Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for a Significant Western Australian Wetland

Lake Wooleen and Yewlands Pool

2008

Figure 1 – Yewlands Pool on Wooleen station.

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Contents

1. Introduction

This Resource Condition Report (RCR) was prepared by the Inland Aquatic Integrity Resource Condition Monitoring project (IAI RCM). It considers the ecological character and condition of Lake Wooleen, a floodplain lake on the Roderick River.

Lake Wooleen 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). Lake Wooleen is significant because it provides habitat for large numbers of waterbirds and a drought refuge for fauna.

At the time of the IAI RCM survey, Lake Wooleen was dry. Therefore, the water quality and aquatic invertebrate data reported here come from Yewlands Pool, a small pool on a creek line at the southern end of the lake system.

1.1. Site Code

Directory of Important Wetlands in Australia: WA061.

Inland Aquatic Integrity Resource Condition Monitoring Project: RCM021.

1.2. Purpose of Resource Condition Report

This RCR provides a summary of information relevant to the ecology of Lake Wooleen. 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 gauging the effectiveness of management planning and actions on the property.

1.3. Relevant Legislation and Policy

The following is a summary of legislation and policy that are relevant to the management of Lake Wooleen.

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 Wooleen because the site is a significant stop-over for migrating 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;

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 Wooleen: migratory species listed under international treaties. Nationally listed threatened flora, fauna and ecological characters are also protected under the EPBC Act and it is possible that some of these may occur at Lake Wooleen.

Western Australia state policy

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 provides protection for flora and fauna within reserve systems.

Aboriginal Heritage Act 1972

The purpose of this Act is to protect Aboriginal remains, relics and sites from undue interference, and to recognise the legitimate pursuit of Aboriginal customs and traditions. Under the Act, it is an offence for a person to excavate, destroy, damage or alter any Aboriginal site. The Act applies to all objects which are of sacred, ritual or ceremonial significance to persons of Aboriginal descent, or which are or were used for any purpose connected with the traditional cultural life of the Aboriginal people and the places where such objects are found. It also protects any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent. Finally, the Act states that, where a representative body of persons of Aboriginal descent who usually live subject to Aboriginal customary law has an interest in a place, that place shall be available to that body for purposes sanctioned by the Aboriginal tradition relevant to that place.

Land Administration Act 1997

Part 7 of the *Land Administration Act* provides the current legislative basis for the granting and administration of pastoral leases over State land in Western Australia. It also provides for the establishment of a Pastoral Lands Board to oversee the administration of such leases.

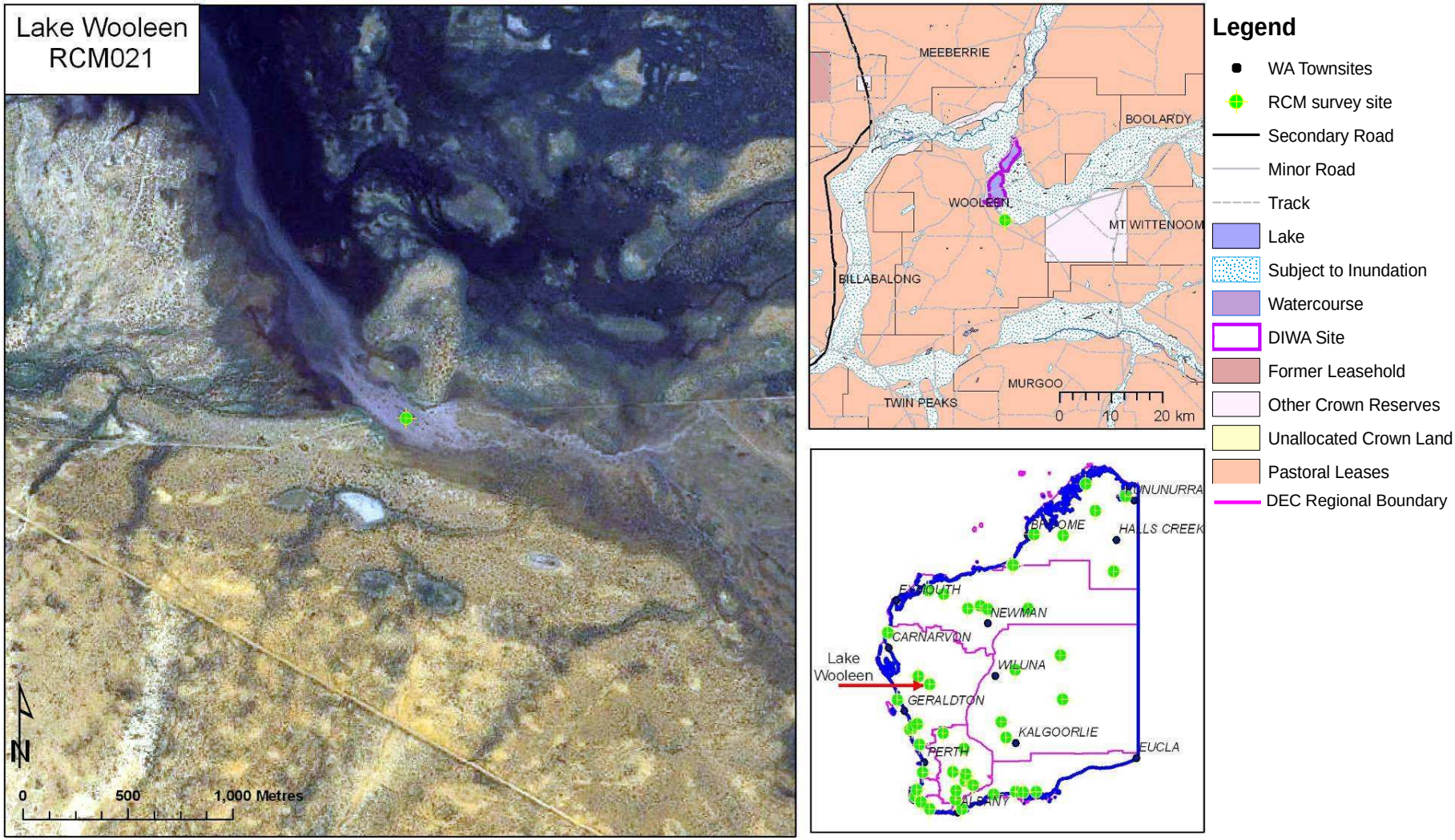


Figure 2 – Aerial photograph showing the location of the survey site at Lake Wooleen. The upper insert shows the extent of the DIWA protected area, the course of the Roderick River and the nature of the surrounding tenure. The lower insert shows the location of the lake in Western Australia and in relation to the remaining IAI RCM sites.

