Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for a Significant Western Australian Wetland

Yeo Lake

2009

Figure 1 – A view across the dry lakebed of Yeo Lake.

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: Yeo Lake.* Department of Environment and Conservation, Perth, Western 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 Yeo Lake, an intermittent saline lake in the Great Victoria Desert. Yeo Lake is a crescent-shaped lake stretching approximately 50 km east-west. Scattered mesoscale to macroscale claypans surround the lake, which are numerous around its south-eastern extremity. A small saline playa on the southern periphery of Yeo Lake was surveyed by the IAI RCM project. The playa, approximately 1 km x 200 m in size was dry at the time of sampling.

Yeo Lake was selected as a study site in the current project due to its status as a *Directory of Important Wetlands in Australia* (DIWA) listed wetland (Environment Australia 2001). The lake floor is vegetated with rich variety of halophyte, some of which are endemic. The Yeo Lake area is also rich in reptiles and is the type locality for several species (Australian Government 1995).

1.1. Site Code

Directory of Important Wetlands in Australia: WA044.

Register of the National Estate Registered Place ID: 9865.

Inland Aquatic Integrity Resource Condition Monitoring Project (DEC): RCM017.

1.2. Purpose of Resource Condition Report

The objective of the RCR is to summarise all available ecological information relevant to Yeo Lake 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 Yeo Lake.

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 which may be relevant to Yeo Lake. The bilateral agreements are:

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

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

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

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

National legislation

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

The EPBC Act is the Australian Government's 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 which is relevant to Yeo Lake, namely migratory species listed under international treaties JAMBA, CAMBA and CMS.

Australian Heritage Council Act 2003

Yeo Lake Nature Reserve has been placed on the Register of the National Estate (registered place). A registered place is in the Register of the National Estate. However, some places may be legally registered because they are within a larger registered area they may not necessarily possess intrinsic significance. Specifically in relation to Yeo Lake, the Heritage Commission is in the process of developing and/or upgrading official statements for places listed prior to 1991. The data for Yeo Lake was mainly provided by the nominator and has not yet been revised by the Commission. Hence, Yeo Lake 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 in Western Australia is protected under section 14 of the *Wildlife Conservation Act 1950*. The Act establishes licensing frameworks for the taking and possession of protected fauna, and establishes offences and penalties for interactions with fauna.

Conservation and Land Management Act 1987

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.

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.

Portions of Yeo Lake are a gazetted Protected Area under the *Aboriginal Heritage Act* 1972 due to their mythological, ceremonial and archaeological significance.

Aboriginal Affairs Planning Authority Act 1972 (AAPA Act)

The AAPA Act repealed earlier Indigenous welfare legislation. It governs most Indigenous land related matters and vests reserves in the Aboriginal Affairs Planning Authority, which promotes the well-being and economic advancement of indigenous Australians. A visitor should always seek and gain permission to enter an Aboriginal community, and in the case of Aboriginal Reserve land, must do so by obtaining an entry permit. Under the AAPA Act, transit permits are required for any person visiting or passing through an Aboriginal reserve, unless he/she is:

- a person of Aboriginal descent;
- a member of either House of Parliament of the State or of the Commonwealth;
- a person exercising a function under the AAPA Act 1972 or otherwise acting in pursuance of a duty imposed by law; or
- a person authorised under the regulations of the AAPA Act 1972.

