

# Lake Mokoan ecological conditions discussion paper (LMFLUP)

Project 2005-45

Stage one of Lake Mokoan Future Land Use Plan

Prepared for:

Department of Sustainability and  
Environment/Goulburn-Broken CMA



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## Acronyms used in this report

AVW	Atlas of Victorian Wildlife
CMA	Catchment Management Authority
DNRE	Department of Natural Resources and Environment (now DSE)
DSE	Department of Sustainability and Environment
EES	Environmental Effects Statement
EIA	Environmental Impact Assessment
EPBC	Environment Protection and Biodiversity Conservation Act 1999
FFG	Flora and Fauna Guarantee Act 1988
FIS	Flora Information System
FSL	Full Supply Level
GMW	Goulburn Murray Water
LMFLUP	Lake Mokoan Future Land Use Plan
NES	National Environmental Significance
P&E	Planning and Environment Act 1987
VPO	Vegetation Protection Overlay

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## 1 Introduction

Ecology Australia was engaged as a sub-consultant to Beca Pty Ltd to contribute to the Lake Mokoan Future Land Use Plan (LMFLUP). The LMFLUP project has been commissioned by Department of Sustainability and Environment subsequent to the Victorian Government decision to decommission Lake Mokoan as a bulk water saving measure.

This report has been prepared as part of Stage 1 of the Land Use Strategy Development. It is a technical review to establish ecological features and issues prior to the development of assessment criteria for various land use options.

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## 2 Objectives

The Lake Mokoan Land Use Plan project is to address and deliver planning for the rehabilitation of wetlands and for the balance of the dryland and interface areas after the decommissioning of Lake Mokoan. The role of Ecology Australia within the consultant team is to provide a review of the ecological conditions and issues and inform the development of the ecological assessment criteria by which strategy options may be evaluated.

Based on the project brief and the project procedures manual prepared by Beca, we have taken the objectives of Stage One to be:

- review the past ecological studies of Lake Mokoan or the wider study area
- as far as possible, based on the information review and site visit:
  - establish existing biological values associated with the study area;
  - summarise important ecological processes in the study area (both past and present);
  - identify key ecological issues associated with the study area in a general sense (not specific to any single proposed land use strategy);
  - identify considerations for down-stream biota and ecological processes;
  - outline the relevance of current Native Vegetation policy to potential future land uses;
  - identify potential direct and indirect impacts on threatened flora and fauna and any legislative implications.
- identify what information gaps exist in returning the lake to the former swamp complex (Winton Swamp, Green Swamp and other lesser swamps).

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### 3 Scope of Work

This discussion paper is a review of existing information regarding the current and past values of Lake Mokoan. Its purpose is to inform the initial stages of a detailed LMFLUP that provides the planning framework and structure for future development of the area following decommissioning of the lake. It is important that information gaps are identified at this initial stage of the development of the LMFLUP, so that where necessary, these gaps can be filled.

The study area for the LMFLUP can be seen as three nested areas. The first (the primary study area) encompasses the lake and surrounding crown land or land owned by Goulburn-Murray Water (GMW), which extends up to and in some cases beyond full supply level (FSL). The primary study area also includes the inlet and outlet channels and their associated buffer strips owned by GMW. In a broader context, the study area is seen as anything within the view-shed, that is, extending to the ridgelines of the surrounding hills and to the Hume Freeway. The broader linkages in the landscape are also of relevance to the LMFLUP and these form the broadest layer of the tiered study area.

The primary study area is the main focus of this discussion paper. It falls mainly within the Victorian Riverina Bioregion, although part of the northern shore of Lake Mokoan extends into the adjacent Northern Inland Slopes Bioregion.

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## 4 Methods

The information review included numerous reports completed for the Lake Mokoan Restoration Project, historical information on Winton Swamp and more recent explorations of decommissioning options. The bulk of the literature reviewed was supplied by the Department of Sustainability and Environment (DSE) or was obtained from the Lake Mokoan website ([www.LakeMokoan.com](http://www.LakeMokoan.com)).

Two state-wide databases curated by the Department of Sustainability and Environment, the 'Flora Information System' (FIS) and 'Atlas of Victorian Wildlife' (AVW), were interrogated for flora and fauna records from the study area. For flora, the lake and its immediate vicinity (about 500 m above FSL) were searched for all records to evaluate the types and extent of data available, as well as a larger search area (10 km radius) to flag rare or threatened taxa which potentially occur within the study area. Identical areas were also searched for fauna records.

The Protected Matters Search tool at the Federal Department of the Environment and Heritage internet site (<http://www.deh.gov.au/epbc/>), was used to identify potential matters of relevance to the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the vicinity of the lake.

Ecological Vegetation Class modelling (pre-1750 and current) for the lake and surrounds was viewed (DSE 2003).

Several locations within the study area were inspected for flora and fauna values and ecological issues during an initial site tour with DSE (23 June 2005) and again on 13 July 2005. These visits were for the purposes of general reconnaissance. Detailed surveys were not undertaken; however notes were made on species present. Locations visited were: Boat Ramp on the northern shore, the Duck Pond, regenerating River Red Gum Woodland at the end of Humphries Lane and nearby unnamed swamp and the eastern-most borrow pit near the dam wall.

Discussions regarding the lake's decommissioning and proposed wetland restoration activities elsewhere were held with various wetland ecologists to glean further insights as to possible issues for consideration and any precedents which may exist.

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## 5 Legislation and policy

### 5.1 Federal *Environment Protection & Biodiversity Conservation Act 1999* (EPBC)

The EPBC establishes a national process for assessment of proposed actions that are likely to have a significant impact on matters of national environmental significance (NES) or on Commonwealth land (this includes listed threatened species and ecological communities, and listed migratory species).

The objects of this Act are:

- to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance; and
- to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and
- to promote the conservation of biodiversity; and
- to promote a co-operative approach to the protection and management of the environment involving governments, the community, land-holders and indigenous peoples; and
- to assist in the co-operative implementation of Australia's international environmental responsibilities; and
- to recognise the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity; and
- to promote the use of indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, the owners of the knowledge.

An action which has the potential for significantly impacting on matters of NES must be referred to the Federal Environment minister for a decision on whether or not the action requires approval under the EPBC Act. An action requiring approval is known as a 'controlled action', and the process of gaining approval can proceed in a number of ways. The level of assessment and documentation can vary from preliminary documentation through to a full Environmental Impact Assessment (EIA) (or accredited state Environment Effects Statement [EES]), or in rare examples to a Commission of Enquiry.