2. Overview of Lake Wooleen

2.1. Location and Cadastral Information

Lake Wooleen is situated on the Wooleen pastoral lease, approximately 30 km southeast of the Murchison settlement (Figure 2). The lake covers an area of approximately 5,500 ha on the floodplain of the Roderick River. The surrounding land is predominantly used for grazing cattle and sheep.

2.2. IBRA Region

Lake Wooleen is within the western subregion (MUR2) of the Murchison Interim Bioregionalisation of Australia (IBRA) region. Extensive hardpan washplains characterise the subregion, mantling the granitic and greenstone strata of the Yilgarn Craton. Surfaces associated with the occluded drainage occur throughout. Mulga low woodlands with ephemeral bunch-grass occur on fine-textured alluvial and eluvial plains, with hummock grasslands on Quaternary sandplains, saltbush shrublands on calcareous soils and *Halosarcia* low shrublands on saline alluvia. Most (~96%) of the region is used for grazing native pastures (Desmond et al. 2001).

2.3. Climate

The nearest Bureau of Meteorology weather station to Lake Wooleen is at Murchison (Bureau of Meteorology 2009). Records have been kept at Murchison since 1987. Climatic conditions at Lake Wooleen would not differ appreciably from those at Murchison.

Murchison experiences a semi-arid, hot climate. It receives a mean annual rainfall of 244.7 mm, mainly falling in the first half of the year (Figure 3). Annual evaporation is approximately 3,200 mm. Temperatures peak in January with a mean minimum/maximum of 22.1 ºC/39.2 ºC and fall to a mean of 6.1 ºC/20.9 ºC in July.

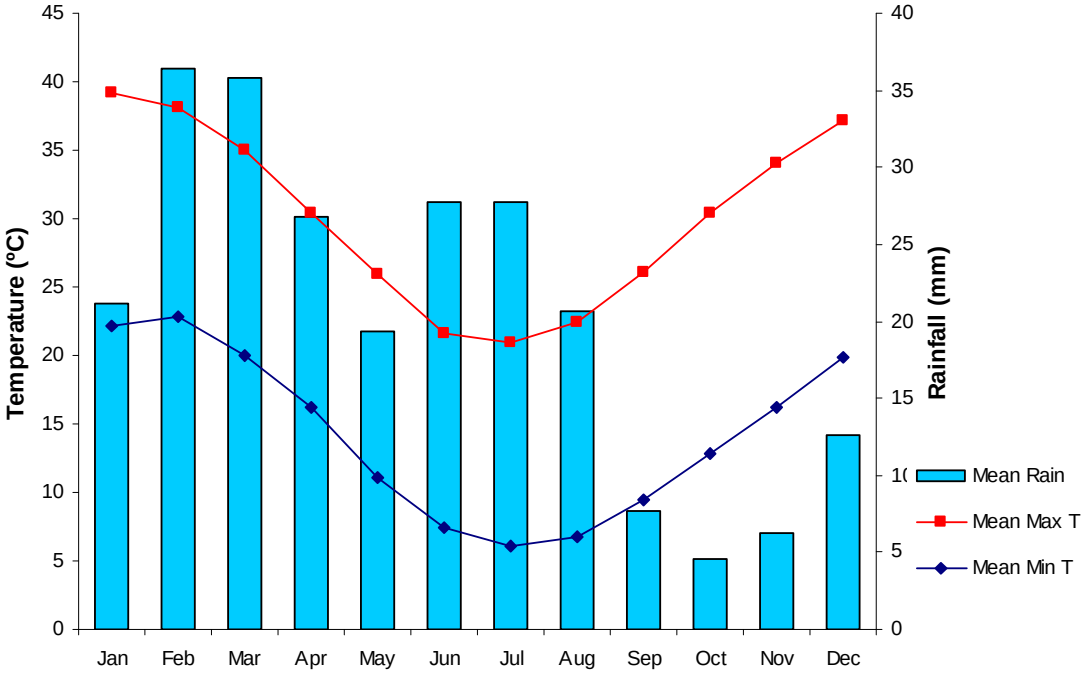


Figure 3 – Climatic averages for Murchison, approximately 30 km northwest of Lake Wooleen.

Lake Wooleen was surveyed by the IAI RCM project on the 24th of August 2008. In the six months preceding the survey, Murchison received 335.6 mm of rain. Over half of this (183 mm) fell in February.

2.4. Wetland Type

The Directory of Important Wetlands in Australia (Environment Australia 2001) describes Lake Wooleen as a 'seasonal/intermittent freshwater lake (>8 ha), or floodplain lake' (type B6). It is a macroscale elongate sumpland, with numerous associated microscale ovoid sumplands (claypans, marshes) (Jaensch 1992). The Roderick River is type B2 - a 'seasonal or irregular river'. Yewlands Pool is a natural pool on a tributary of the Roderick River, but has been excavated to increase its size, depth and permanence.

2.5. Directory of Important Wetlands in Australia Criteria

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

- It is a good example of a wetland type occurring within a biogeographic region in Australia.
- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.

More specifically, the key features of Lake Wooleen that contributed to it being nominated as a DIWA site are:

- It is a good example of a major floodplain lake, one of few in southern WA.
- It is a major breeding area for Gull-billed Terns (*Gelochelidon nilotica*) in WA.

2.6. Values of Lake Wooleen

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'. Lake Wooleen is a registered place of Aboriginal significance (DIA 2009). It is likely that local Aboriginal people would have traditionally used the lake and its surrounds for consumptive purposes. There is no evidence of contemporary consumptive use, however.

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 Wooleen has a long history of productive use as a source of fodder for stock, although the lake floor was fenced in 2005 to exclude stock. The pastoralist is exploring other productive uses for the lake, such as harvesting seed from the native grass to be used in revegetation (D. Pollock, pers. comm.).

c. 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. Lake Wooleen is likely to play an important role in the regional hydrology. It also supports significant biodiversity. The lake is an important waterbird breeding habitat and is particularly significant as a breeding site for Gull-billed Terns (*Gelochelidon nilotica*) (Desmond et al. 2001).

d. Amenity

Amenity describes features of the natural environment that make life more pleasant for people. For instance, pleasant views, or shade and wind shelter from a stand of trees. It is difficult to quantify the amenity value of a site such as Lake Wooleen, but it is evidently valued by the lessee, and visitors to the area, for the amenity it provides.

