in the southwest of the arid interior. Several bird species that utilise the system are considered rare in inland areas.

The Rowles Lagoon System supports at least forty-one species of waterbirds, including eight protected by international treaties. No other wetland in temperate parts of the arid interior is known to support a comparable number of species of waterbird (Jaensch 1993). Migrant shorebirds regularly use the area briefly before continuing south and east (Handley 1996).

Freckled Ducks have been recorded from Rowles Lagoon and the surrounding lakes. They are a nationally threatened species and Australia's rarest waterbird. The Freckled Duck inhabits open lakes and wetlands surrounded by thick vegetation, and, in particular, swamps in which lignum grow - habitats characteristic of the Rowles Lagoon System. A significant sighting of 85-90 individuals was recorded in August 1993 (Jaensch 1993; Handley 1996).

The dense thickets of *Melaleuca* sp. found at Rowles Lagoon provide ideal nesting sites for many of the sixteen species of waterbirds that breed within the wetland system, including Freckled Ducks (Table 7). Hoary-headed Grebe, Pink-eared Duck and Eurasian Coot breed at Rowles Lagoon regularly. When water levels are high, as in November 1992, the areas most favoured by waterfowl are the inundated woodlands/shrublands some distance from the open water of Rowles Lagoon (Jaensch 1993).

Other species recorded within the Rowles Lagoon System include Marsh Harrier (*Circus aeruginosus*), Australian Crake (*Porzana fluminea*) and Silver Gull (*Larus novaehollandiae*), as well as the migrant shorebird species Grey Plover (P*luvialis squatarola*), Black-tailed Godwit (*Limosa limosa*) and Ruddy Turnstone (*Arenaria interpres*). All of these species, though widespread in temperate areas, are rare in the arid interior and immediately adjacent parts of south-western Australia (Jaensch 1993).

Seven species of waterbirds were observed at Rowles Lagoon during the 2008 IAI RCM survey (Table 7). One of these species was unidentified (grebe species). Two of the species, Common Sandpiper (*Actitis hypoleucos*) and Pacific Black Duck (*Anas superciliosa*), though not previously recorded specifically at Rowles Lagoon, have been observed at Clear and Muddy Lakes Reserves, within the Rowles Lagoon System. The remaining four species have all previously been sighted at Rowles Lagoon.

Table 7 – Waterbirds observed at Rowles Lagoon (numbers in parentheses indicate abundance).

Organisation/Project **Duration of project**		**DEC** **1973 - 1989**	**DEC/RCM** **18/08/2008**
Common name	**Latin name**		
Australasian Grebe	*Tachybaptus novaehollandiae*	✓	
Australasian Shoveler	*Anas rhynchotis*	✓	
^ Australian Shelduck	*Tadorna tadornoides*	✓	✓ (45)
^ Australian Wood Duck	*Chenonetta jubata*	✓	
Banded Lapwing	*Vanellus tricolor*	✓	
Black-fronted Dotterel	*Elseyornis melanops*	✓	
Black-winged Stilt	*Himantopus himantopus*	✓	
Black-tailed Native Hen	*Gallinula ventralis*	✓	

Organisation/Project Duration of project		DEC 1973 - 1989	DEC/RCM 18/08/2008
Common name	**Latin name**		
^ Black Swan	*Cygnus atratus*	✓	
Blue-billed Duck	*Oxyura australis*	✓	
* Common Greenshank	*Tringa nebularia*	✓	
Common Sandpiper	*Actitis hypoleucos*		✓
^ Eurasian Coot	*Fulica atra*	✓	✓ (19)
^ Freckled Duck	*Stictonetta naevosa*	✓	✓ (1)
* Glossy Ibis	*Plegadis falcinellus*	✓	
Great Crested Grebe	*Podiceps cristatus*	✓	
* Great Egret	*Egretta alba*	✓	
^ Grey Teal	*Anas gracilis*	✓	✓ (8)
Hardhead	*Aytha australis*	✓	
^ Hoary-headed Grebe	*Poliocephalus poliocephalus*	✓	
Little Black Cormorant	*Phalacrocorax sulcirostris*	✓	
Little Pied Cormorant	*Phalacrocorax melanoleucos*	✓	
^ Musk Duck	*Biziura lobata*	✓	
^ Pacific Black Duck	*Anas superciliosa*		✓ (55)
^ 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*	✓	
Straw-necked Ibis	*Threskiornis spinicollis*	✓	
Unidentified Grebe			✓ (29)
^ White-faced Heron	*Egretta novaehollandiae*	✓	
White-necked Heron	*Ardea pacifica*	✓	
^ Yellow-billed Spoonbill	*Platalea flavipes*	✓	