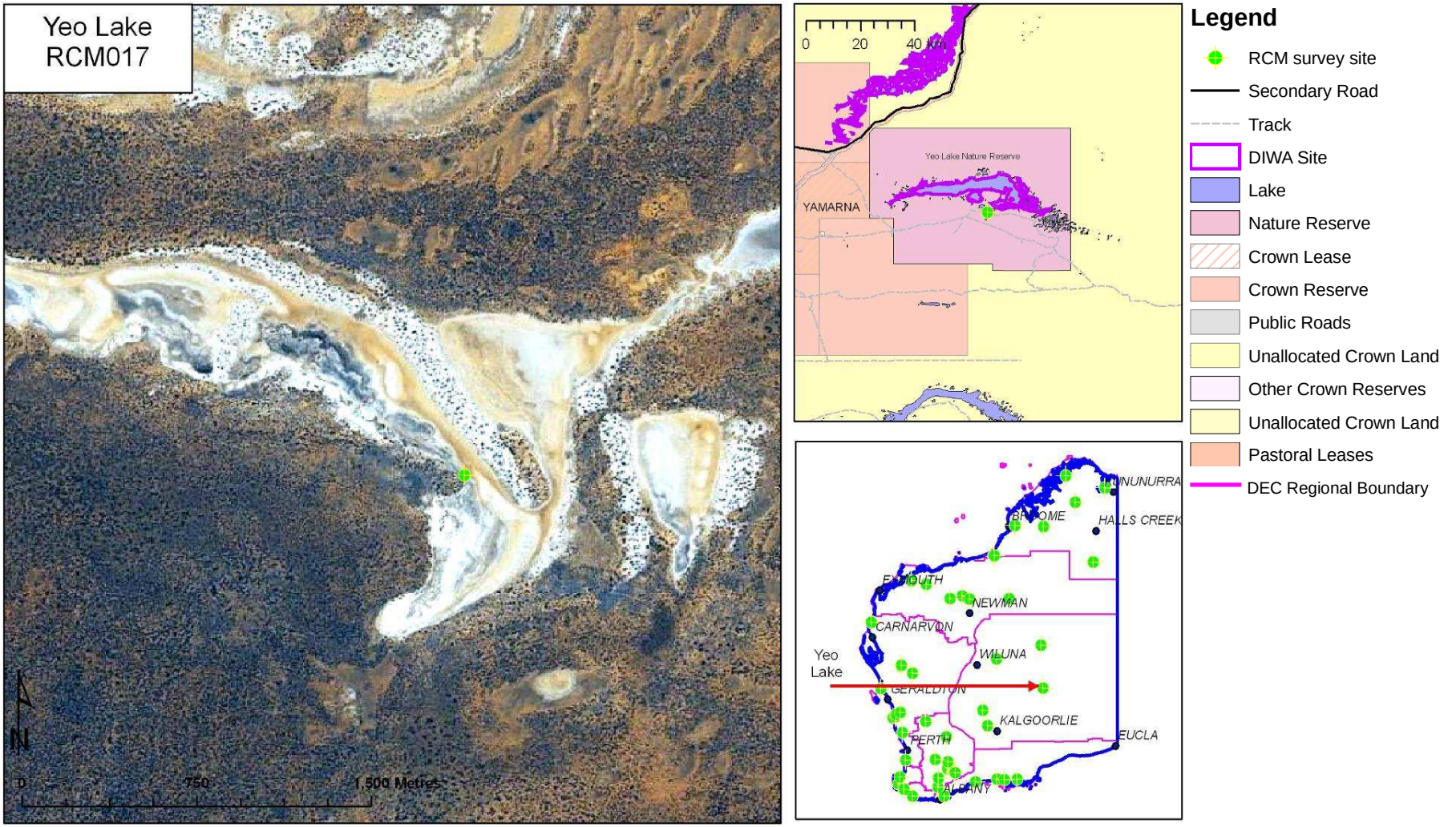

Figure 2 – Aerial photograph showing the location of the riparian transect at Yeo Lake. The upper insert shows the tenure of surrounding land and the extent of the DIWA listed area. The lower insert shows the location of the lake in the state of Western Australia and in relation to other IAI RAM project sites.

2. Overview of Yeo Lake

2.1. Location and Cadastral Information

Yeo Lake lies in the Great Victoria Desert, approximately 180 km east-northeast of Laverton (Fig. 2). The lake is entirely contained within Yeo Lake Nature Reserve, which adjoins the eastern side of the Cosmo Newberry Aboriginal Reserve.

2.2. IBRA Region

Yeo Lake lies within the central subregion (GDV2) of the Great Victoria Desert Interim Biogeographic Regionalisation of Australia (IBRA) region. This subregion is an active sand-ridge desert with extensive dune fields of deep Quaternary aeolian sands overlying Permian strata of the Gunbarrel Basin. The vegetation consists primarily of a tree steppe of *Eucalyptus gongylocarpa*, Mulga (*Acacia*) and *E. youngiana* over hummock grassland dominated by *Triodia basedowii* on the aeolian sands. The *Acacia* dominates colluvial soils with *Eremophila* and *Santalum* spp. Halophytes are confined to the edges of salt lakes and saline drainage systems (Cowan and Barton 2002).

2.3. Climate

The nearest Bureau of Meteorology weather station to Yeo Lake is at Laverton, approximately 180 km to the west-southwest of Yeo Lake (Bureau of Meteorology 2009). Climatic conditions at Yeo Lake would not differ markedly from those at Laverton, although annual rainfall may be slightly lower at Yeo.

Laverton experiences an arid climate. It receives a mean annual rainfall of 232.6 mm, mostly falling in the first half of the year (Fig. 3). Summer rainfall is usually associated with decaying tropical lows, while winter rainfall results from the occasional cold fronts that penetrate the state's interior. Annual evaporation at Laverton is approximately 3,600 mm, meaning that surface water is short lived after rain. Temperatures peak in January with a mean daily minimum/maximum of 20.5 ºC/35.8 ºC and fall to 5.2 ºC/17.8 ºC in July.