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 changes occurring elsewhere in the natural world. They also act as 'control' sites that allow us to benchmark other, altered habitats. As an important breeding site for waterbirds, Lake Wooleen may present opportunities for advancing the science of wetland ecology and knowledge of waterbird life-histories.

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. Wooleen Station is operated partly as an ecological tourism venture. The homestead provides accommodation for tourists wishing to enjoy the natural surrounds, including Lake Wooleen. As such, Lake Wooleen is highly valued for the passive recreation opportunities it provides. It is particularly popular with birdwatchers, when the lake is full.

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. Lake Wooleen is a recognised place of Aboriginal cultural significance (DIA 2009). It is a mythological place and a hunting grounds for local indigenous people. It is also held in high esteem by its contemporary owners and contains sites that are significant to the European history of the region.

h. Opportunities for future use

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

The intent of nature conservation is usually to maintain the ecosystem services, scientific and educational uses and opportunities for future use at a given site. Doing so is likely to have

positive effects on the amenity provided, recreational opportunities 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. That said, Lake Wooleen forms part of an active pastoral lease, and may be esteemed by the lessees for its productive values. These conflicting value sets should be considered when attempting to implement conservation management at the site.

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

The objective of the Lake Wooleen 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 Wooleen'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 Wooleen.

Component	Summary description
Geomorphology	Macroscale elongate sumpland, with numerous associated microscale ovoid sumplands, situated in the Yilgarn Craton, in alluvial and lacustrine valley-fill deposits in the floodplain of the Roderick River.
Hydrology	Inflow via Roderick River and creeks; outflow to Murchison River; seasonally inundated, intermittently flooded; catchment moderately disturbed.
Water Quality	Poikiohaline: fresh when relatively full, tending to brackish as the lake dries out.
Benthic Plants	*Myriophyllum verrucosum* and *Lepilaena australis* have been recorded.
Littoral Vegetation	Dominated by *Eucalyptus victrix* over a mixture of low herbs and sedges; shrubland composed of *Atriplex semilunaris*, *Frankenia laxiflora*, *Tecticornia indica* subsp. *leiostachya*; weeds present.
Invertebrates	36 species recorded in Yewlands Pool – no previous surveys of the main lake body have been undertaken.
Fish	Unidentified fish were observed in Yewlands Pool.
Waterbirds	45 species of waterbird have been recorded, including many breeding. Significant sightings include Freckled Duck (*Stictonetta naevosa*) and Gull-billed Tern (*Gelochelidon nilotica*).

3.1. Geology and Soils

Lake Wooleen is situated in the Yilgarn Craton. It lies on alluvial and lacustrine valley-fill deposits in the floodplain of the Roderick River. The surrounding country is gently undulating with isolated hills (Jaensch 1993).

3.2. Hydrology

Lake Wooleen is a floodplain lake, comprised of two claypans joined by a neck, with associated marshes on the Roderick River (Morton *et al.* 1995). The lake covers 5,500 ha and is approximately 3 km x 27 km when full.

Lake Wooleen receives surface inflow mainly from the Roderick River, which originates 110 km to the northeast. Inflow is also received from creeks originating up to 12 km southwest and south of the south basin and east of the north basin. The lake is situated in the Murchison River catchment, which is moderately disturbed (Jaensch 1993). Lake Wooleen outflows from the north end of the lake to the Murchison River, 6 km downstream (Jaensch 1993; Morton *et al.* 1995). When in flood, the Murchison River can flow back into the lake (Anonymous 2008).

The lake is seasonal, with some inundation occurring in most years, and episodic filling of the whole lake and surrounding marsh approximately once every five to ten years. Filling usually occurs following summer-autumn rain events of tropical origin (Jaensch 1993; Morton *et al.* 1995). Water depth may reach several metres when the lake is full (Jaensch 1993; Morton *et al.* 1995) and the lake may take up to ten months to dry following filling (Frances 2009a).

3.3. Water Quality

Water quality in Lake Wooleen is closely related to the water regime. The lake is fresh when full, but becomes brackish as salts are concentrated in the drying phase. At the time of the IAI RCM survey, the main lake was dry. Water quality measurements were taken in Yewlands Pool, at the southern end of the lake. This site is actually a pool of the Roderick River, rather than a true part of the lake, but was the only free water in the area.

Yewlands Pool was fresh and had an unusually high pH when sampled, perhaps associated with the very dense beds of *Ruppia* and *Myriophyllum* in shallow water. Total phosphorus concentrations are higher than the ANZECC (2000) interim trigger values for south-western Australia (40 µg/L for total soluble phosphorous and 60 µg/L for total phosphorous) and are higher than recorded for most freshwater wetlands and river pools by Halse *et al*. (2000). The concentration of total nitrogen is just above the ANZECC trigger value of 1,500 µg/L and also higher than recorded in most freshwater wetlands by Halse *et al*. (2000). The high nutrient concentrations were probably in part due to the low water level in the wetland concentrating nutrients. Chlorophyll concentrations were low, indicating the absence of an algal bloom.

Table 2 – Water quality parameters measured in Yewlands Pool in August 2008.

pH	10.5	**Chlorophyll (ug/L)**	2
Alkalinity (mg/L)	95	**Na (mg/L)**	70.2
TDS (g/L)	0.26	**Mg (mg/L)**	3.2
Turbidity (NTU)	38	**Ca (mg/L)**	6.3
Colour (TCU)	40	**K (mg/L)**	9.3
Total nitrogen (ug/L)	1,600	**Cl (mg/L)**	74
Total phosphorus (ug/L)	90	**SO_4 (mg/L)**	12.5
Total soluble nitrogen (ug/L)	1,600	**HCO_3 (mg/L)**	31
Total soluble phosphorus (ug/L)	40	**CO_3 (mg/L)**	42

3.4. Littoral Vegetation

The vegetation of Lake Wooleen consists of low shrubland (samphire, mainly *Halosarcia* spp.) in periform or latiform arrangement in the lake, and low shrubland (lignum, *Muehlenbeckia cunninghamii*) and low open-woodland (*Eucalyptus camaldulensis*) in parts of the lake margins and in adjacent claypans. The surrounding vegetation is tall open-shrubland (Jaensch 1993; Morton *et al.* 1995).

As part of the IAI RCM project, two vegetation transects were established adjacent to Yewlands Pool, Lake Wooleen (Table 3).