A number of EPBC-listed threatened species and communities, and also migratory/marine species, have been identified within the Lake Mokoan study area (see Chapter 7). Any action which changes the ecological character of the existing Lake Mokoan may also have an impact

on listed matters of NES. We believe that the decommissioning of Lake Mokoan is a matter which should be referred, and the likelihood of it being declared a controlled action (ie. requiring EPBC Act approval), currently based only on a desktop study of values, is moderate.

## 5.2 Victorian Flora & Fauna Guarantee Act 1988 (FFG)

The primary State legislation for the protection of flora and fauna in Victoria is the *Flora and Fauna Guarantee Act 1988* (FFG Act). The FFG Act builds on broader National and International policy in conservation of biodiversity.

The *FFG Act* was assented to on 24 May 1988. Under Section 70 of the FFG Act the *Wildflowers and Native Plants Protection Act 1958* was repealed. The 45 taxa (approximately 680 species) formerly protected under the *Wildflowers and Native Plants Protection Act 1958* were declared to be protected flora under Section 46 of the *FFG Act* on 25 September 1988.

Protected flora consists of:

- The approximately 680 species formerly protected under the *Wildflowers and Native Plants Protection Act 1958* declared to be protected flora by Governor in Council Order;
- Any other taxa declared to be protected by Governor in Council Order;
- And the fauna, flora taxa and communities listed on Schedule 2 of the *FFG Act 1988*.

A number of FFG-listed threatened species and communities, and threatening processes, have been identified within the Lake Mokoan study area (see Chapter 7).

## 5.3 Victorian Catchment & Land Protection Act 1994 (CaLP)

Declared noxious weeds in Victoria are plants that have been proclaimed under the *Catchment and Land Protection (CaLP) Act 1994*. These plants cause environmental or economic harm or have the potential to cause such harm, and can also present risks to human health. There are four categories of noxious weeds defined under the Act:

- State Prohibited Weeds
- Regionally Prohibited Weeds
- Regionally Controlled Weeds
- Restricted Weeds.

A number of declared noxious weed species (declared for the North East region under the *CaLP Act*) have been identified at Lake Mokoan. These weeds and their status are identified in Table 1.

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## 5.4 Native Vegetation Framework – ‘Net Gain’ policy

Victoria has adopted a policy of ‘Net Gain’ with regards to native vegetation. This approach is presented in the DNRE (now DSE) publication: *Victoria’s Native Vegetation Management: a framework for action* (NRE 2002b). The Framework specifically focuses on achieving biodiversity goals on private land, in the context of modification and clearing of native vegetation.

The implementation of Net Gain is part of Victoria’s Biodiversity Strategy (DNRE 2002b). The Biodiversity Strategy has been prepared under Section 17 of the *Flora and Fauna Guarantee Act 1988*. Being a statutory document, government agencies are required to respond appropriately to its intent and direction. The Strategy has also been incorporated into the Victorian Planning Provisions, which requires planning authorities to have regard for the Strategy in their planning work.

Net Gain may be relevant to the consideration of future land use at Lake Mokoan in two ways:

1. Any proposal which involves loss of native vegetation will need to satisfy the three step approach set out in the framework (explained below).
2. Revegetation and restoration or management of areas of indigenous vegetation may be regarded as ‘gains’ and therefore could potentially be used as off-sets for losses occurring elsewhere in the bioregion.

The three-step approach which must be applied to satisfy the requirement of Net Gain involves demonstration of:

1. Avoidance of adverse impacts, particularly through vegetation clearance.
2. If impacts cannot be avoided, minimization of impacts through appropriate consideration in planning processes and expert input to project design or management.
3. Identification of appropriate offset options.

Offsets are required to compensate for the losses associated with the proposed works. Appropriate offsets are determined by first quantifying the losses and determining the conservation significance of the vegetation being lost.

With regards to the potential for ‘gains’ to be made on the Lake Mokoan site, if the proponent of a development elsewhere (preferably within the bioregion) is seeking a site to meet offset obligations, these gains may attract financial backing. Such an arrangement would be subject to negotiations with DSE, and would not necessarily require such a proponent to take ownership of the land.

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## 5.5 Benalla Planning Scheme – Victorian *Planning & Environment Act 1987* (P&E)

Planning Schemes contain goals, actions, policies and other provisions designed to bring about planning outcomes outlined in Section 4(1) of the Victorian *Planning & Environment Act 1987* (*P & E Act*). Of the seven *P&E Act* objectives, the three most relevant to biodiversity conservation are as follows:

- To provide for the fair, orderly, economic and sustainable use and development of land.
- To provide for the protection of natural and man-made resources and the maintenance of ecological processes and genetic diversity.
- To conserve and enhance those buildings, areas or other places which are of scientific, aesthetic, architectural or historical interest, or otherwise of special cultural value.

Relevant issues and proposed solutions from the Benalla Planning Scheme's Environment Strategy (DSE 2005) are as follows:

### Issues

- Removal of native vegetation and its affect on salinity and ground water.
- Pressure from residential and recreational uses on water quality and the environs of waterways and lakes.
- Important natural values of the municipality's waterways.

### Strategies and Objectives

- Protect the natural values of the municipality's rivers.
- Prevent development in the catchment that is detrimental to water quality.
- Protect land and waterways from further degradation.

### Implementation

- Develop programs to reduce water turbidity and to prevent toxicants reaching streams.

### Native flora and fauna

The Benalla Planning Scheme acknowledges that large areas of native vegetation within the municipality have been cleared since settlement for agriculture and other land uses. Although the rate of clearing has slowed, the incremental loss of remaining vegetation is still a major

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issue in the municipality, for example in the Warby Ranges and Chesney Vale areas. Protection of remnant vegetation within the municipality is a high priority.

### **Zoning and overlays**

Most of the landscape surrounding Lake Mokoan is zoned Rural Use Zone (RUZ).

The lake surface, inlet and outlet channels are zoned Public Use Zone (PUZ1 – Service & Utility), and the perimeter has a discontinuous narrow band which is zoned Public Park and Recreation Zone (PPRZ).

Between Chesney Vale Road and McGann Hill Road, adjoining Lake Mokoan Road, a small area is zoned Rural Living Zone (RLZ), and directly abuts another small area zoned Public Conservation and Resource Zone (PCRZ).

There are no environmental significance (ESO) or vegetation protection (VPO) overlays covering Goulburn-Murray land on and around Lake Mokoan, though land around the town of Winton on the east side of the Hume Freeway (several hundred metres east) is covered by a VPO.

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## 6 Literature Review

The available literature relevant to the ecology of Lake Mokoan is summarised in Appendix 4.

The vegetation of the Winton Swamp wetland complex, including a species inventory, was documented by Helen Aston of the National Herbarium (1959-62). In the two decades after the creation of Lake Mokoan in 1968 it appears little or no ecological data were collected. Although some of the more recent literature makes reference to the lake being macrophyte-dominated for the first decade or so of operation (e.g. Lloyd 2004), no studies documenting plant or animal species using the lake during this period are available.