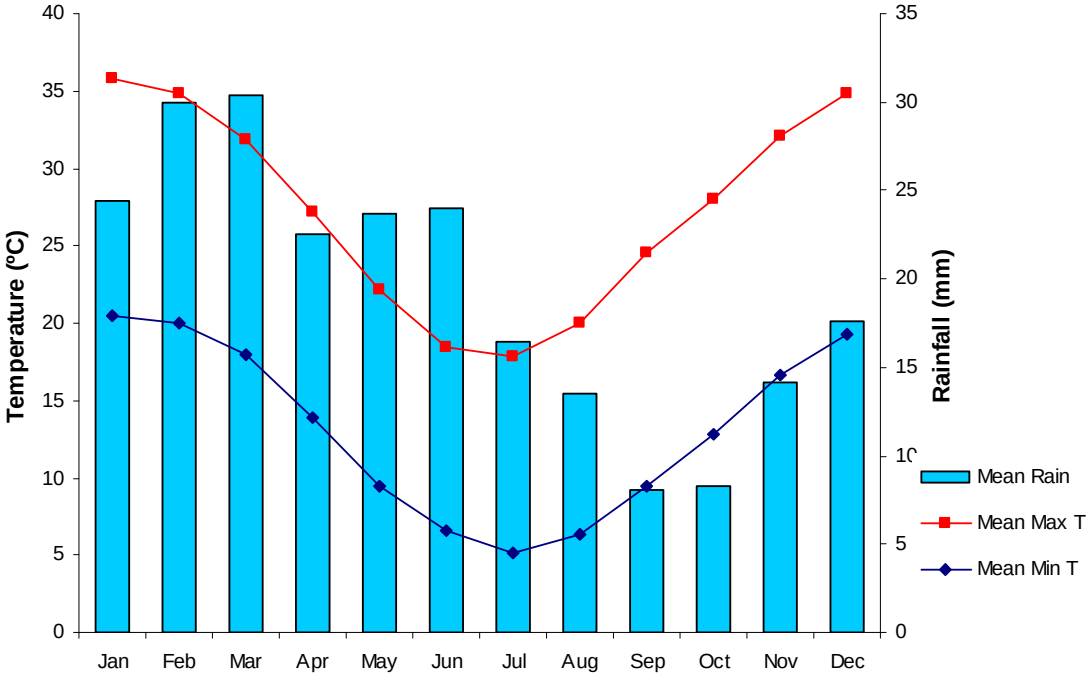

Figure 3 – Climatic averages for Laverton.

Yeo Lake was surveyed by the IAI RCM project on the 20th of August 2008. In the six months preceding the survey, Leonora received 90 mm of rain, almost all of which (78.8 mm) fell in February. There was no rainfall in the first twenty days of August 2008.

2.4. Wetland Type

The *Directory of Important Wetlands in Australia* (Environment Australia 2001) describes Yeo Lake as a 'seasonal/intermittent saline lake' (type B8). Two creeks (the western one is a linear drainage approximately 20 km long and the eastern one is a forked drainage approximately 15 km long) enter Yeo Lake from the south. These are described as 'seasonal and irregular rivers and streams' (type B2).

Yeo Lake is a megascale irregular elongate (crescent–shaped) lake stretching approximately 50 km east-west. The lake is surrounded by scattered mesoscale to macroscale claypans, particularly around its south-eastern extremity (Jaensch 1992).

2.5. *Directory of Important Wetlands in Australia* Criteria

Yeo Lake is designated as a wetland of national importance under criteria 1 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 a good example of a system of salt lakes in the Great Victorian Desert bioregion.

6. *The wetland is of outstanding historical or cultural significance.* The Yeo Lake area is of cultural significance to the local Aboriginal people and has been used by them historically. It has ethnographic (with several ceremonial and mythological sites) and archaeological components (including painting and artefact sites). In the vicinity is an important mythological site which is a gazetted Protected Area under the Aboriginal Heritage Act (Jaensch 1992).

2.6. Values of Yeo Lake

Values are the internal principles that guide the behaviour of an individual or group. Value systems determine the importance people place on the natural environment and how they view their place within it. Divergent values may result in people pursuing different objectives in relation to nature conservation, having different reasons for desiring a commonly agreed outcome, or favouring different mechanisms to achieve that outcome. 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'. Residents of the Cosmo Newberry Community value the Yeo Lake area for its consumptive uses. Historical use of the area has been established, and this continues to 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. No known productive use is currently made of Yeo Lake.

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. Yeo Lake may

support endemic or rare taxa. Such unique features would increase the potential for future opportunities to present.

d. Ecosystem services

There are many naturally occurring phenomena that bring enormous benefit to mankind. For instance, plants generate oxygen, insects pollinate food crops and wetlands mitigate floods by regulating water flows. The term 'ecosystem services', is used as a broad umbrella to cover the myriad of benefits delivered, directly or indirectly, to humankind by healthy ecosystems. Yeo Lake is biologically important for the different assemblage of plants and animals present. It may act as a drought refuge for fauna as it provides some permanent and semi-permanent water holes in otherwise arid region (Australian Government 1995).

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 Yeo Lake, but it is certainly valued by both the local community and tourists for the amenity it provides.

f. Scientific and educational uses

Parts of the natural environment that remain relatively unmodified by human activity represent great educational opportunities. Such sites allow us to learn about the changes that have occurred to the natural world. They can also be considered 'control' sites that allow us to benchmark other, altered habitats. The Yeo Lake area is biologically rich and diverse, presenting opportunities for scientific research and education. A biological survey (vertebrate fauna) of the Yeo Lake area was conducted by the WA Wildlife Research Centre (now Department of Environment and Conservation - DEC) in March 1976 (McKenzie and Burbidge 1979).

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. Yeo Lake lies just off the Anne Beadell Highway, a popular road for tourists that stretches for 1,025 km and is considered the four wheel drive alternative to the Nullarbor Plain (Cantrell and Cantrell 2007). The abandoned Yeo Station homestead has been restored by the Department of Conservation and Land Management (now DEC) to provide a camping shelter for travellers (Jaensch 1992). As a popular destination for an overnight rest break while travelling on the Anne Beadell Highway, Yeo Lake receives significant visitation from travellers.

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. The area around the neighbouring Lake Throssell has been used by Aboriginal people and has ethnographic (several ceremonial and mythological sites) and archaeological components (including painting and artefact sites). In the vicinity is an important mythological site which is a gazetted 'Protected Area' (since 1979, under the Aboriginal Heritage Act 1972) (Jaensch 1992). Some of these mythological sites are located on Hoffman Range, which is located in between Lake Throssell and Yeo Lake. A site containing Aboriginal artefacts is also located to the south of

Yeo Lake. Therefore, there is evidence that Yeo Lake provides significant spiritual value to Aboriginal people.