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

Transect			R1	R2
Datum			WGS84	WGS84
Zone			50	50
Easting			421040	421033
Northing			6998522	6998536
Length			50 m	30 m
Bearing			300	120
Wetland state			Drying	Drying
Soil state (%)		Dry	0	100
		Waterlogged	100	0
		Inundated	0	0
Substrate (%)	Observed	Bare	70	20
		Rock	0	0
		Cryptogam	0	0
		Litter	1	20
		Trash	1	1
		Logs	0	0
	Expected	Bare	?	?
		Rock	0	0
		Cryptogam	0	0
		Litter	1	?
		Trash	1	?
		Logs	0	0
Time since last fire			no evidence	no evidence
Community condition			Impacted/Degraded	Impacted
Upper Stratum		Cover (%)	42.85373	-
		Height (m)	12	-
Mid Stratum		Cover (%)	-	41.9
		Height (m)	-	<0.75
Ground Cover		Cover (%)	26.6	27.83333
		Height (m)	<0.2	<0.2

Transect RCM021-R1

Transect RCM021-R1 was established within 5 m of the water's edge (Figure 4). Soil was waterlogged at the time of the survey. Vegetation was dominated by *Eucalyptus victrix* mid to high trees (42.9% cover, 12 m tall) over a mixture of low herbs and sedges. (26.6% cover, <0.2 m tall). Table 4 provides a complete list of taxa recorded along the transect RCM021-R1. The abundance of *Myriophyllum verrucosum* covering the ground was a clear indication that this area was recently inundated.

One species of weed (*Juncus bufonius*) was recorded along the transect. The overall community condition was considered 'impacted/degraded' (Table 11 in Appendix 1), largely due to historical stock grazing.

Figure 4 – Yewlands Pool vegetation transect RCM021-R1.

Table 4 – Plant taxa recorded along Lake Wooleen Vegetation transect RCM021-R1 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Eucalyptus	*victrix*	10	U1	Tree
Myriophyllum	*verrucosum*	0.05	G1	Forb
Myriocephalus	*oldfieldii*	0.3	G1	Forb
Peplidium	*aethocheilum*	0.01	G1	Forb
Centipeda	*crateriformis* subsp. *crateriformis*	0.05	G1	Forb
Isolepis	*congrua*	0.05	G1	Sedge
**Juncus*	*bufonius*	0.05	G1	Forb
Glossostigma	*diandrum*	0.01	G1	Forb
Cyperus	*gymnocaulos*	1	G1	Sedge
Dysphania	*plantaginella*	0.05	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

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

U1+ ^*Eucalyptus victrix*\tree\7\i; *Myriophyllum verrucosum*, *Myriocephalus oldfieldii*, *Peplidium aithocheilum*, *Centipeda crateriformis* subsp. *crateriformis*, *Isolepis congrua*, **Juncus bufonius*\^forb, sedge\1\c.

Transect RCM021-R2

Transect RCM021-R2 was established approximately 15 m from the water's edge (Table 10). The soil surface was completely dry at the time of survey. Vegetation was dominated by *Atriplex semilunaris*, *Frankenia laxiflora*, *Tecticornia indica* subsp. *leiostachya* mid to high shrubland (41.9% cover, <0.75 m tall) over a mixture of herbs and grasses (27.8% cover, <0.2 m tall). Table 5 provides a complete list of taxa recorded along the transect RCM021-R2.

Four species of weeds were recorded along this transect. The overall community condition is considered 'impacted' (Table 11 in Appendix 1).

Table 5 – Plant taxa recorded along Lake Wooleen vegetation transect RCM021-R2 (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Atriplex	*semilunaris*	0.8	M1	Chenopod
Frankenia	*?laxiflora*	0.4	M1	Shrub
Tecticornia	*indica* subsp. *leiostachya*	0.5	M1	Chenopod
Atriplex	*amnicola*	0.9	M1	Chenopod
Eremophila	*laanii*	2	M1	Shrub
Salsola	*australis*	0.6	M1	Chenopod
Sida	*kingii*	0.5	M1	Shrub
Lotus	*cruentus*	0.3	G1	Forb
Eragrostis	*dielsii*	0.1	G1	Grass
Lawrencia	*glomerata*	0.5	G1	Forb
Myriocephalus	*oldfieldii*	0.3	G1	Forb
Nicotiana	*occidentalis* subsp. *obliqua*	1	G1	Forb
**Anagallis*	*arvensis* var. *caerulea*	0.3	G1	Forb
Swainsona	*pterostylis*	0.3	G1	Forb
Goodenia	sp.	0.2	G1	Forb
Heliotropium	*ammophilum*	0.3	G1	Shrub
Ptilotus	*humilis* subsp. *humilis*	0.1	G1	Forb
**Sonchus*	*oleraceus*	1	G1	Forb
**Solanum*	*nigrum*	0.8	G1	Forb
Brachyscome	*ciliaris*	0.3	G1	Forb
Eragrostis	*falcata*	0.4	G1	Grass
Rhodanthe	*stricta*	0.2	G1	Forb
**Heliotropium*	*curassavicum*	0.05	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

Figure 5 – Lake Wooleen vegetation transect RCM021-R2.

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

M1+ ^*Atriplex semilunaris*, *Frankenia ?laxiflora*, *Tecticornia indica* subsp. *leiostachya, Atriplex amnicola*\chenopod shrub, shrub\2\c; G1 ^*Lotus cruentus*, *Eragrostis dielsii Lawrencia glomerata*, *Myriocephalus oldfieldii*\ forb, tussock grass\1\c.

3.5. Benthic Plants

The aquatic plants *Myriophyllum verrucosum* and *Lepilaena australis* formed a closed aquatic bed across Yewlands Pool (Figure 6).

Figure 6 – Aquatic vegetation (*Myriophyllum verrucosum* and *Lepilaena australis*) of Yewlands Pool, Lake Wooleen.

3.6. Aquatic Invertebrates

Aquatic invertebrate samples were collected from three locations, representing two habitat types within Yewlands Pool:

1. Bare sandy sediment
2. Macrophyte – *Ruppia* and *Myriophyllum*
3. Macrophyte – *Ruppia* and *Myriophyllum*

A total of thirty-six macroinvertebrate species, belonging to twenty-one families, was collected from Yewlands Pool, Lake Wooleen. The number of species present in this small drying pool is as expected for freshwater wetlands in the region (approximate average of thirty-six macroinvertebrate taxa for wetlands with TDS <1 g/L in the southern Carnarvon Basin collected by Halse *et al*. 2000). Specimens in some subsamples have not been identified to species level (due to time constraints) but this would not have increased macroinvertebrate richness by more than about 10%. Almost all species are widespread. An exception may be the water mite tentatively identified as a *Piersigiidae*. This would be the first record of this mite genus from Western Australia but the identification is yet to be confirmed.