The main body of literature available on Lake Mokoan was generated during the 1990 as part of the Lake Mokoan Restoration Project, in response to loss of macrophytes, high turbidity and blue-green algal blooms. Several studies were undertaken for GMW and the Goulburn-Broken CMA by AWT (formerly Water Ecoscience). These studies were targeted at aspects of lake ecology perceived as integral to improving water quality and included various revegetation trials including macrophyte transplants and direct seeding along the shoreline (Appendix 4). Although some 'vegetation assessments' were conducted as part of this work, such assessments were not systematic inventories of vegetation around the lake and were concerned primarily with vegetation function (e.g. turbidity reduction and erosion control) rather than indigenous flora biodiversity or fauna habitat opportunities.

The most recent additions to the Lake Mokoan ecological literature are the reports associated with the proposed decommissioning of the lake. The SKM report on water savings in bulk systems evaluated in broad terms the likely ecological impacts and gains of draining the lake and other options. The Lake Mokoan Study by URS made more detailed evaluations for each of the options and included statements regarding downstream ecological impacts and general guidelines for revegetation, yet did not involve collection of biological data for the lake or any other parts of the study area. This document raises numerous environmental considerations that are highly applicable to the current study, however the lack of adequate base data on the biota of the lake limits the authority of predictions made and means many important considerations such as high threat weeds and/or threatened taxa may not have been adequately considered.

The study of Lloyd (2004), titled "One Scenario for the Rehabilitation of Wetlands and Marginal Lands at the Lake Mokoan Site", which is once again a review based on previous data and ecological theory rather than recent field observations, broadly identifies many of the issues likely to be encountered in the rehabilitation of wetland complexes. The report also summarises conceptual models of current ecosystem function at Lake Mokoan and potential future ecosystem function for restored wetlands.

## 7 The former wetland system

Lake Mokoan was created over an existing major wetland system, the major water-body being known as Winton Swamp. The original wetland complex was described in the 1950s and 1960s by Helen Aston, a wetland ecologist and plant taxonomist at the National Herbarium of Victoria. Her main observations were made in February 1959 and August 1962 (Aston 1959, 1962 and 1991), and reflect the receding water and plant community structure at the time of the year when surveyed.

The complex consisted of three large wetlands, the Central and Western Wetlands in what is now the western half of Lake Mokoan, and Greens Swamp immediately to the north-east. Green Swamp was the shallowest and was separated from the Central Wetland by a wide neck. A number of smaller wetlands also lay to the east of these larger wetlands, including Ashmeads, Humphries, Taminick, Black and Lindays Swamps.

The Winton Swamp wetland complex would have made a very significant contribution to regional biodiversity and the resilience of the fauna and flora population to environmental stress. The system featured a wide range of habitat components that would have supported diverse plant, bird, fish and invertebrate communities. The system was large (approximately 3,000 ha) and would have had a high carrying capacity for dependent species. The structure and floristics of vegetation of the Central and Western Wetlands indicates a hydrological regime of regular flooding, and the system was probably a drought refuge for waterbirds and other fauna.

The former swamp complex would have experienced a natural wetting and drying cycle, although there is no data on the typical frequency and extent of fluctuation in this cycle. Some reports from local community members who remember the former swamps suggest that Greens Swamp (the Red Gum swamp in the eastern section) would dry out most summers whereas Winton Swamp, which was deeper and comprised some expanses of open water, would only dry out in drought years. It is not clear whether these reports of 'drying' refer to total drying of the swamp beds or low water level periods when there would be no visible expanses of water (water potentially being obscured by emergent vegetation). Vegetation was apparently able to cope well with this drying cycle, as Aston's notes suggest abundance of aquatic vegetation (especially Cane Grass *Eragrostis infecunda*) and low turbidity levels during higher water level periods. Further anecdotal evidence suggests the pre-European water level during wet periods would have been two or three feet higher than high water levels observed in the 1950s and 60s, due to a lowering of the swamp in the late 19<sup>th</sup> or early 20<sup>th</sup> century to provide increased grazing country around the margins (Briggs 2003).

Winton Swamp is believed to have only discharged into the Broken River downstream in Spring of some years (URS 2003a; p.3-25)

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## 8 Existing ecological conditions

### 8.1 Non biological features

At Full Supply Level (FSL) Lake Mokoan occupies approximately 8,000 ha. It is currently filled to approximately 20 % capacity, and there is therefore a substantial area of dryland (with minor natural depressions forming ephemeral wetlands) within the primary study area. The lake last reached FSL in 1993, and it rose to approximately 70 or 80% FSL in 1997.

The current topography of the inundated land is uncertain: erosion and sedimentation is likely to have had some impact on the shape of the lake bottom over the past 30+ years and some local residents report up to 2 metres of soil shift, indicated by buried fence-posts in recently exposed areas of the lake. A GIS project conducted in 1998-99 included a bathymetric study concentrating on the western part of the lake. This study found some minor shifts in topography but the general landform of the former Winton Swamp was still clearly present. An updated and complete bathymetric study of the lake, coupled with land surveying of exposed areas up to full supply level, is required to determine whether the natural wetland levi-banks and other landforms are still present.

Some intentional alterations to topography have also occurred during the history of the lake. One such change is the channel dredged from the former Winton Swamp to the current dam wall. This channel is believed to be quite silted-up and narrow; however it may prevent the former swamp from holding its former water level once the lake is drawn down. Other alterations include the construction of the Duck Pond (an artificial wetland in the north-eastern corner of the lake) and the borrow pits, and more recently the construction of embankments to catch runoff and nutrients where Seven Mile and Eleven Mile Creeks drain into the lake – thus creating artificial wetlands at these two locations below FSL. The dam wall itself is a major topographic alteration to the original wetland landscape, involving approximately 1 million cubic metres of rock and other material being deposited.

The catchment of the former swamp complex remains more or less unmodified in terms of waterflows, with the exception of the inlet and outlet channels. The 17 km long inlet channel does not correspond to a natural drainage line and would therefore not contribute to the filling of the wetlands after decommissioning. The 8km long outlet channel follows Stockyard Creek, this having originally been the natural discharge outlet from the wetland complex.

The soil types around the lake area reportedly variable however heavy clays are the dominant soil type in the south-eastern part of the lake, giving rise to the former Gilgai formation (ie. crabholey terrain). The DPI soil mapping available for the area shows major soil types to be Grey, Brown and Yellow Sodosols and Grey Vertosols (DPI 2005). Shoreline erosion has resulted in loss of topsoil around the perimeter of the lake and some local residents report a

complete lack of topsoil from expansive areas below FSL. It is not known what affect the long period of inundation has had on soil chemistry. A soil study is required to establish the types of soils present, how they have been affected by the lake, and their suitability for proposed future land uses.