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 that the site's natural environment contributes to. Consumptive and productive uses of the natural environment are not usually considered as these are often incompatible with nature conservation. That said, Yeo Lake is valued for its consumptive uses by the local Aboriginal people, who are likely to use the lake in an ecologically sustainable manner.

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

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

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

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

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

Component	Summary description
Geomorphology	Megascale irregular elongate lake surrounded by scattered mesoscale to macroscale claypans, situated in the Officer Basin
Hydrology	Surface inflow along intermittent drainages and direct precipitation
Water Quality	Hypersaline, poikilohaline
Benthic Plants	Rich variety of halophytes (some endemic)
Littoral Vegetation	Samphire flats, low open-shrublands
Invertebrates	No data
Fish	No data
Birds	64 bird species previously recorded in Yeo Lake area, including 7 species of waterbird
Terrestrial Vertebrates	23 species of vertebrates found by McKenzie and Burbidge (1979). 9 species recorded by the WA Museum.

3.1. Geology and Soils

Yeo Lake is situated in the Officer Basin, in a wide, shallow Cainozoic depression over undifferentiated Permian-Mesozoic sedimentary rocks. The lake bed consists of Quaternary sand, silt and clay, and is covered by an indurated crust of crystalline gypsum and salt. The prevailing westerly winds have created low dunes on the eastern margins of the lake (Jaensch 1992). To the west, south-west and north of Yeo Lake are extensive sand plains and dunes interspersed with rocky hills and breakaways (Australian Government 1995).

3.2. Hydrology

Inflow to Yeo Lake is derived from two creeks, which enter from the south, and direct precipitation. The western creek is a linear drainage approximately 20 km long and the eastern one is a forked drainage approximately 15 km long. Yeo Lake and nearby Lake Throssell were formerly part of a major river system (the Throssell Palaeoriver) which flowed south-east to the ocean, but are now ponding areas for the modern internal drainage (Jaensch 1992).

Yeo Lake is episodically inundated. Although the lake is usually dry, its sediments are saturated with salt water. Data on Yeo Lake's water regime are lacking, but it is expected the maximum water depth when inundated may be no more than 0.1 m (Jaensch 1992).

3.3. Water Quality

Yeo Lake was dry at the time of sampling by the IAI RCM project; and so no water quality data were collected. While no historical quantitative data have been collected on the water quality of Yeo Lake, it has been described as 'probably hypersaline and poikilohaline' (Jaensch 1992). Following inundation, Yeo Lake is probably fresh initially, before becoming saline. The eastern watercourse which drains northward to Yeo Lake contained a series of freshwater pools (near the abandoned Yeo Homestead) in March 1976 (McKenzie and Burbidge 1979).

3.4. Benthic Plants

Benthic plants were not recorded by the IAI RCM project as Yeo Lake was dry at the time of sampling. The floor of Yeo Lake has previously been recorded as sparsely vegetated with a rich variety of halophytes, some of which were endemic (Australian Government 1995).

3.5. Littoral Vegetation

The floor of Yeo Lake is mostly bare, but extensive depressions and drainage channels associated with the lake are vegetated with a rich variety of halophytes (some endemic) (Jaensch 1992; Australian Government 1995). These include low shrublands of bluebush (*Maireana pyramidata*) and saltbush (*Atriplex* sp.) with Pigface (*Disphyma crassifolium* subsp. c*lavellatum*) and samphire (*Halosarcia* spp.) Small patches of the grass *Diplachne muelleri* and the shrub *Rutidosis helichrysoides* grow along the watercourses. Outlying pans are covered with a low open-shrubland of samphire, saltbush and Pigface (Beard 1974; Jaensch 1992). Between the pans are gypsum dunes, approximately 3 - 4 m in height. Distinctive vegetation changes occur at the base of these dunes. The dunes support low open-woodlands of *Callitris columellaris* and *Casuarina pauper* (to 7 m) over scattered saltbush and tufts of native grass (Jaensch 1992).

A vegetation transect was established within a samphire-dominated saline playa on the southern periphery of Yeo Lake (Table 2). The dunes to the north were dominated by *Casuarina obesa* and *Callitris columellaris* trees to 5 m tall, with a bare understorey on eroding soils (**Error! Reference source not found.**). The dunes to the south of the transect are dominated by *Acacia burkittii* low open woodland over *Jacksonia arida*, *Eremophila miniata*, *E. glabra* subsp. *glabra*, *E. serrulata* mid-high open shrubland over *Eragrostis eriopoda*, *Aristida* sp. mid-high sparse grasses (Figure 4).

Table 2 – Site attributes of the vegetation transect at Yeo Lake.

Datum			WGS84
Zone			51
Easting			636711
Northing			6895006
Length			30 m
Bearing			310
Wetland state			Dry
Soil state (%)		dry	0
		waterlogged	100
		inundated	0
Substrate (%)	Observed	bare	30
		rock	0
		cryptogam	0
		litter	0
		trash	0
		logs	0
	Expected	bare	30
		rock	0
		cryptogam	0
		litter	0
		trash	0
		logs	0
Time since last fire			no evidence
Community condition			Natural
Upper Stratum		Cover (%)	-
		Height (m)	-
Mid Stratum		Cover (%)	-
		Height (m)	-
Ground Cover		Cover (%)	45.5
		Height (m)	0.4

Figure 4 – Yeo Lake looking south with samphire-dominated shrubland in the foreground and *Acacia burkittii* dominated dunes in the background.