Table 6 – Aquatic invertebrate species identified from Yewlands Pool in August 2008.

Class	Order	Family	Lowest ID	Sample*
Gastropoda	Basommatophora	Planorbidae	*Glyptophysa* cf. *gibbosa*	1,2,3
Arachnida	Acariformes	Hydrachnidae	*Hydrachna* (*Hydrachna*) sp. 1	2
		Piersigiidae	?Piersigiidae sp. 1	2
		Arrenuridae	*Arrenurus balladoniensis*	2
Crustacea	Conchostraca	Cyzicidae	*Caenestheriella packardi*	1,2,3
Insecta	Coleoptera	Dytiscidae	*Allodessus bistrigatus*	1
			Sternopriscus multimaculatus	1
			Necterosoma sp.	1
			Megaporus howitti	1
			Dytiscidae	2,3
		Hydrophilidae	*Berosus macumbensis*	1
			Hydrophilidae	2
		Hydraenidae	Hydraenidae	2
	Diptera	Culicidae	Culicidae	3
		Ceratopogonidae	*Bezzia* sp.	2,3
			Monohelea sp.	2
		Tabanidae	Tabanidae	3
		Chironomidae	*Coelopynia pruinosa*	1,2,3
			Procladius paludicola	1,2,3
			Larsia albiceps	1,3
			Cricotopus albitarsus	1
			Tanytarsus P6	2
			Tanytarsus sp. C (?*bispinosus*)	2
			Dicrotendipes 'CA1' Pilbara type 2	1,2
			Polypedilum sp. S1	3
	Ephemeroptera	Baetidae	Baetidae	2,3
			Offadens (ex genus 1) *soror* (ex WA sp. 1)	1
	Hemiptera	Corixidae	*Agraptocorixa parvipunctata*	1
			Micronecta robusta	1
			Micronecta gracilis	1
		Notonectidae	*Anisops thienemanni*	1
	Lepidoptera	Pyralidae	Pyralidae nr. sp. 39/40	3
	Odonata	Coenagrionidae	*Austroagrion watsoni*	2

Class	Order	Family	Lowest ID	Sample*
Insecta	Odonata	Coenagrionidae	*Xanthagrion erythroneurum*	2
			Coenagrionidae	3
		Aeshnidae	*Hemianax papuensis*	2
		Libellulidae	*Diplacodes bipunctata*	2
			Orthetrum caledonicum	2
			Libellulidae	3
		Hemicorduliidae	*Hemicordulia tau*	2
			Hemicorduliidae	3
	Trichoptera	Leptoceridae	*Oecetis* sp.	1
			Triplectides ciuskus seductus	1
			Leptoceridae	2,3

* Numbers indicate samples as listed above.

3.7. Fish

Fish were observed in Yewlands Pool during the IAI RCM survey, but were not identified.

3.8. Waterbirds

Several thousands of waterbirds sometimes occur at Lake Wooleen when breeding colonies are active. Higher numbers probably occur as the lake dries out (Jaensch 1993). Lake Wooleen is a well-known breeding site for Gull-billed Tern (*Gelochelidon nilotica*). About 5,000 Gull-billed Terns, as well as Black Swans (*Cygnus atratus*) and Pink-eared Ducks (*Malacorhynchus membranaceus*) were reported breeding at the lake in the 1970s (Jaensch 1993; Morton *et al.* 1995). Australia's most threatened waterbird, the Freckled Duck (*Stictonetta naevosa*) was recorded in lignum surrounding the lake on 5 October 1980, when the lake was full; conditions appeared suitable for breeding at the time (Jaensch 1993; Morton *et al.* 1995).

Nine species of waterbirds were recorded at Lake Wooleen during the IAI RCM survey (Table 7). All of these species had previously been recorded from Wooleen Station by Birds Australia. For a full list of waterbirds recorded from Wooleen Station, see Appendix 3.

Table 7 – Waterbirds observed at Lake Wooleen during the IAI RCM survey.

Latin Name	Common Name	Number of Birds
Elseyornis melanops	Black-fronted Dotterel	1
Ardea pacifica	White-necked Heron	1
Himantopus himantopus	Black-winged Stilt	2
Tachybaptus novaehollandiae	Australasian Grebe	1
Poliocephalus poliocephalus	Hoary-headed Grebe	2
Fulica atra	Eurasian Coot	1
Anas gracilis	Grey Teal	6
Tadorna radjah	Australian Shelduck	4
Malacorhynchus membranaceus	Pink-eared Duck	1

3.9. Other Fauna

As well as birds and fish, Lake Wooleen provides habitat for a variety of wildlife, including crustaceans, frogs and turtles (Frances 2009b). The lesees of Wooleen Station note the presence of kangaroos (*Macropus rufus*), emus (*Dromaius novaehollandiae*), bungarras (*Varanus*

rosenbergii) and banjo frogs (*Limnodynastes dorsalis*) on the station's website (Anonymous 2008). Western Australian Museum records of fauna recorded within 5 km of Lake Wooleen are listed below.

Table 8 – Western Australian Museum records for fauna collected within 5 km of Lake Wooleen (WA Museum 2009).

Scientific Name	Common Name	Year
Ctenophorus maculatus	Spotted Military Dragon	
Egernia depressa	Pygmy Spiny-tailed Skink	
Gehyra punctata	Spotted Dtella	1990, 1991, 1993
Gehyra variegata	Tree Dtella	1993
Heteronotia binoei	Bynoe's Gecko	1992, 1993
Lerista nichollsi	Inland Broad-blazed Slider	1987

4. Interactions between Ecological Components at Lake Wooleen

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 criteria for nomination for the Directory of Important Wetlands in Australia, as the criteria are very similar. Accordingly, the primary determinants of ecological character at Lake Wooleen are:

- The characteristics that make the site a good example of a wetland type occurring within a biogeographic region in Australia.
- 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 to support these populations.