* Listed under Migratory Bird Agreements JAMBA, CAMBA and ROKAMBA
^ Recorded breeding

3.9. Terrestrial Vertebrates

Twenty-one species of reptile and one frog have been recorded from the Rowles Lagoon System (Chapman 2000). The skink, *Morethia adelaidensis*, is at the western limit of its range at Rowles Lagoon, usually occurring on the Nullarbor Plain (Chapman 2000).

The mammal fauna of the system is depauperate, with only five species of native mammal recorded from the system (Chapman 2000). This is due to the limited availability of terrestrial macrohabitats. The flooding-drying cycle of the system's lakes causes rapid tree deaths and regeneration, and periodic weed invasions. Such variable vegetation composition is tolerated by highly mobile species, such as waterbirds, but mammals prefer more stable conditions. The effects of past grazing by sheep and cattle and the high numbers of introduced fauna that are present are also likely to limit opportunities for native mammals (Chapman 2000).

Seven introduced mammas species have been recorded at Rowles Lagoon. Cattle tracks, and rabbit tracks and scats were observed during the 2008 IAI RCM survey. Rabbits have been noted to favour the gypsum dunes on the east side of Rowles Lagoon as a warren site (Chapman 2000).

4. Interactions between Ecological Components at Rowles Lagoon

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 Rowles Lagoon 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; and
- the site's outstanding historical and cultural significance.

Table 8 summarises the interactions between key components and processes at Rowles Lagoon. 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 Rowles Lagoon 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 Fire regime Water quality Soils and sediments	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Grazing by stock and introduced pest animals Siltation Soil erosion Weeds Predation of fauna
Ecosystem Service Value It is a good example of a wetland type occurring within a biogeographic region in Australia	Freshwater lake/swamp system that is inundated regularly	Vegetation communities	Geomorphology of the Lagoon and surrounding wetlands Hydrological regime Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Grazing by stock or introduced pest animals Soil erosion Siltation Weeds
Ecosystem Service Value It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex	Rowles Lagoon basin – a drought refuge	Vegetation communities Aquatic invertebrates	Soils and sediments Hydrological regime Geomorphology of the Lagoon and surrounding wetlands Habitat extent and distribution	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Grazing by cattle or introduced pest animals Erosion Weeds Loss of migratory bird populations due to offsite factors

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	**Abiotic**	
Recreational Value Bird watching Bushwalking Camping Sailing Swimming Water/jet skiing Canoeing Picnicking	Landscape amenity Waterbird populations Vegetation communities Significant flora Significant fauna	Invertebrate populations and phytoplankton Vegetation communities	Geomorphology of the Lagoon and surrounding wetlands Hydrological regime Water quality Soils and sediments	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Grazing by stock and introduced pests Excessive nutrient inputs from stock Siltation Erosion Weeds Predation by introduced fauna Loss of migratory bird populations due to offsite factors
Cultural Value The wetland is of outstanding historical or cultural significance	Geomorphology of lake and surrounds Association with early pastoral industry Vegetation communities Waterbird communities Landscape amenity	Flora and fauna populations Pollinators and food sources for above	Geomorphology of the Lagoon and surrounding wetlands Hydrological regime Water quality Soils and sediments	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Grazing by stock and introduced pests Excessive nutrient inputs from stock Weeds Siltation Predation by introduced fauna Loss of migratory bird populations due to offsite factors Erosion

5. Threats to the Ecology of Rowles Lagoon

The ambition for management at Rowles Lagoon 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 freshwater lake/swamp system of the temperate arid interior, support the unusual teatree/lignum plant community, and make the lagoon a 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 plant 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. These are the same as the above listed influences on the primary determinants of ecological character, with the addition of landscape amenity.