## 8.2 Flora

Dryland, littoral and inundated habitats around Lake Mokoan are vegetated to a greater or lesser extent by indigenous and exotics species. Despite numerous revegetation trials and 'vegetation surveys' being carried out in the 1990s as part of the Lake Mokoan restoration program (see Appendix 4), no comprehensive inventories are known to have been conducted. Lake vegetation surveys were primarily concerned with establishment of macrophyte cover (for the role played in turbidity reduction) and recorded only common or dominant species. No dryland surveys are known to have been conducted.

### Species diversity

A review of records held in the Flora Information System (administered by DSE) revealed only 76 species within a search area which extended approximately 500m beyond full supply level (Table 1). The AWT macrophyte and shoreline survey data has apparently not been entered into the database. A site reconnaissance over several hours during a visit by EA in preparation for this report (13 July 2005) recorded more than 20 species that were not known from the FIS data review or from the AWT surveys, including a probable record of the EPBC listed Swamp Wallaby Grass (*Amphibromus fluitans*) and confirmed record of Purple Love Grass (*Eragrostis lacunaria*) which is Vulnerable in Victoria (DSE 2005). This highlights the substantial lack of data available at present; a survey of the full range of habitats associated with the lake would reveal many more indigenous and exotic plant species.

Given the paucity of data available for the immediate surrounds of the lake, a broader search area (10 km radius) was also reviewed on the FIS. This search revealed that 13 rare or threatened plant taxa have been recorded, including two EPBC listed taxa (Table 2). Most are dryland species and are therefore unlikely to be dependent on the lake but they may occur on the dryland slopes within the study area. Others are known from wetland fringes, soaks or poorly drained sites and may be present below full supply level.

Few of the records from the former Winton Swamp (Ashton 1959 and 1962) have been entered into the FIS database. A review of the species lists prepared by Ashton (1962) reveal three wetland species of state significance further to those listed in Table 2. They are: *Najas tenuifolia* (Water Nymph), *Lipocarpus microcephala* (Button Rush) and *Gratiola pedunculata* (Stalked Brooklime). It appears that these species and their habitats were lost in the flooding of the

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former wetlands. The potential for habitat restoration and re-introduction of these species to the restored wetlands requires further investigation.

Exotic species are a major component of the littoral and dryland areas of the study area. As for the indigenous species, current paucity of field data records means actual weed diversity is unknown, however the data review has confirmed the presence of numerous environmental weeds and at least 10 species listed on the Catchment and Land Protection Act as either Regionally Controlled, Regionally Prohibited or State Prohibited (Table 1). Serrated Tussock (*Nassella trichotoma*), a weed of National Significance, is known from within or adjacent to the study area.

Table 1: Plant species recoded within approximately 500m of FSL at Lake Mokoan according to records in the Flora Information System, indicating weeds and their status where appropriate.

Note: includes some records from pre-lake construction but apparently does not include data collected by AWT in the 1990s and early 2000s

C = Regionally controlled; S = State Prohibited; R = Regionally Prohibited; WONS= Weed of National Significance

An asterisk denotes exotic (introduced) species

	Name	Common name	Weed status
	<i>Acacia aspera</i>	Rough Wattle	
*	<i>Aster subulatus</i>	Aster-weed	
	<i>Brachyscome basaltica</i> var. <i>gracilis</i>	Woodland Swamp-daisy	
	<i>Carex tereticaulis</i>	Poong'ort	
	<i>Centipeda cunninghamii</i>	Common Sneezeweed	
	<i>Chenopodium pumilio</i>	Clammy Goosefoot	
	<i>Chloris truncata</i>	Windmill Grass	
*	<i>Cirsium vulgare</i>	Spear Thistle	C
*	<i>Conyza</i> spp.	Fleabane	
	<i>Correa glabra</i> var. <i>glabra</i>	Rock Correa	
	<i>Cynodon dactylon</i>	Couch	
*	<i>Cyperus eragrostis</i>	Drain Flat-sedge	
	<i>Cyperus gymnocaulos</i>	Spiny Flat-sedge	
*	<i>Digitaria sanguinalis</i>	Summer Grass	
	<i>Dysphania glomulifera</i> ssp. <i>glomulifera</i>	Globular Pigweed	
*	<i>Echinochloa crus-galli</i>	Barnyard Grass	
*	<i>Echinochloa muricata</i> var. <i>microstachya</i>	Prickly Barnyard-grass	
*	<i>Echium plantagineum</i>	Paterson's Curse	C
	<i>Epilobium billardierianum</i>	Variable Willow-herb	
	<i>Eragrostis diandra</i>	Close-headed Love-grass	
	<i>Eragrostis parviflora</i>	Weeping Love-grass	
	<i>Eucalyptus camaldulensis</i>	River Red-gum	
	<i>Eucalyptus melliodora</i>	Yellow Box	
	<i>Eucalyptus microcarpa</i>	Grey Box	
	<i>Glinus lotoides</i>	Hairy Carpet-weed	
	<i>Glossostigma</i> spp.	Mud Mat	
V v	<i>Goodenia macbarronii</i>	Narrow Goodenia	
*	<i>Hordeum hystrix</i>	Mediterranean Barley-grass	
*	<i>Hypericum perforatum</i> subsp. <i>veronense</i>	St John's Wort	C
*	<i>Hypochoeris radicata</i>	Cat's Ear	
	<i>Isoetes muelleri</i>	Rock Quillwort	
*	<i>Isolepis hystrix</i>	Awned Club-sedge	
	<i>Isolepis marginata</i>	Little Club-sedge	
	<i>Isolepis</i> spp.	Club Sedge	
	<i>Juncus aridicola</i>	Tussock Rush	