Table 9 summarises the interactions between key components and processes at Lake Wooleen. 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 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 9 – The relationship between the services and benefits delivered by Lake Wooleen 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	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Nutrient enrichment from feral animals and stock Overgrazing Siltation Inappropriate fire regimes Weeds Predation by introduced animals
Ecosystem Service Value It is a good example of a wetland type occurring within a biogeographic region in Australia	A good example of a major floodplain lake, one of the few in southern WA	Plant communities	Hydrological regime Geomorphology	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Erosion Siltation
Ecosystem Service Value It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail	Breeding Gull-billed Terns Other waterbirds that utilise the site as a breeding grounds and drought refuge	Invertebrate populations (food source) Benthic plant biomass Plant communities (habitat)	Soils and sediments Water quality Hydrology Habitat extent and distribution	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Siltation Inappropriate fire regimes Predation by introduced animals 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 Picnicking Photography Bush walking	Landscape amenity Waterbird populations Plant communities Significant flora Significant fauna	Invertebrate populations (food source) Phytoplankton (food source) Benthic plant biomass	Soils and sediments Water quality Hydrology Climate	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Nutrient enrichment from feral animals and stock Overgrazing by pest animals Siltation Inappropriate fire regimes Weeds Predation by introduced animals Loss of migratory bird populations due to offsite factors
Spiritual Value The wetland is of outstanding historical or cultural significance	Geomorphology of lake and surrounds Native flora and fauna communities	Flora and fauna populations Pollinators and food sources for above	Soils and sediments Hydrology Climate Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Nutrient enrichment from feral animals and stock Overgrazing by pest animals Siltation Inappropriate fire regimes Weeds Predation by introduced animals Loss of migratory bird populations due to offsite factors

5. Threats to the Ecology of Lake Wooleen

The objective for nature conservation at Lake Wooleen 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 floodplain lake and a suitable breeding refuge site for 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 plant 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 Lake Wooleen 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 10. In summary, failure to achieve the management goal for Lake Wooleen is most likely to result due to the lake's long history of cattle pastoralism and associated impacts such as weeds, erosion and siltation, and eutrophication of the water body. However, stock have been removed from the lakebed and there is evidence of regeneration of vegetation and recovery of the system.

The condition of Lake Wooleen has been described as fair to good, with recovery of the system requiring management intervention (Desmond *et al.* 2001). In 2001, the primary threatening processes acting on Lake Wooleen were identified as grazing pressure and feral animals (particularly goats, foxes, cats and rabbits) (EPA 2007). Siltation of the water body was seen as a potential threat to Lake Wooleen should overgrazing occur (Jaensch 1993). While the lakebed was destocked and fenced three years ago, the long-lasting impacts of a history of cattle access are still evident at the wetland. The IAI RCM survey noted vegetation disturbance and the presence of weeds.

The impacts of feral animals were also noted, though these may also be historical. The construction of fencing surrounding Lake Wooleen would limit access by goats. However, rabbits, foxes and cats may still access the wetland and potentially impact on the vegetation and wildlife. Rabbits may hinder the regeneration of littoral vegetation through grazing pressure, as well as contribute to eutrophication of the wetland from their feaces. Cats and foxes could significantly impact on breeding waterbird populations by predating on chicks and eggs. It is difficult to quantify the impact feral animals may be having without a longer term study.

Table 10 – Threat assessment for Lake Wooleen.

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 Wooleen, thus ensuring it remains a suitable breeding area and drought refuge 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 is no evidence of alteration to the hydrology of the Lake Wooleen area, nor does there appear to be any likelihood of any alteration in the foreseeable future.
	Carbon cycle and climate change	1	1	Changes to rainfall are expected to be minimal in the Lake Wooleen area, with a possible mild increase. This rise in rainfall is mainly attributed to more frequent extreme rainfall events. Average annual temperature rose by 0.1 ˚C between 1910 and 2004, with further rises expected (EPA 2007). As a floodplain lake highly reliant on rainfall, it is likely climate change would affect the hydrological regime of Lake Wooleen. The impacts of such change are difficult to predict.
Impacts of introduced plants and animals	Environmental weeds	10	5	Five species of weeds were identified during the vegetation surveys at Lake Wooleen. Although the lake does not currently appear to be heavily impacted by weeds, its long history of grazing activities has made it highly susceptible to weed invasion. Alteration to natural fire regimes may facilitate the establishment of weed species in the area.
	Herbivory, wallowing and trampling by introduced species	10	5	Rabbits have been reported in the area and have been recognised as a possible threat to Lake Wooleen. Goats also occur, but the lake has been fenced to exclude stock, which may also limit goat access.
	Predation by introduced carnivores	10	5	Cats, foxes and wild dogs are all known to occur in the area and may have a significant impact on nesting waterbirds.
Impacts of problem native species	Overgrazing by native species	0	0	No impacts evident.
Impacts of disease	Plant pathogens	0	0	No impacts evident.
Detrimental regimes of physical disturbance events	Fire regimes	3	1	There was no evidence of fire at Lake Wooleen. However, the lake's vegetation is susceptible to fire and an inappropriate regime could potentially impact on the vegetation and possibly reduce waterbird breeding habitat.

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	5	5	Rainfall projections show that climate change may result in longer periods of drought, interspersed with severe storms and heavy rainfall (EPA 2007). The impacts of this on the ecology of Lake Wooleen are difficult to predict. It is possible that it may lead to some alteration in the composition of vegetation at the site.
	Flood	5	5	Flooding of Lake Wooleen may become more frequent. Alteration to rainfall and hydrological fluxes, associated with global climate change may impact on the vegetation. The nature of the impacts is not clear and should be monitored.
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 broad scale cropping is practiced in the catchment.
Impacts of competing land uses	Recreation management	0	0	Recreational usage of Lake Wooleen is low impact and unlikely to have any deleterious impacts.
	Nutrient enrichment of water body	5	0	It is likely that cattle accessing the lake will result in nutrient enrichment of the water body. However, the regular flushing of the system following seasonal rainfall events appears to prevent the development of eutrophic conditions.
	Urban and industrial development	0	0	Lake Wooleen is contained in a pastoral lease. Urban or industrial development is therefore highly unlikely.
	Consumptive uses	0	0	The are currently no consumptive uses of Lake Wooleen.
	Illegal activities	0	0	No evidence of any threat.
	Mines and quarries	0	0	No mineral potential.
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	1	1	Lake Wooleen is connected to areas of natural or near-natural environment. 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 for Future Monitoring

Apart from the small amount of information gathered by the IAI RCM survey, very few quantitative data have been collected from Lake Wooleen. In particular, water quality and aquatic invertebrates have not been sampled from the main lake body.

The lesees of Wooleen Station have been implementing projects to help restore the natural environment on the property. Ongoing monitoring of the condition of Lake Wooleen would be beneficial throughout this process. Monitoring would help to determine if the condition of the lake is changing as a result of restoration works and whether this change is positive. Monitoring would also help to inform and prioritise future management decisions. Vegetation monitoring is of particular importance to record regeneration and changes in plant community extent and distribution.