Threats to Rowles Lagoon must be considered in relation to their likelihood of causing failure of the above management goal for the lake. An assessment of each threatening process was conducted to assess the probability that goal failure would result as a consequence of each particular threatening process. The results of this assessment are presented in Table 9. In summary, failure to achieve the management goal for Rowles Lagoon is most likely to result due to the impacts of feral animals (including stray stock) and recreation. If further development of the mining industry occurs in the area, this also has the potential to significantly affect Rowles Lagoon. Weeds, altered hydrology and climate change should also be considered. The Rowles Lagoon System has been classified as in fair condition (recovery requires significant management intervention), but its condition trend is static (Cowan 2001).

The key issues for future management of Rowles Lagoon Conservation Park and Clear and Muddy Lakes Nature Reserve, as identified by the management plan (Chapman 2000) are to:

- implement inter-agency catchment management for wetlands;
- provide further interpretative information on wetland values, systems and processes; and
- manage recreational pressures, particularly when Rowles Lagoon contains water.

Feral animals and stock

Rowles Lagoon Conservation Park and Clear and Muddy Lakes Nature Reserves have the unfortunate distinction of being the only reserves in the Goldfields Region for which the number of introduced species of mammals (including stock) exceeds the number of recorded species of native mammals (Chapman 2000). Introduced animals present at Rowles Lagoon include goats, rabbits, cats, foxes and bees. Feral cats and rabbits have been recorded in particularly high numbers. Domestic stock (sheep and cattle) may also stray into the conservation park if fencing is inadequate or damaged by floods. Feral animals may have a detrimental effect on vegetation, habitat and both vertebrate and invertebrate native fauna (Chapman 2000). Siltation of Rowles Lagoon may also occur as a result of overgrazing and the resulting loss of vegetation and soil (Jaensch 1993; DEWHA 1995). Soil erosion was certainly observed during the IAI RCM survey. Signs of impacts caused by rabbits and of cattle faeces and tracks were also recorded. Faeces originating from stock have the potential to cause eutrophication of the water body and may result in algal blooms, aquatic vegetation death, and fish kills (Chapman 2000). On a broader scale, the catchment is moderately disturbed by grazing which may have downstream effects. Some management measures have been undertaken by the owners of the neighbouring Credo pastoral lease by fencing the tributary to Rowles Lagoon (Jaensch 1992).

Recreation

Rowles Lagoon is used for waterskiing, power boating, canoeing, windsurfing, sailing, swimming and various passive recreational activities. Waterskiing has the potential to cause damage to the ecosystem of Rowles Lagoon, although the activity occurs sporadically and away from the waterbird breeding areas (Jaensch 1993; DEWHA 1995). The Rowles Lagoon System has been

previously disturbed by waterskiing and other recreational use (DEWHA 2009). The use of motorised boats and jet skis also introduces the risk of input of pollutants into the lagoon (Chapman 2000). The effects of recreational usage of Rowles Lagoon were evident from car tracks and some rubbish sighted during the IAI RCM survey.

Fire

Rowles Lagoon is a popular camping and recreation area. It is usual for campers to light open fires for cooking and warmth. There is a risk of fire escaping and affecting the vegetation of the area. Usually, there is little understorey to sustain a fire and areas of non-flammable succulent steppe separate the individual lakes. However, inundation of the lake may see a co-occurrence of annual grass growth and high levels of recreational usage of the site. This creates a situation in which the spread of wildfire is more likely.