Name	Common name	Weed status
<i>Juncus bufonius</i>	Toad Rush	
<i>Juncus flavidus</i>	Gold Rush	
<i>Juncus holoschoenus</i>	Joint-leaf Rush	
<i>Juncus semisolidus</i>	Plains Rush	
<i>Juncus spp.</i>	Rush	
<i>Lachnagrostis filiformis</i>	Common Blown-grass	
<i>Lachnagrostis filiformis var. l</i>	Common Blown-grass	
* <i>Lolium perenne</i>	Perennial Rye-grass	
* <i>Lotus angustissimus</i>	Slender Bird's-foot Trefoil	
<i>Lythrum hyssopifolia</i>	Small Loosestrife	
* <i>Marrubium vulgare</i>	Horehound	C
* <i>Nassella trichotoma</i>	Serrated Tussock	P (WONS)
<i>Panicum spp.</i>	Panic	
* <i>Paspalum dilatatum</i>	Paspalum	
* <i>Paspalum distichum</i>	Water Couch	
<i>Persicaria hydropiper</i>	Water Pepper	
<i>Persicaria lapathifolia</i>	Pale Knotweed	
<i>Persicaria prostrata</i>	Creeping Knotweed	
* <i>Physalis viscosa</i>	Sticky Ground-cherry	P
* <i>Polygonum arenastrum</i>	Wireweed	
<i>Pseudognaphalium luteoalbum</i>	Jersey Cudweed	
<i>Pseudoraphis spinescens</i>	Spiny Mud-grass	
* <i>Reseda luteola</i>	Weld	C
* <i>Rosa rubiginosa</i>	Sweet Briar	C
* <i>Rubus polyanthemus</i>	Blackberry	C
<i>Rumex spp.</i>	Dock	
<i>Rumex tenax</i>	Narrow-leaf Dock	
<i>Senecio quadridentatus s.l.</i>	Cotton Fireweed	
* <i>Setaria spp.</i>	Pigeon Grass	
* <i>Solanum nigrum</i>	Black Nightshade	
* <i>Sonchus asper s.l.</i>	Rough Sow-thistle	
* <i>Sonchus oleraceus</i>	Common Sow-thistle	
<i>Swainsona procumbens</i>	Broughton Pea	
* <i>Trifolium angustifolium var. angustifolium</i>	Narrow-leaf Clover	
* <i>Trifolium arvense var. arvense</i>	Hare's-foot Clover	
* <i>Trifolium glomeratum</i>	Cluster Clover	
* <i>Trifolium striatum</i>	Knotted Clover	
* <i>Trifolium subterraneum</i>	Subterranean Clover	
* <i>Vellereophyton dealbatum</i>	White Cudweed	
* <i>Xanthium spinosum</i>	Bathurst Burr	C
* <i>Xanthium strumarium spp. agg.</i>	Noogoora Burr species aggregate	S

Table 2: Rare or threatened plant taxa that have been recorded within 10 km of Lake Mokoan according to Flora Information System records

Note 'Wetland' species is used here to denote species of wet or waterlogged conditions, not necessarily confined to more permanent wetlands.

	Name	Common Name	Dryland (D) or Wetland (W)
k	<i>Caesia parviflora</i> var. <i>vittata</i>	Pale Grass-lily	D
v	<i>Digitaria divaricatissima</i>	Umbrella Grass	D
f e	<i>Dipodium hamiltonianum</i>	Yellow Hyacinth-orchid	D
f v	<i>Diuris punctata</i> var. <i>punctata</i>	Purple Diuris	D
r	<i>Eriocaulon scariosum</i>	Common Pipewort	W
v	<i>Fimbristylis dichotoma</i>	Common Fringe-sedge	W
f V v	<i>Goodenia macbarronii</i>	Narrow Goodenia	W
r	<i>Goodia medicaginea</i>	Western Golden-tip	D
r	<i>Hybanthus monopetalus</i>	Slender Violet-bush	D
r	<i>Pterostylis hamata</i>	Scaly Greenhood	D
r	<i>Pultenaea platyphylla</i>	Flat-leaf Bush-pea	D
f e	<i>Santalum lanceolatum</i>	Northern Sandalwood	D
f E e	<i>Swainsona recta</i>	Mountain Swainson-pea	D

f=Listed under Schedule 2 of the *Flora and Fauna Guarantee Act 1988*. Ee = Endangered (Nationally and Victoria respectively), Vv = Vulnerable (nationally and Victoria respectively); k = poorly known; r = rare in Victoria

## Vegetation types

Persisting indigenous vegetation in the study area, although scarce and frequently confined to scattered trees, is indicative of former communities or Ecological Vegetation Types. DSE's modelling of pre-1750 EVCs in the area has also been used for speculating on the former vegetation types present and assessing extant values. Although current EVC modelling shows only two or three EVCs persisting as very small remnants around the lake, the pre 1750s modelling indicates a mosaic of wet and dryland vegetation types would have occurred across the former wetlands and surrounding plains now occupied by the lake and its fringing vegetation (Figure 1). These types are broadly outlined below.

### Wetland vegetation

According to EVC modelling, the wetland complex flooded by Lake Mokoan (or occurring within FSL) would have included:

- Wetland Formation (EVC 74) – in the deepest parts of the central and western areas (the old Winton Swamp)
- Red Gum Wetland (EVC 235) – the north-eastern section known as Greens Swamp

- Plains Grassy Woodland/Gilgai Plains Woodland/Wetland Mosaic (EVC 294) – in the north-eastern section, extending almost to or beyond FSL

All three EVCs are regarded as Endangered in the Victorian Riverina Bioregion (DSE 2005b). Extant EVC mapping and field observations suggest a degraded form of the third EVC (Plains Grassy Woodland/Gilgai Plains Woodland/Wetland Mosaic) is currently occupying an area of unknown extent near the Eleven Mile Creek wetland.

Red Gum Wetland and Wetland Formation are not mapped as being extant in the study area, and all former examples are now flooded, however the constructed wetlands of the Duck Pond, Seven and Eleven Mile Creeks, and the Borrow Pits near the dam wall probably represent a derived form of ‘Wetland Formation’ or other wetland EVC.

The former Red Gum Wetland area (Greens Swamp) would probably have supported “Red Gum Swamp Community”, which is listed under the *Flora and Fauna Guarantee Act 1988*.

### **Dryland vegetation**

According to EVC modelling, the dryland vegetation occurring within the Lake Mokoan FSL prior to European settlement would have included:

- Lunette Woodland (EVC 652) – the uplifted area now known as ‘the spit’
- Plains Grassy Woodland (EVC 55) – the major vegetation type of dryland areas surrounding the former wetland complex
- Box Ironbark Forest/Grassy Woodland complex (EVC 247) – on the slopes north of the old Winton Swamp, extending down to the waters edge midway along the northern shore (note that this area is in the Northern Inland Slopes Bioregion rather than Victorian Riverina)
- Riverina Plains Grassy Woodland/Shrubby Granitic Outwash Grassy Woodland (EVC 234) – on the northern shore, north of the former Greens Swamp
- Grassy Woodland (EVC 175) – extends down to part of what is now the northern shore
- Creekline Grassy Woodland (EVC 68) – a strip along Eleven-mile and Seven-mile Creeks.

All are considered Endangered in the Victorian Riverina Bioregion (or Northern Inland Slopes Bioregion for those occurring in this bioregion in the study area), with the exception of Box Ironbark Forest/Grassy Woodland Complex, which is considered Vulnerable (DSE 2005b).

There is no doubt that some remnant vegetation derived from one or more of the above-listed dryland communities does persist in the study area, however the condition, extent and distribution of such remnants can only be evaluated with further fieldwork.