On a subregional scale, data gaps include vegetation and regional ecosystem mapping (at a scale finer than 1:500,000), systematic fauna survey data, floristic data, and ecological and life-history data. There are also no quantitative data on the effect of exotic predators, weed colonisation, fragmentation, fire or mineral-extraction on greenstone surfaces (Desmond *et al.* 2001).

References

Anonymous. (2008) Wooleen Station: Lake Wooleen. <http://wooleen.com.au/attractions/lake-wooleen/> Accessed on 20 May 2009.

Birds Australia. (2006) *Birds of Wooleen Station*. Number 09b in a series of Bird Guides of Western Australia. Birds Australia Western Australia Inc., Perth, Australia. January 2006.

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

Desmond, A., Cowan, M., and Chant, A. (2001) Murchison 2 (MUR2 – Western Murchison 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.

DIA. (2009) Aboriginal Heritage Inquiry System: Register of Aboriginal Sites. Department of Indigenous Affairs.

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.

Frances. (2009a) Cyclone Dominic Brings Water to Wooleen. <http://wooleen.com.au/cyclone-dominic-brings-water-to-wooleen/> Accessed on 20 May 2009.

Frances. (2009b) Wooleen Lake is Teeming with Life. <http://wooleen.com.au/wooleen-lake-is-teeming-with-life/ > Accessed on 20 May 2009.

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.

Jaensch, R. P. (1992) Wooleen Lake - WA061. In *Australian Wetlands Database*. Department of Environment, Heritage and the Arts. Accessed on 19 February 2009.

Jaensch, R. P. (1993) Wooleen Lake - WA061. In *Australian Wetlands Database*. Department of Environment, Heritage and the Arts. Accessed on 19 February 2009.

Morton, S. R., Short, J., and Barker, R. D. (1995) *Refugia for biological diversity in arid and semi-arid Australia*. Biodiversity Series Paper No. 4. Biodiversity Unit, Department of Environment, Sport and Territories, Canberra, Australia.

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 11 – Overall Vegetation Community Condition Rating as adapted from Thackway and Lesslie (2005). Shading indicates the condition of Yewlands Pool.

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 records

Plant specimens submitted to the Western Australian Herbarium:

Lepilaena australis (RCM021-A1)

Myriophyllum verrucosum (RCM021-R1-04)

Table 12 – Herbarium Records for Lake Wooleen.

Search Coordinates: NW corner 26.9964°S, 116.1525° E; SE corner 27.1578°S, 116.2534°E

Family	Species	Alien	Cons. Status
Amaranthaceae	*Ptilotus beardii*		P3
Asteraceae	*Cephalipterum drummondii*		
Caesalpiniaceae	*Senna artemisioides* subsp. *x sturtii*		
	Senna glutinosa subsp. *chatelainiana*		
	Senna glutinosa subsp. x *luerssenii*		
Chenopodiaceae	*Atriplex amnicola*		
	Atriplex aff. *cephalantha*		
	Chenopodium gaudichaudianum		
	Maireana amoena		
	Maireana tomentosa subsp. *tomentosa*		
	Sclerolaena gardneri		
	Sclerolaena recurvicuspis		
	Sclerolaena tridens		
Chloanthaceae	*Pityrodia paniculata*		
Frankeniaceae	*Frankenia* sp.		
Mimosaceae	*Acacia ramulosa* var. *linophylla*		
	Acacia cuthbertsonii subsp. *cuthbertsonii*		
	Acacia grasbyi		
	Acacia rhodophloia		
Myoporaceae	*Eremophila galeata*		
	Eremophila glandulifera		
	Eremophila platycalyx subsp. *platycalyx*		
	Eremophila pterocarpa		
Myrtaceae	*Calytrix divergens*		
Papilionaceae	*Chorizema racemosum*		
	Lotus cruentus		
	Muelleranthus trifoliolatus		
	Swainsona affinis		
	Swainsona gracilis		
	Swainsona kingii		
Poaceae	*Eragrostis parviflora*		
	Paspalidium jubiflorum		

Family	Species	Alien	Cons. Status
Poaceae	*Sporobolus mitchellii*		
Proteaceae	*Grevillea deflexa*		
Stackhousiaceae	*Stackhousia* sp.		
Sterculiaceae	*Rulingia luteiflora*		
Surianaceae	*Stylobasium spathulatum*		
Tiliaceae	*Corchorus crozophorifolius*		
Tamaricaceae	*Tamarix chinensis*	Y	

Appendix 3: Waterbird records

Birds Australia Western Australia Inc. have produced a list of birds recorded from Wooleen Station (Birds Australia 2006). Of these, the birds that may be associated with Lake Wooleen (waterbirds) are reproduced here.

WATERFOWL
Blue-billed Duck
Black Swan
Australian Shelduck
Australian Wood Duck
Pacific Black Duck
Australasian Shoveler
Grey Teal
Chestnut Teal
Pink-eared Duck
Hardhead

GREBES
Australasian Grebe
Hoary-headed Grebe

PELICANS, CORMORANTS, ALLIES
Darter
Little Black Cormorant
Australian Pelican

HERON, IBIS
White-faced Heron
White-necked Heron
Great Egret
Glossy Ibis
Australian White Ibis
Straw-necked Ibis
Yellow-billed Spoonbill

SKUAS, GULLS, TERNS
Gull-billed Tern
Whiskered Tern

HAWKS, EAGLES, FALCONS
Black-breasted Buzzard
Whistling Kite
Spotted Harrier
Brown Goshawk
Wedge-tailed Eagle
Little Eagle
Brown Falcon
Australian Hobby
Peregrine Falcon
Nankeen Kestrel
Baillon's Crake
Australian Spotted Crake
Buff-banded Rail
Black-tailed Native-hen
Eurasian Coot
Australian Bustard

WADERS
Common Greenshank
Wood Sandpiper
Grey-tailed Tattler
Sharp-tailed Sandpiper
Black-winged Stilt
Red-capped Plover
Inland Dotterel
Black-fronted Dotterel
Red-kneed Dotterel
Banded Lapwing

Appendix 4: Aboriginal heritage records

Government of **Western Australia**
Department of **Indigenous Affairs**

Aboriginal Heritage Inquiry System

Register of Aboriginal Sites

Search Criteria

10 sites in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6995707	411055
7021915	431018