Altered water regime

There have been historical changes to the hydrology of Rowles Lagoon, with the installation of a pump on the lakebed in 1915. Although there is insufficient data to determine the natural hydrological state of the wetland, it is likely inundation events have increased in frequency and duration as a result of surrounding pastoral practices. The loss of vegetation due to grazing is thought to have increased runoff from these areas. Rowles Lagoon shows evidence of past impacts of flooding. Excessive inundation has caused tree death. Too frequent and prolonged inundation may cause further vegetation death and limit recruitment.

Weeds

Weeds are identified as one of the threatening processes to the ecology of Rowles Lagoon (DEWHA 2009). The declared weed, Bathurst Burr (*Xanthium spinosum*) has been recorded in the Rowles Lagoon Conservation Park and Clear and Muddy Lakes Nature Reserves. Environmental weeds Saffron Thistle (*Carthamus lanatus*), Southern Liquorice (*Glycyrrhiza acanthocarpa*), Brom Grass (*Bromus rubens*) and *Solanum nigram* have also been recorded. Control programs for these weeds were implemented following the release of the management plan (Chapman 2000). While these weeds were not observed during the IAI RCM survey, four other introduced plant species were recorded: prickly paddy melon (*Cucumis myriocarpus*), wild sage (*Salvia verbenaca*), Ward's weed (*Carrichtera annua*), and common storksbill (*Erodium cicutarium*). Further vegetation surveys would be required to determine if the aforementioned declared and environmental weeds are still present within the conservation park.

Mining

While there are no mines currently operating in the near vicinity of Rowles Lagoon, the wetland lies within a prospective area for mineral extraction and exploration activities have occurred within the conservation park (Chapman 2000). A gold mine has been proposed by the Tropicana Joint Venture, east of Rowles Lagoon, on tenements covering 13,000 km^2 (Figure 6). The Environmental Impact Assessment process for this is expected to be completed in 2010. It is unknown if, or how, such catchment disturbance may affect the hydrology of Rowles Lagoon. Mining activities could introduce threats such as pollution from inflow water containing leachate from mine sites as well as changes to the present groundwater regime (Jaensch 1993; Chapman 2000). Groundwater in the area is saline to hypersaline. There is anecdotal evidence that the groundwater table lies not far beneath Rowles Lagoon. Therefore, there is potential for mining activities such as groundwater abstraction to de-stabilise the present groundwater regime (Chapman 2000).