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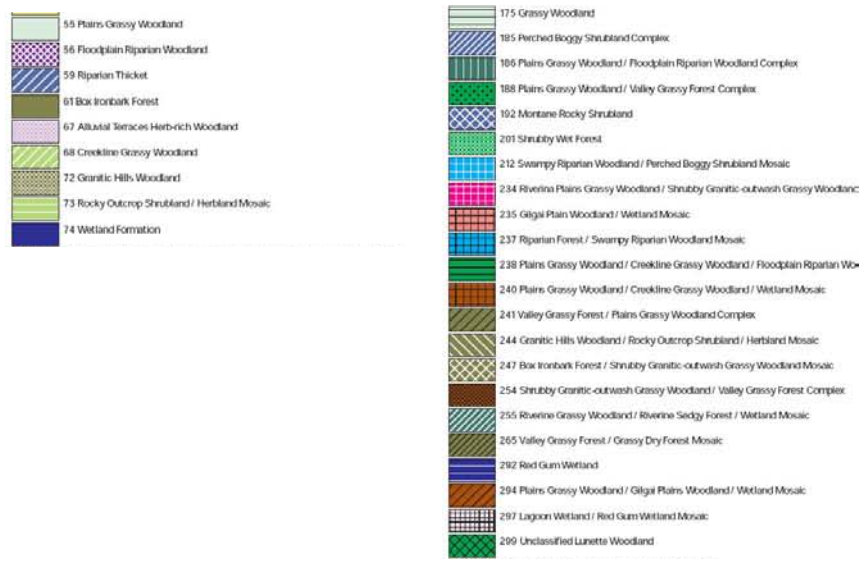
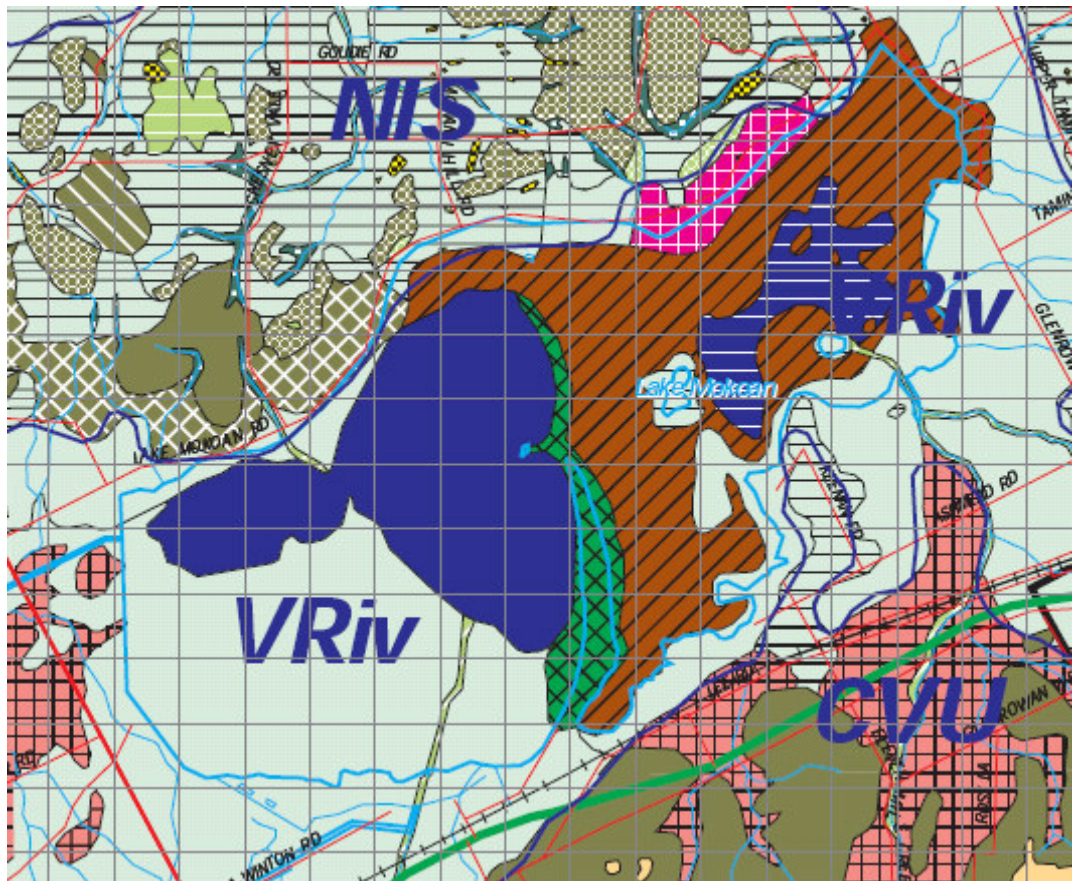
Two EPBC-listed communities are known from the area, these being:

- Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions;
- Grassy White Box Woodlands

Remnant indigenous vegetation that was observed during the field visit, particularly trees, indicate that these listed communities formerly existed within the study area. They may have occurred as part of one or more of the above-listed EVCs that are likely to have occupied the study area. The quality and extent of these remnants needs to be determined by field survey.

Dryland areas in the study area were also observed to support planted Australian natives, mostly exotic to the region. It is possible that some remnant indigenous species have recolonised the understorey or persist in or adjacent to these revegetated areas, and if so, any proposal to clear these revegetated areas may trigger Net Gain. Some of the exotic trees planted are naturalising and are therefore regarded as weeds.

Figure 1: Pre-1750 EVC modelling of the Lake Mokoan study area and surrounds.



### 8.3 Terrestrial fauna

Lake Mokoan is on the boundary of the Northern Inland Slopes and Victorian Riverina bioregions, and the relatively species-rich fauna of the area is a reflection of the habitat diversity resulting from its position – on the transition between southern and northern biogeographic influences.

The wetland fauna includes most of the common waterbirds and frogs encountered in freshwater systems across north-east Victoria, as well as a number of threatened and significant species. Likewise the dryland habitats (essentially grassy woodland and grassland) contain a suite of moderately common birds, reptiles and mammals, as well as a number of threatened and significant species. The connectivity of dryland habitats around the lake with that in the nearby hills (Chesney Vale Hills and Warby Ranges) is crucial for maintaining a diverse dryland fauna component in the matrix of wetland/dryland habitats of Lake Mokoan.

The numerous large stags (dead trees) that occur within the lake (resulting from the flooding of the lake) are likely to be providing, or have the potential to provide, valuable fauna habitat for some species. The main species currently using these trees appears to be Little Corellas (nesting in hollows and using them as roost trees). The FFG listed White-bellied Sea-Eagle has apparently nested in these stags. Terrestrial reptiles and mammals may find suitable habitats in these stags when the water level is drawn-down, however the extent and quality of suitable habitat stags is not known at this stage. The lake is likely to also contain some fallen stags (large logs) which may be providing aquatic habitats for fish and invertebrates.