The vegetation transect was established within 20 m of the nearby dune system. Soils were waterlogged below the surface at the time of survey but there was no standing water. Vegetation consisted of a single stratum of *Tecticornia laevigata*, *T. pruinosa*, *T. calyptrata* low open chenopod shrubland (45.5% cover 0.4 m tall) (Figure 5). No other plant taxa were recorded along this transect (Table 3).

There was no evidence of recruitment by the *Tecticornia* spp. observed. The condition of the vegetation along the transect was considered 'natural' (Table 8 in Appendix 1), despite some minor disturbance by camels.

Figure 5 – Samphire shrubland along the vegetation transect at Yeo Lake.

Table 3 – Plant taxa recorded along the vegetation transect at Yeo Lake.

Genus	Species	Height (m)	Stratum[1]	Form
Tecticornia	*laevigata*	0.4	G1	Chenopod
Tecticornia	*pruinosa*	0.4	G1	Chenopod
Tecticornia	*calyptrata*	0.3	G1	Chenopod

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).

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

G1+ ^*Tecticornia laevigata*, *Tecticornia pruinosa*, *Tecticornia calyptrata*\^samphire shrub\1\c.

3.6. Aquatic Invertebrates

Yeo Lake was dry at the time of sampling by the IAI RCM project. Therefore, no aquatic invertebrates were collected. Yeo Lake has not been previously surveyed for invertebrates.

3.7. Fish

Yeo Lake was dry at the time of sampling by the IAI RCM project. Therefore, fish were not observed. No previous survey results were found and it is unlikely Yeo Lake would support fish.

3.8. Birds

Yeo Lake was dry at the time of sampling by the IAI RCM project. Therefore, a waterbird survey was not conducted. However, about sixty-four bird species were recorded in the Yeo Lake area by a biological survey in 1979. That survey included Yeo Lake and its associated claypans or fresh pools along ephemeral drainages (McKenzie and Burbidge 1979; Jaensch 1992). Waterbirds recorded in the Yeo Lake area included White-faced Heron (*Ardea novaehollandiae*), Grey Teal (*Anas gibberifrons*), Australian Wood Duck (*Chenonetta jubata*), Black-tailed Native Hen (*Gallinula ventralis*), Banded Plover (*Vanellus tricolor*), Black-fronted Plover (*Charadrius melanops*) and Red-kneed Dotterel (*Erythrogonys cinctus*). Some of the more abundant waterbird species included sixty Australian Wood Ducks, observed on a claypan near the Yeo Hills, and forty Banded Plovers, observed on claypans near the abandoned Yeo Homestead (approximately 6 km south of the lake) in May 1966.

3.9. Terrestrial Vertebrates

No evidence of native terrestrial vertebrates was observed during the 2008 IAI RCM survey. However, there was considerable evidence of camel presence.

The Yeo Lake area is rich in reptiles and provides suitable habitat for several species. During 1975 and 1976 the WA Wildlife Research Centre (now DEC) organised three wildlife surveys into desert regions of WA. The Yeo Lake Area, which includes Yeo Lake and its associated claypans or fresh pools along ephemeral drainages, was visited in March 1976 (McKenzie and Burbidge 1979). A list of species recorded during the survey is provided in Table 4. Museum records indicate several other reptiles occur in the area (Table 5).

Masses of tadpoles, belonging to the species *Cyclorana maini*, were reported in drying pools in Yeo Lake in March 1976 (McKenzie and Burbidge 1979; Jaensch 1992)

Table 4 – Vertebrate species found in the Yeo Lake Area by McKenzie and Burbidge (1979).

Scientific Name	Common Name
Amphibolurus clayi	Black-collared Dragon
Amphibolurus inermis	Ctenophorus nuchalis
Canis lupus familiaris	Common Dog
Ctenophorus fordi	Mallee Dragon
Ctenophorus isolepis	Central Military Dragon
Ctenophorus scutulatus	Lozenge-marked Dragon
Ctenotus brooksi	Wedgesnout Ctenotus
Ctenotus colletti	Buff-tailed Finesnout Ctenotus
Ctenotus dux	Fine Side-lined Ctenotus
Ctenotus grandis	Grand Ctenotus
Ctenotus helenae	Clay-soil Ctenotus
Ctenotus leae	Orange-tailed Finesnout Ctenotus
Ctenotus leonhardii	Leonhardi's Ctenotus
Ctenotus pantherinus	Leopard Ctenotus
Ctenotus piankai	Coarse Sands Ctenotus
Ctenotus quattordecimlineatus	Fourteen-lined Ctenotus
Ctenotus schomburgkii	Barred Wedgesnout Ctenotus
Macropus robustus	Common Wallaroo
Macropus rufus	Red Kangaroo
Notomys alexis	Spinifex Hopping-mouse

Scientific Name	Common Name
Pseudomys hermannsburgensis	Sandy Inland Mouse
Tachyglossus aculeatus	Short-beaked Echidna
Vespedalus finlaysoni	Inland Cave Bat

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

Accession ID/s	Scientific Name	Common Name	Year/s
R117148 R117149 R117150	*Ctenophorus reticulatus*	Western Netted Dragon	1993
R53564	*Ctenotus helenae*	Clay-soil Ctenotus	1976
R114536	*Egernia inornata*	Desert Skink	1992
R53536 R53537 R53538 R53539 R117146 R117147	*Gehyra purpurascens*	Purplish Dtella	1976 1993
R117145	*Gehyra variegata*	Variegated Tree Dtella	1993
R117143 R145047 R146766 R146772 R146791 R146796	*Heteronotia binoei*	Bynoe's Gecko	1993 2001
R53566 R117158	*Pogona minor*	Dwarf Bearded Dragon	1976 1993
R117144	*Strophurus strophurus*	Western Spiny-tailed Gecko	1993
R36683 R68886	*Varanus gouldii*	Gould's Goanna	

4. Interactions between Ecological Components at Yeo Lake

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

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

- the characteristics that make the site a good example of a wetland type occurring within a biogeographic region in Australia; and
- the site's outstanding historical and cultural significance.