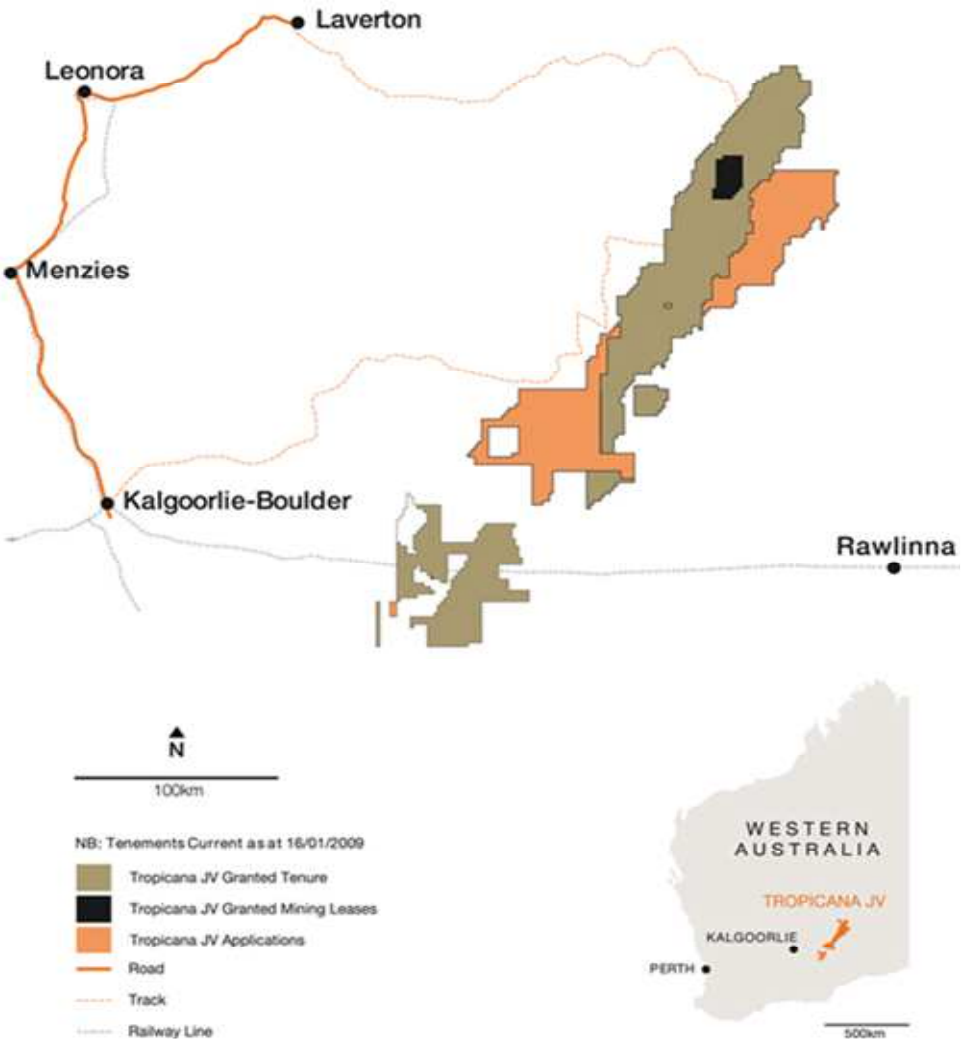

Figure 6 – Location of the mining tenements proposed for the Tropicana Joint Venture gold mine (AngloGold Ashanti Australia Ltd and Independence Group NL 2009).

Climate Change

Climate change should also be considered as a potential threatening process. Temperature has been rising in WA by about 0.1 ˚C per decade since 1910 and this trend is expected to continue. Annual rainfall is also expected in increase in inland Australia, including the Goldfields region. This is expected to occur as a consequence of an increased frequency extreme rainfall events (EPA 2007). It is possible that an increase in heavy rainfall events could result in more frequent and longer periods of inundation. A higher inflow of water may be partially offset by an increase in evaporation associated with higher temperatures. It is unclear how climate change may affect the ecology of the lake, and this should be closely monitored. Given the impacts of previous flooding, climate change could potentially significantly degrade the vegetation of Rowles Lagoon.

Table 9 – Threat assessment for Rowles Lagoon.