#### Species diversity

The 10km radius Data Review Area (DRA) around Lake Mokoan contains 225 terrestrial fauna species (from the AVW and additional records), as follows:

- Birds (190 species of which six are exotic);
- Mammals (13 species of which four are exotic);
- Reptiles (15 species);
- Frogs (seven species).

During site reconnaissance of the primary Lake Mokoan study area for this project, a total of 57 fauna species were recorded, as follows:

- Birds (51 species of which one is exotic);
- Mammals (three species of which two are exotic);

- Frogs (three species).

Fauna either known, or regarded as at least moderately likely, to occur within Lake Mokoan and its immediately surrounding dryland habitats included a number of species of conservation significance (Tables 3, 4 & 5), including:

- Four nationally threatened species listed under the *EPBC Act*;
- 14 nationally threatened species listed under national action plans;
- 25 species and one community threatened in Victoria and listed under the *FFG Act*;
- 14 species threatened in Victoria and included in DSE's (2003) advisory list.

### **Wetland fauna**

The range of wetland habitats represented in Lake Mokoan can be broken down into five broad groupings:

- Open water – varying depths;
- Standing water with dead trees;
- Mud flats;
- Marsh with macrophytes (eg. Duck Pond); and
- Small pools with fringing macrophytes (eg. borrow pits).

Of the 39 threatened species either known, or regarded as at least moderately likely, to occur within Lake Mokoan and its immediately surrounding dryland habitats, 23 of these utilise wetland habitats.

Noteworthy examples of threatened wetland fauna at Lake Mokoan include the:

- White-bellied Sea-Eagle *Haliaeetus leucogaster* (FFG listed), which has nested in dead trees in the lake (AVW);
- Hardhead *Aythya australis* and Australasian Shoveler *Anas rhynchotis* – two duck species regarded as Vulnerable in Victoria (DSE 2003), which are invertebrate and plankton eaters (respectively);
- Australasian Bittern *Botaurus poiciloptilus* (FFG listed, and regarded as nationally Vulnerable (Garnett & Crowley 2000)); a large secretive bird which is largely confined to macrophyte beds (Cumbungi and reeds).

### **Dryland fauna**

Dryland habitats of Lake Mokoan and surrounds include these broad groupings:

- Grassy woodland;
- Plantations of Australian native but not indigenous trees and shrubs; and
- Grassland.

Of the 39 threatened species either known, or regarded as at least moderately likely, to occur within Lake Mokoan and its immediately surrounding dryland habitats, 18 of these utilise dryland habitats – many of these species (up to 19 – 20) are included in the FFG listed community ‘Victorian Temperate Woodland Bird Community’. Many of the grassy woodland fauna species from the Warby Ranges and Chesney Vale Hills extend in range down to the woodland remnants around the lake, and represent a largely unrecognised but significant component of the lake and surrounding dryland biodiversity. Significant habitats on nearby hills include:

- Box-ironbark forest; and
- Rocky outcrop shrubland/woodland.

Noteworthy examples of threatened dryland fauna include the:

- Inland Carpet Python *Morelia spilota metcalfei* (FFG listed), for which the Chesney Vale hills and Warby Ranges are a Victorian stronghold, and snakes from these hills range down to the woodland on the north-west – north edge of the lake (AVW; Heard et al. 2004);
- Threatened woodland birds such as the Swift Parrot *Lathamus discolor* (EPBC listed), Brown Treecreeper *Climacteris picumnus victoriae* and Diamond Firetail *Stagonopleura guttata* (both nationally Vulnerable (Garnett & Crowley 2000)); all use woodland remnants around the lake (AVW; LEC pers. obs.);
- Brown Quail *Coturnix ypsilophora* (Near Threatened in Victoria (DSE 2003)); moderately abundant at times in rank grassy areas along and near the lake margins (AVW; LEC pers. obs.).

Table 3: Summary of threatened fauna species distribution by dryland/wetland habitats

	EPBC	NAP	FFG	DSE	Total
Wetland	3	5	13	23	23
Dryland	1	12	12	18	18



Plate 1: Panoramic view of southern Lake Mokoan, dam wall and outlet channel (Lawrie Conole, 23 June 2005).



Plate 2: Panoramic view of easternmost borrow pit adjacent to Lake Mokoan dam wall (Lawrie Conole, 13 July 2005).



Plate 3: Regenerating River Red Gum woodland, Humphries Lane, Lake Mokoan (Lawrie Conole, 23 June 2005).



Plate 4: Planted eucalypts, Duck Pond, Lake Mokoan (Lawrie Conole, 23 June 2005).



Plate 5: Southern Chesney Vale hills from dam wall, Lake Mokoan (Lawrie Conole, 23 June 2005).



Plate 6: Woodland regrowth and dieback from dam wall, Lake Mokoan (Lawrie Conole, 23 June 2005).