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

Copyright

Legend

Restriction

- **N** No restriction
- **M** Male access only
- **F** Female access

Access

- **C** Closed
- **O** Open
- **V** Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

- **[Reliable]** The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.
- **[Unreliable** The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Status

- **L** Lodged
- **I** Insufficient Information
- **P** Permanent register
- **S** Stored data
- **IR** Insufficient Information (as assessed by Site Assessment Group)
- **PR** Permanent register (as assessed by Site Assessment Group)
- **SR** Stored data (as assessed by Site Assessment Group)

Site Assessment Group (SAG)

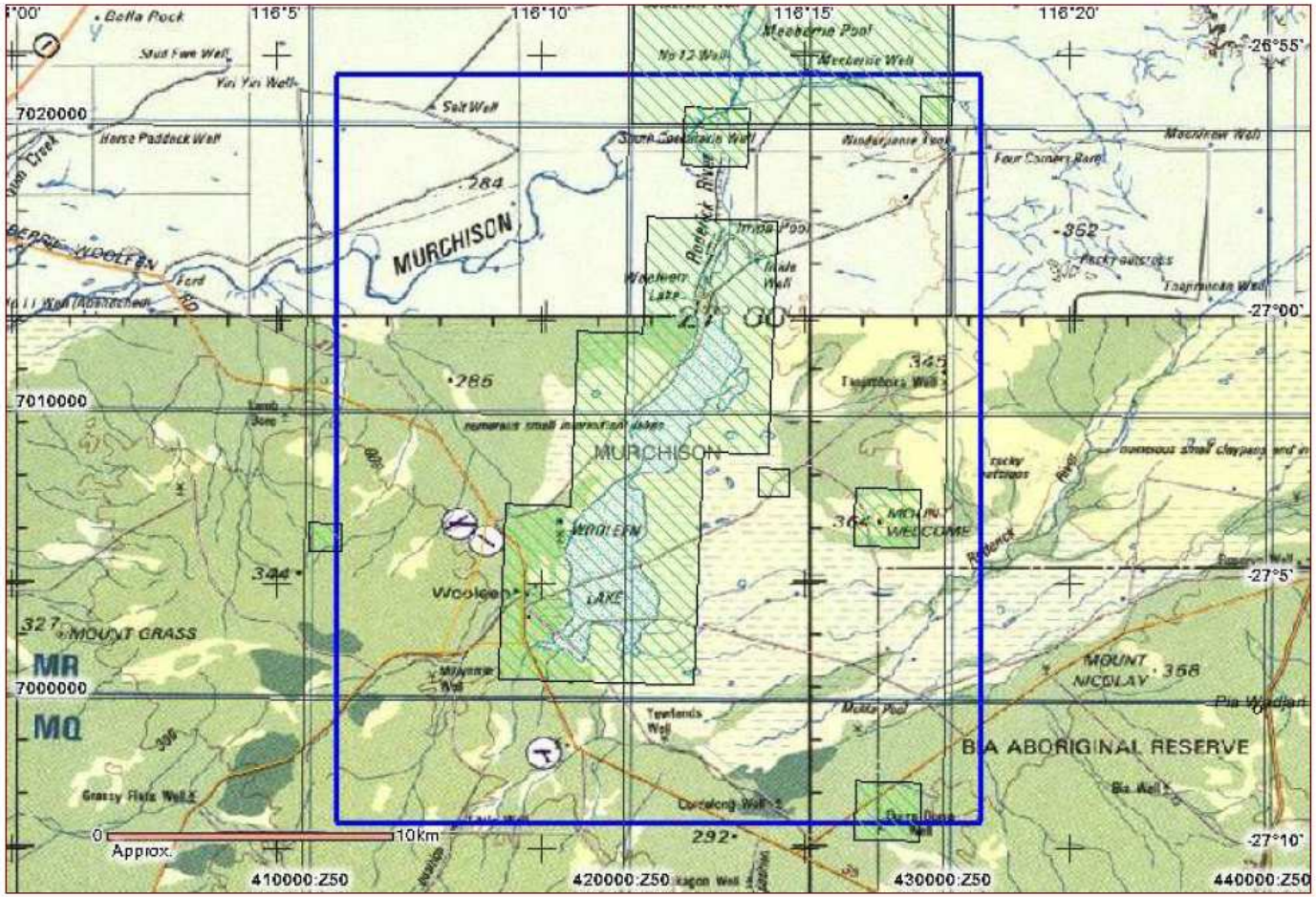
Sites lodged with the Department are assessed under the direction of the Registrar of Aboriginal Sites. These are not to be considered the final assessment.

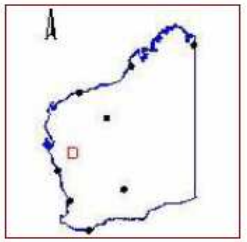
Final assessment will be determined by the Aboriginal Cultural Material Committee (ACMC).

Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of sites, especially for sites with an access code "closed" or "vulnerable". Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting / Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
6316	P	O	N	Meeberrie Pool Burial	Skeletal material/Burial			425137mE 7025153mN Zone 50 [Unreliable]	P06633
8328	P	C	N	Burra Burra Well.	Ceremonial	Water Source	*Registered Informant names available from DIA.	Not available for closed sites	P04327
8329	P	C	N	Kurkalja Pool.	Ceremonial, Artefacts / Scatter	Meeting Place, Camp, Water Source	*Registered Informant names available from DIA.	Not available for closed sites	P04328
11437	P	O	N	Irrida Pool	Engraving			424639mE 7007652mN Zone 50 [Unreliable]	P00733
11438	I	O	N	Wooleen.	Artefacts / Scatter	Camp		410639mE 7005652mN Zone 50 [Unreliable]	P00734
11846	P	O	N	Gravity Tank	Painting			429639mE 7020652mN Zone 50 [Unreliable]	P00337
11869	P	C	N	Lake Wooleen.	Mythological	Hunting Place	*Registered Informant names available from DIA.	Not available for closed sites	P00306
11872	P	C	N	Mt Welcome.	Ceremonial, Mythological	Water Source	*Registered Informant names available from DIA.	Not available for closed sites	P00309
19682	L	O	N	Wooleen Station Cave	Historical	Rockshelter	*Registered Informant names available from DIA.	428691mE 7017639mN Zone 50 [Reliable]	
19685	L	O	N	Wooleen Station Burial	Skeletal material/Burial		*Registered Informant names available from DIA.	417000mE 7002914mN Zone 50 [Reliable]	





Legend

- Highlighted Area
- Town
- Map Area
- Search Area