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 Rowles Lagoon, thus ensuring it retains characteristic plant communities, 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	0	There have been historical changes to the hydrology of Rowles Lagoon, with the installation of a pump on the lakebed in 1915. Although there is insufficient data to determine the natural hydrological state of the wetland, it is likely inundation events have increased in frequency and duration as a result of surrounding pastoral practices.
	Carbon cycle and climate change	5	5	Temperature and annual rainfall are both expected to increase. Extreme rainfall events are also expected to be more frequent. This may result in longer and more frequent inundation of Rowles Lagoon. This could cause further tree death and an overall decline in vegetation.
Impacts of introduced plants and animals	Weeds	5	1	Weeds are identified as one of the threatening processes to the ecology of Rowles Lagoon. A declared weed and several environmental weeds have been recorded in Rowles Lagoon Conservation Park and Clear and Muddy Lakes Nature Reserves. These were not recorded during the RCM survey. However, four other species of weeds were identified.
	Herbivory, wallowing and trampling by introduced species	10	5	Significant impacts of grazing are evident. Cattle faces and tracks were also present. Overgrazing and stock access may result in vegetation loss, soil erosion, and siltation of the waterbody. While fencing is present, there is evidence stock are still accessing the wetland.
Impacts of problem native species	Overgrazing by native species	0	0	No impacts evident.
Impacts of disease	Plant pathogens	0	0	No impacts evident.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Detrimental regimes of physical disturbance events	Fire regimes	10	5	Wildfire in the Goldfields is a relatively infrequent event, due to the generally low flammability and sparseness of vegetation. However, fire control is an important component of management because recovery from fire is slower than in wetter areas and plants generally are not as well adapted to fire. The risk of wildfire is elevated at Rowles Lagoon as episodic high rainfall events, which increase the fire risk by increasing plant growth, also coincide with a high rate of recreational use of the conservation park. Unlike elsewhere in the Goldfields, there are no plans for prescribed burning. There is also no peripheral or internal system of fire breaks (Chapman 2000).
	Drought	1	1	Climate change projections for inland Australia show an increase in rainfall. Therefore, drought is unlikely to affect Rowles Lagoon.
	Flood	5	2	Rowles Lagoon shows evidence of past impacts of flooding. Excessive inundation has caused tree death. Too frequent and prolonged inundation may cause further vegetation death and limit recruitment.
Impacts of pollution	Herbicide, pesticide or fertiliser use and direct impacts	0	0	Pastoralism usually does not make use of such chemical and, at present, no intensive agriculture or broadscale cropping is practiced in the catchment.
Impacts of competing land uses	Recreation management	20	0	Rowles Lagoon received high levels of recreational usage, including waterskiing and power boating. Such activities have the potential to disturb waterbirds and also provide a means of input of pollutants into the waterbody. A management plan is in place (DEWHA 1995; Chapman 2000).
	Nutrient enrichment of water body	5	0	It is likely that cattle accessing the lake will result in nutrient enrichment of the water body.
	Urban and industrial development	0	0	It is unlikely there will be industrial or urban development near Rowles Lagoon in the near future.
	Consumptive uses	0	0	There is no evidence of current consumptive use of Rowles Lagoon
	Illegal activities	1	0	Tyre tracks and rubbish were observed at Rowles Lagoon.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
	Mines and quarries	5	0	No mines are operating in immediate vicinity. However, Rowles Lagoon lies within a prospective area for minerals and exploration has occurred in the past. Several mines exist in the area and catchment disturbance may affect the hydrology of Rowles Lagoon, but it is unknown how.
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	1	1	Rowles Lagoon is connected to extensive areas of natural or near-natural environment. Populations are likely to 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 for Future Monitoring

The primary knowledge gap identified during this project is that Rowles Lagoon had not been previously sampled for aquatic invertebrates. This is a significant data gap in terms of wetland ecology and needs to be addressed through repeated surveys over several seasons. This would allow the limited data collected by the IAI RCM project to be expanded to include the full suite of invertebrates and seasonal trends in community composition to be captured.

Repeated vegetation surveys are also highly recommended. The teatree sampled during the IAI RCM survey was identified as *Melaleuca phoidophylla* and this was confirmed by the Western Australian Herbarium (pers.comm. R. Davis). The teatree present at Rowles Lagoon has previously been described as *Melaleuca xerophila* (Jaensch 1993). It is possible that the teatree was originally misidentified. However, it is also possible that *M. xerophila* occurs elsewhere around the lake, away from the IAI RCM sampling site. Further investigation into this issue is required. An extensive vegetation survey of the wetland would be of benefit. Further vegetation survey would also help determine if the previously recorded declared and environmental weeds are still present within the conservation park.

If mining is to be conducted in the area, a thorough study of Rowles Lagoon's hydrology, including interactions with groundwater, may also be required.

References

ABC. (2004) Lagoon dries up for first time in years. In *ABC News*.

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

Chapman, A. (2000) *Rowles Lagoon Conservation Park and Clear and Muddy Lakes Nature Reserve Management Plan 2000-2010*. Prepared by the Department of Conservation and Land Management for the National Parks and Nature Conservation Authority Perth, Australia.