Table 6 summarises the interactions between key components and processes at Yeo Lake. The table lists the components that are directly responsible for the provision of each service or benefit of the wetland and the biotic and abiotic factors that support or impact these components. Also listed are the key threats that may affect the components or processes. This information assists in the identification of the primary determinants of ecological character.

Table 6 – The relationship between the services and benefits delivered by Yeo Lake and the key components and processes that support them

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Consumptive Value Waterholes and bush tucker	Palatable plants and animals Freshwater pools associated with Yeo Lake	Plant pollinators Animal food sources	Hydrological regime Fire regime Habitat requirements Water quality	Overexploitation Salinisation Changed fire regimes Altered hydrology due to climate change, water extraction or catchment perturbation Weeds
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 Inappropriate fire regimes Weeds Competition with or predation by introduced fauna Excessive nutrient inputs from feral stock Trampling/erosion/pugging/grazing by feral stock
Ecosystem Service Value Good example of a wetland type occurring within a biogeographic region in Australia	Belongs to a system of salt lakes	Vegetation communities	Hydrological regime Water quality Geomorphology	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Excessive nutrient inputs from feral stock Trampling/erosion/pugging/grazing by feral stock Weeds

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Recreational Value Bird watching Picnicking Bush walking	Landscape amenity Waterbird populations Vegetation communities Significant flora Significant fauna	Invertebrate populations (food source) Phytoplankton (food source) Vegetation communities	Sediments Water quality Hydrological regime	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Inappropriate fire regimes Weeds Competition with or predation by introduced fauna Excessive nutrient inputs from feral stock Trampling/erosion/pugging/grazing by feral stock
Spiritual Value The wetland is of outstanding historical or cultural significance	Geomorphology of lake and surrounds Native flora and fauna communities Association with local Aboriginal history and culture	Flora and fauna populations Pollinators and food sources for above	Sediments Hydrology Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Inappropriate fire regimes Weeds Competition with or predation by introduced fauna Excessive nutrient inputs from feral stock Trampling/erosion/pugging/grazing by feral stock

5. Threats to the Ecology of Yeo Lake

The aim for management at Yeo Lake is to maintain those elements of the ecology that resulted in its nomination as a DIWA site. The critical components of the ecology are the geomorphologic, hydrologic and water quality factors that make the lake a good example of a saline lake in an arid zone and that maintain the Aboriginal heritage values of the site. Also of importance is Yeo Lake's suitable habitat for a rich diversity of flora, particularly endemic halophytes, and fauna, particularly reptiles. These factors are the primary determinants of the lake's ecological character. They are influenced by, and exert an influence on, the vegetation communities that surround the water body, the aquatic invertebrate and benthic vegetation communities that inhabit the water body and the threatening processes that face the flora and fauna of the water body and its surrounds. Also of importance are the elements of the system that contribute to its scientific and recreational value, which are the same influences as those on the primary determinants of Yeo Lake's ecological character, with the addition of landscape amenity.

Threats to Yeo Lake 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 7. In summary, failure to achieve the management goal for Yeo Lake is most likely to result from impacts of feral animals. The impacts of mining and climate change on Yeo Lake are unknown but could potentially affect the lake's ecology and should be monitored.

The integrity of Yeo Lake, an ex-pastoral lease, has already been altered by grazing of livestock (Handley 1996). Nevertheless, the lake's condition was assessed as good and improving, with recovery expected to occur in the short term with minimum intervention (Cowan and Barton 2002). This was attributed to the removal of stock when the pastoral lease was reclassified as a nature reserve, aiding in the recovery of the wetland system. Yamarna Station, an active pastoral lease adjacent to Yeo Lake Reserve, has been fenced. This fence will require maintenance to prevent livestock re-entering the reserve. This is particularly important considering the presence of camels in the area, which are known to frequently damage fences (DAg 2000).

The presence of feral animals within the Yeo Lake Reserve is an ongoing problem. Grazing and browsing occur in the vicinity of Yeo Lake and, while this appears to be having minor impacts on the values of the system, it does present a potential source of degradation. The saltbush-bluebush association of the salt lake is particularly palatable to camels (DAg 2000) and, given the low regrowth rate, is particularly vulnerable to overgrazing and consequent degradation (Jaensch 1992). Grazing removes native ground cover, providing a niche for weed establishment and allowing soil erosion to occur. Heavy grazing pressure will also kill larger plants, particularly when combined with excessive nutrient inputs from animal waste. Germinants and regenerating plants are highly susceptible to grazing, as they tend to be more palatable to herbivores. The loss of a generation of young plants to grazing can prevent the system from rebounding following events such as flood or fire. Erosion is also facilitated by soil disturbance from hoofed animals.