Cowan, M. (2001) Coolgardie 3 (COO3 – Eastern Goldfields 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.

DEWHA. (1995) Rowles Lagoon System, Coolgardie, WA, Australia. In *Australian Heritage Database*. Department of Environment, Water, Heritage and the Arts. Accessed on 26 February 2009.

DEWHA. (2009) Australian Natural Resources Atlas: Biodiversity Assessment - Coolgardie. Department of Environment, Water, Heritage and the Arts. <http://www.anra.gov.au/topics/vegetation/assessment/wa/ibra-coolgardie.html> Accessed on 18 April 2009.

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.

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., R. J. Shiel, et al. (2000). "Aquatic invertebrates and waterbirds of wetlands and rivers of the southern Carnarvon Basin, Western Australia." *Records of the Western Australian Museum.* Supplement No. **61**: 217-265.

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

Jaensch, R. P. (1992) Rowles Lagoon System - WA015. In *Australian Wetlands Database*. Department of Environment, Heritage and the Arts. Accessed on 26 February 2009.

Jaensch, R. P. (1993) Rowles Lagoon System - WA015. In *Australian Wetlands Database*. Department of Environment, Heritage and the Arts. Accessed on 26 February 2009.

National Herbarium of New South Wales (2009) Australian Virtual Herbarium - *Goodenia pusilliflora <http://pngplants.org/web2printer/web2printer4.phpimg=0&lnk=3&style=/style.css>* Accessed on 27 July 2009

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.

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.

Appendix 1 – Vegetation Condition

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

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

Plant specimens submitted to the Western Australian Herbarium:
Melaleuca phoidophylla (RCM015-R1-04)
Trigonella suavissima (RCM015-R1-02)

Table 11 – Herbarium Records for Rowles Lagoon.

Search Coordinates: NW corner 30°23'48"S, 120°48'5 7"E; SE corner 30°27'18"S, 120°52'52"E

Family	Genus	Species	Rank	Infraspecies	Alien	Cons. Status
Amaranthaceae	*Ptilotus*	*exaltatus*	var.	*villosus*		
		gaudichaudii				
		holosericeus				
Asteraceae	*Angianthus*	*tomentosus*				
	Asteridea	*athrixioides*				
	Brachyscome	*ciliaris*				
	Centipeda	*crateriformis*	subsp.	*crateriformis*		
	Chthonocephalus	sp.				
	Erymophyllum	*ramosum*	subsp.	*ramosum*		
	Gnephosis	sp.				
	Kippistia	*suaedifolia*				
	Oligocarpus	*calendulaceus*			Y	
	Podolepis	*capillaris*				
	Rhodanthe	*chlorocephala*				
		floribunda				
	Sonchus	*oleraceus*			Y	
	Trichanthodium	*skirrophorum*				
	Vittadinia	*eremaea*				
	Waitzia	*acuminata*				
Boraginaceae	*Heliotropium*	*curassavicum*				
Casuarinaceae	*Casuarina*	sp.				
Chenopodiaceae	*Atriplex*	*acutibractea*				
		lindleyi	subsp.	*inflata*		
		pumilio				
		semibaccata				
	Chenopodium	*nitrariaceum*				
	Dissocarpus	*paradoxus*				
	Maireana	*brevifolia*				
		pyramidata				
		radiata				
		sp.				
		triptera				
	Rhagodia	*spinescens*				
	Sclerolaena	*cuneata*				

Family	Genus	Species	Rank	Infraspecies	Alien	Cons. Status
Chenopodiaceae	*Sclerolaena*	*diacantha*				
		patenticuspis				
Convolvulaceae	*Convolvulus*	*remotus*				
Cuscutaceae	*Cuscuta*	*australis*				
Cyperaceae	*Isolepis*	*marginata*			Y	
Geraniaceae	*Erodium*	*cicutarium*			Y	
Goodeniaceae	*Goodenia*	*pinnatifida*				
Haloragaceae	*Haloragis*	*trigonocarpa*				
Juncaceae	*Juncus*	*aridicola*				
Loranthaceae	*Lysiana*	*exocarpi*	subsp.	*exocarpi*		
Lythraceae	*Lythrum*	*wilsonii*				
Malvaceae	*Abutilon*	*malvifolium*				
		oxycarpum				
	Lawrencia	*squamata*				
	Sida	*intricata*				
Marsileaceae	*Marsilea*	*hirsuta*				
Myoporaceae	*Eremophila*	*scoparia*				
Myrtaceae	*Eucalyptus*	*aequioperta*				
		cylindrocarpa				
		myriadena				
	Melaleuca	sp.				
Papilionaceae	*Glycyrrhiza*	*acanthocarpa*				
	Swainsona	*canescens*				
		sp.				
Plantaginaceae	*Plantago*	*drummondii*				
Poaceae	*Aristida*	*contorta*				
	Austrostipa	*scabra*				
	Bromus	*rubens*			Y	
	Chloris	*truncata*				
	Eragrostis	*australasica*				
		dielsii				
		setifolia				
	Genus	sp.				
	Rostraria	*cristata*			Y	
Polygonaceae	*Muehlenbeckia*	*florulenta*				
	Polygonum	*plebeium*				
	Rumex	*crystallinus*				P2
Solanaceae	*Solanum*	*hoplopetalum*				
		nigrum			Y	
Zygophyllaceae	*Zygophyllum*	*billardierei*				
		eremaeum				

Appendix 3 – Fauna Museum Records

Table 12 – Western Australian Museum records for fauna collected within 5 km of Rowles Lagoon (WA Museum 2009).

Accession ID/s	Scientific Name	Common Name	Year/s
R126585, R126593	*Cryptoblepharus plagiocephalus*	Fence Skink	1993, 1995
R120034, R126488, R126588	*Ctenotus leonhardii*	Leonhardi's Ctenotus	1994, 1995
R126596	*Delma australis*	Marble-faced Delma	1995
R26317	*Diplodactylus granariensis*	Wheat-belt Stone Gecko	
R18	*Diplodactylus pulcher*	Fine-faced Gecko	1993
R126563, R126576	*Egernia formosa*	Goldfields Crevice-skink	1995, 1996
R126562	*Gehyra purpurascens*	Purplish Dtella	1995
R126572, R126575, R126586, R126587	*Gehyra variegata*	Tree Dtella	1995
R126571, R135788, R135831, R135861, R135874	*Heteronotia binoei*	Bynoe's Gecko	1993, 1995
R126590, R126591, R126597, R126598	*Lerista muelleri*	Wood Mulch-slider	1996
R126565, R126569	*Lerista picturata*	Southern Robust Slider	1995
R126589, R126592, R126594	*Menetia greyii*	Common Dwarf Skink	1995
R120041, R120042, R126567, R126568, R126574	*Morethia adelaidensis*	Saltbush Morethia Skink	1994, 1995
R126570, R126573	*Morethia butleri*	Woodland Morethia Skink	1995
R30	*Neelaps bimaculatus*	Black-naped Snake	1995
R126467, R127340, R127341	*Neobatrachus kunapalari*	Kunapalari Frog	1995, 1996
R31	*Pseudonaja nuchalis*	Western Brown Snake	1993
R27	*Ramphotyphlops australis*	Southern Blind Snake	1993
R26	*Ramphotyphlops bituberculatus*	Prong-snouted Blind Snake	1993
R120040, R126566	*Rhynchoedura ornata*	Beaked Gecko	1994, 1995
R28	*Simoselaps bertholdi*	Jan's Banded Snake	1993
R126595	*Strophurus wellingtonae*	Western Shield Spiny-tailed Gecko	1995
R13, R14	*Underwoodisaurus milii*	Thick-tailed Gecko	1993
R68886, R100238	*Varanus gouldii*	Gould's Goanna	1987