Evidence of a significant camel population was observed during the IAI RCM survey. The effect of camels on the vegetation was considered to be slight and the vegetation appeared to be in natural condition. However, water quality should be monitored for elevated nutrient levels, resulting from camel faeces. Other feral animals previously recorded in the area include goats, foxes, cats and house mice (McKenzie and Burbidge 1979; Cowan and Barton 2002).

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.

Table 7 – Threat assessment for Yeo Lake.

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

Goal: to maintain the geomorphology and hydrology of Yeo Lake, thus ensuring it retains its rich flora (particularly halophytes, some endemic) and fauna (particularly reptiles), 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 Yeo Lake, nor does there appear to be any likelihood of any alteration in the foreseeable future.
	Carbon cycle and climate change	1	1	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 Lake Ballard. The impacts of climate change are unclear and difficult to predict.
Impacts of introduced plants and animals	Environmental weeds	0	0	There was no evidence of weeds at Yeo Lake.
	Herbivory, wallowing and trampling by introduced species	5	2	The lake's peripheral chenopod vegetation is highly preferred for grazing and browsing by introduced and native animals, rendering it susceptible to overgrazing and consequent degradation. However, there is no evidence of this posing a significant threat to Yeo Lake. This threat is also readily addressed by fencing the lake to exclude larger feral herbivores such as goats or camels. Rabbits may be more difficult to control.
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	0	0	Fire is unlikely to significantly affect the predominately chenopod vegetation surrounding Yeo Lake. Large fires in the catchment may lead to increased sedimentation of the lake.
	Drought	0	0	Climate change projections for inland Australia show an increase in rainfall. Therefore, drought is unlikely to affect Yeo Lake.
	Flood	5	5	Alteration to rainfall and hydrological fluxes, associated with global climate change may impact on the vegetation of Yeo Lake. The nature of the impacts is not clear and should be monitored.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Impacts of pollution	Herbicide, pesticide or fertiliser use and direct impacts	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 Yeo Lake is low impact and unlikely to have any deleterious impacts.
	Nutrient enrichment of water body	?	?	Due to a lack of water quality data, it is unknown if nutrient enrichment occurs. However, the presence of camels and other feral animals makes this a likely possibility.
	Urban and industrial development	0	0	The surrounding land use includes Aboriginal usage and sparse settlement. The low population density of the region makes it unlikely that any development in the area would be pursued.
	Consumptive uses	0	0	There is no evident of current consumptive uses of Yeo Lake.
	Illegal activities	0	0	No evidence of any threat.
	Mines and quarries	?	?	No mines are operating in immediate vicinity. However, several mines exist in the subregion and a 13,000 km^2 mine has been proposed. Such catchment disturbance may affect the hydrology of Yeo Lake, but it is unknown how.
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	0	0	Yeo Lake is well 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

Yeo Lake has not previously been surveyed for aquatic invertebrates or water quality, and currently there is no information on its hydrological regime. As such, these are significant knowledge gaps that can be rectified with additional surveys when the lake is inundated. Such surveys would need to be conducted opportunistically, in response to rainfall events in the catchment.

On a subregional scale, knowledge gaps include fine scale vegetation and ecosystem mapping, a lack of systematic fauna survey, floristic data, and ecological and life history data. There are also no quantitative data on the effect of exotic predators, introduced herbivores or weed colonisation (Cowan and Barton 2002).

References

Australian Government. (1995) Yeo Lake Nature Reserve, Serpentine Lakes Rd, Cosmo Newbery Mission via Laverton, WA, Australia In *Australian Heritage Database*. Department of Environment, Heritage and the Arts. Accessed on 4 March 2009.

Beard, J. S. (1974) *The vegetation of the Great Victoria Desert area*. Explanatory notes to Sheet 3 of Vegetation Survey of Western Australia: Great Victoria Desert. University of Australia Press, Perth, Australia.

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

Cantrell, A., and Cantrell, J. (2007) Australian 4x4 Travel - The Anne Beadell Highway. <http://www.australian-4x4.com.au/anne-beadell-highway-australia.html> Accessed on 5 March 2009.

Cowan, M., and Barton, B. (2002) Great Victoria Desert 2 (GVD2 – Great Victoria Desert Central 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.

DAg. (2000) *Farmnote: Feral camel*. Farmnote 122/2000. Department of Agriculture and Food, Perth, Australia.

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.

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

Jaensch, R. P. (1992) Yeo Lake/Lake Throssell - WA044. In *Australian Wetlands Database*. Department of Environment, Heritage and the Arts. Accessed on 4 March 2009.

McKenzie, N. L., and Burbidge, A. H. (1979) The wildlife of some existing and proposed Nature Reserves in the Gibson, Little Sandy and Great Victoria Deserts, Western Australia. *Wildlife Research Bulletin Western Australia* **8**: 1-36.

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

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

Appendix 2 – Herbarium Plant Records

Plant specimens submitted to the Western Australian Herbarium:
Tecticornia calyptrata (RCM017-R1-03)
Tecticornia laevigata (RCM017-R1-04)
Callitris columellaris (RCM017-opp08)

Table 9 – Herbarium Records for Yeo Lake.

Search Coordinates: NW corner 27°25'23"S, 123°51'4 9"E; SE corner 28°19'01"S, 124°44'51"E

Family	Genus	Species	Rank	Infraspecies	Alien	Cons. Status
Adiantaceae	*Cheilanthes*	*sieberi*	subsp.	*sieberi*		
Amaranthaceae	*Alternanthera*	*denticulata*				
	Ptilotus	*aervoides*				
		chamaecladus				
Asteraceae	*Brachyscome*	*ciliaris*	var.	*lanuginosa*		
	Calotis	*multicaulis*				
		plumulifera				
	Cratystylis	*subspinescens*				
	Helipterum	*craspedioides*				
	Lawrencella	*davenportii*				
	Olearia	*eremaea*				
		incana				
	Rhodanthe	*charsleyae*				
		chlorocephala	subsp.	*rosea*		
		citrina				
		maryonii				
		stricta				
	Rutidosis	*helichrysoides*				
	Streptoglossa	*liatroides*				
	Vittadinia	*sulcata*				
Boraginaceae	*Halgania*	*cyanea*	var.	Allambi Stn (B.W. Strong 676)		
				cyanea		
Brassicaceae	*Lepidium*	*oxytrichum*				
	Stenopetalum	*anfractum*				
		lineare	var.	*lineare*		
Caesalpiniaceae	*Senna*	*artemisioides*	subsp.	*helmsii*		
		glutinosa	subsp.	*chatelainiana*		
		pleurocarpa	var.	*pleurocarpa*		
Casuarinaceae	*Casuarina*	*obesa*				
		pauper				
Chenopodiaceae	*Atriplex*	*nana*				
		vesicaria				

Family	Genus	Species	Rank	Infraspecies	Alien	Cons. Status
Chenopodiaceae	*Chenopodium*	*saxatile*				
	Halosarcia	*indica*	subsp.	*cf. bidens*		
	Maireana	*amoena*				
		carnosa				
		pentatropis				
		platycarpa				
		pyramidata				
		tomentosa	subsp.	*tomentosa*		
		villosa				
	Sclerolaena	*convexula*				
		cuneata				
		eurotioides				
		fimbriolata				
		patenticuspis				
		x georgei				
	Tecticornia	*pruinosa*				
Colchicaceae	*Wurmbea*	*deserticola*				
Convolvulaceae	*Bonamia*	*rosea*				
Cyperaceae	*Fimbristylis*	*dichotoma*				
		dichotoma (desert form)				
Frankeniaceae	*Frankenia*	*interioris*	var.	*interioris*		
		setosa				
		sp.				
Goodeniaceae	*Brunonia*	*australis*				
	Dampiera	*ramosa*				
	Scaevola	*collaris*				
Gyrostemonaceae	*Gyrostemon*	*ramulosus*				
Haloragaceae	*Haloragis*	*trigonocarpa*				
Lamiaceae	*Dicrastylis*	*exsuccosa*				
Loranthaceae	*Amyema*	*fitzgeraldii*				
		preissii				
	Lysiana	*exocarpi*	subsp.	*exocarpi*		
Malvaceae	*Abutilon*	*leucopetalum*				
	Alyogyne	*pinoniana*				
Marsileaceae	*Marsilea*	sp.				
Mimosaceae	*Acacia*	*abrupta*				
		aneura				
		burkittii				
		colletioides				
		ligulata				
		nyssophylla				

Family	Genus	Species	Rank	Infraspecies	Alien	Cons. Status
Mimosaceae	*Acacia*	*rhodophloia*				
		rigens				
Molluginaceae	*Mollugo*	*cerviana*				
Myoporaceae	*Eremophila*	*battii*				
		forrestii	subsp.	*forrestii*		
		gilesii	subsp.	*variabilis*		
		glabra	subsp.	*glabra*		
		homoplastica				
		miniata				
		oppositifolia				
		platythamnos	subsp.	*exotrachys*		
		serrulata				
		youngii	subsp.	*youngii*		
Myrtaceae	*Aluta*	*maisonneuvei*	subsp.	*auriculata*		
	Eucalyptus	*comitae-vallis*				
		concinna				
		effusa	subsp.	*exsul*		
		eremicola				
			subsp.	*peeneri*		
		glomerosa				
		lucasii				
		rigidula				
		sp.				
		trivalva				
		websteriana	subsp.	*websteriana*		
	Melaleuca	*eleuterostachya*				
	Micromyrtus	*hymenonema*				
Nyctaginaceae	*Boerhavia*	*coccinea*				
Papilionaceae	*Indigofera*	*georgei*				
	Jacksonia	*arida*				
	Swainsona	*canescens*				
		tenuis				
Pittosporaceae	*Pittosporum*	*angustifolium*				
Poaceae	*Enneapogon*	*polyphyllus*				
	Eragrostis	*dielsii*				
		falcata				
		kennedyae				
		laniflora				
		leptocarpa				
Poaceae	*Eragrostis*	*setifolia*				
	Iseilema	*eremaeum*				

Family	Genus	Species	Rank	Infraspecies	Alien	Cons. Status
Poaceae	*Paspalidium*	*clementii*				
	Tragus	*australianus*				
	Triodia	*schinzii*				
	Tripogon	*loliiformis*				
Proteaceae	*Hakea*	*lorea*	subsp.	*lorea*		
Pucciniaceae	*Uromyces*	*striatus*				
Rubiaceae	*Psydrax*	*suaveolens*				
Santalaceae	*Anthobolus*	*leptomerioides*				
	Exocarpos	*aphyllus*				
Solanaceae	*Duboisia*	*hopwoodii*				
	Nicotiana	*occidentalis*				
Stylidiaceae	*Stylidium*	*induratum*				
Zygophyllaceae	*Zygophyllum*	*aurantiacum*				
		compressum				
		iodocarpum				