Table 4: Significant fauna species of Lake Mokoan wetland habitats

Common name	Scientific name	EPBC	NAP	FFG	DSE	Status
<b>Species</b>						
Brown Quail	<i>Coturnix ypsilophora</i>				NT	At times abundant in wet grassy edges of the lake and surrounding woodland.
Pied Cormorant	<i>Phalacrocorax varius</i>				NT	Regularly occurs.
Whiskered Tern	<i>Chlidonias hybridus javanicus</i>				NT	Regularly occurs.
Latham's Snipe	<i>Gallinago hardwicki</i>				NT	Regularly occurs.
Australian Painted Snipe	<i>Rostratula australis</i>	VU	VU	L	CR	No known records from the lake, but also no targeted surveys. Abundance of suitable habitat and the species is at least moderately likely to regularly occur in small numbers.
Brolga	<i>Grus rubicunda</i>			L	VU	Regularly occurs.
Glossy Ibis	<i>Plegadis falcinellus</i>				NT	Regularly occurs.
Royal Spoonbill	<i>Platalea regia</i>				VU	Regularly occurs.
Intermediate Egret	<i>Ardea intermedia</i>			L	CR	Regularly occurs.
Great Egret	<i>Ardea alba</i>			L	VU	Regularly occurs.
Nankeen Night Heron	<i>Nycticorax caledonicus hillii</i>				NT	Regularly occurs.
Australasian Bittern	<i>Botaurus poiciloptilus</i>		VU	L	EN	Would have occurred more widely in previous decades, as it favours beds of large macrophytes such as <i>Typha</i> and <i>Phragmites</i> . Probably still occurs in wetlands such as the Duck Pond, 11 and 7 Mile swamps. One local record (1990, AVW).
Australian Little Bittern	<i>Ixobrychus dubius</i>		NT	L	EN	Would have occurred more widely in previous decades, as it favours beds of large macrophytes such as <i>Typha</i> and <i>Phragmites</i> . Probably still occurs in wetlands such as the Duck Pond, 11 and 7 Mile swamps. No local records.
Australasian Shoveler	<i>Anas rhynchotis</i>				VU	Regularly occurs.
Freckled Duck	<i>Stictonetta naevosus</i>			L	EN	Regularly occurs.
Hardhead	<i>Aythya australis</i>				VU	Regularly occurs.
Blue-billed Duck	<i>Oxyura australis</i>			L	EN	Regularly occurs.
Musk Duck	<i>Biziura lobata</i>				VU	Regularly occurs.
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>			L	VU	Has bred at Lake Mokoan; regularly occurs there; probably not more than one pair.
Brown Toadlet	<i>Pseudophryne bibronii</i>		IK	L	EN	No recent records (last 1970, AVW), but both cryptic and rare, and no recent targeted surveys. May occur in locations such as the Duck Pond and 11 Mile swamp.
Growling Grass Frog	<i>Litoria raniformis</i>	VU	VU	L	EN	No recent records (last 1970, AVW), no recent targeted surveys. May occur in smaller wetland locations such as the Duck Pond and borrow pits.
Murray Cod	<i>Maccullochella peelii peelii</i>	VU		L	EN	Stocked population, not indigenous to Lake Mokoan or Winton Swamp. May not be self-sustaining.
Golden Perch	<i>Macquaria ambigua</i>			L	VU	Stocked population, not indigenous to Lake Mokoan or Winton Swamp. May not be self-sustaining.

Table 5: Significant fauna species and communities of Lake Mokoan dryland habitats

Common name	Scientific name	EPBC	NAP	FFG	DSE	Status
<b>Species</b>						
Brown Quail	<i>Coturnix ypsilophora</i>				NT	At times abundant in wet grassy edges of the lake and surrounding woodland.
Bush Stone-curlew	<i>Burhinus grallarius</i>		NT	L	EN	Rare woodland bird, present in region, no local records; likely to occur in woodland habitats around the margins of the lake.
Spotted Harrier	<i>Circus assimilis</i>				NT	Uncommon grassland and grassy woodland raptor; likely to occur regularly in open country around Lake Mokoan.
Square-tailed Kite	<i>Lophoictinia isura</i>			L	VU	Rare breeding raptor in surrounding hill areas (Warbys, Chesney Vale, Strathbogies), and would have previously foraged in the Winton Swamp woodlands.
Barking Owl	<i>Ninox connivens connivens</i>		NT	L	EN	Very rare woodland owl; few local records, Victorian stronghold in NE (Warbys – Killawarra, Chiltern – Mt Pilot, etc.); much suitable habitat around lake. Likely to occur in wooded areas around Chesney Vale, borrow pits, Duck Pond and 11 Mile wetland.
Turquoise Parrot	<i>Neophema pulchella</i>		NT	L	NT	Grassy woodland species occurring particularly around the north end of the lake (AVW).
Swift Parrot	<i>Lathamus discolor</i>	EN	EN	L	EN	Many records from box-ironbark forest in the Warby Ranges and Killawarra Forest (AVW); likely to occur in scattered flowering White Box <i>Eucalyptus albens</i> and planted natives around the lake during winter.
Hooded Robin	<i>Melanodryas cucullata cucullata</i>		NT	L	VU	Grassy woodland species occurring particularly around the north end of the lake (AVW).
Grey-crowned Babbler	<i>Pomatostomus temporalis temporalis</i>		NT	L	EN	Records from scattered plains woodland remnants around Lake Mokoan, and from the River Red Gum regrowth at Humphries Lane (AVW).
Speckled Warbler	<i>Chthonicola sagittata</i>		NT	L	VU	Many records from box-ironbark forest in the Warby Ranges and Chesney Vale hills (AVW); likely to occur around the north end of the lake (AVW).
Brown Treecreeper	<i>Climacteris picumnus victoriae</i>		NT		NT	Many records from box-ironbark forest in the Warby Ranges and Chesney Vale hills (AVW); recorded in woodland at the Duck Pond and Humphries Lane (this study); likely to occur around the north end of the lake down to the dam wall on the east side.
Black-chinned Honeyeater	<i>Melithreptus gularis gularis</i>		NT		NT	Many records from box-ironbark forest in the Warby Ranges and Killawarra Forest (AVW); likely to occur in scattered flowering White Box <i>Eucalyptus albens</i> and planted natives around the lake during winter.
Painted Honeyeater	<i>Grantiella picta</i>		NT	L	VU	Many records from box-ironbark forest in the Warby Ranges and Killawarra Forest (AVW); likely to occur in scattered White Box <i>Eucalyptus albens</i> and planted natives, wherever mistletoe occurs, around the lake during summer.
Diamond Firetail	<i>Stagonopleura guttata</i>		NT	L	VU	Grassy woodland species occurring particularly around the north end of the lake (AVW); recorded in woodland at the Duck Pond and Humphries Lane (this study).
Eastern Bearded Dragon	<i>Pogona barbata</i>				DD	Likely to occur in most grassy fringing habitats around the lake.
Tree Goanna	<i>Varamus varius</i>				VU	Woodland species with numerous records from the Chesney Vale hills down to the lake edge (AVW).
Inland Carpet Python	<i>Morelia spilota metcalfei</i>			L	EN	Present on nearby rocky hills and down to lake margins in Chesney Vale area (AVW, Heard et al. 2004); would have originally occurred in River

Common name	Scientific name	EPBC	NAP	FFG	DSE	Status
						Red Gum woodland around Winton Swamp.
Brown Toadlet	<i>Pseudophryne bibronii</i>		IK	L	EN	No recent records (last 1970, AVW), but cryptic and rare, no recent targeted surveys. May occur in locations such as the Duck Pond and 11 Mile swamp.
<b>Communities</b>						
Victorian Temperate Woodland Bird Community				L		19 members of this threatened community are either known or thought highly likely to be present in woodland remnants and regrowth around the shores of the lake ( <i>viz.</i> Barking Owl, Black-chinned Honeyeater, Brown Treecreeper, Brown-headed Honeyeater, Bush Stone-curlew, Diamond Firetail, Fuscos Honeyeater, Grey-crowned Babbler, Hooded Robin, Red-capped Robin, Jacky Winter, Little Lorikeet, Painted Button-quail, Painted Honeyeater, Speckled Warbler, Swift Parrot, Turquoise Parrot, Western Gerygone, Yellow-tufted Honeyeater).

**Key:**

- EPBC Federal Environment Protection & Biodiversity Conservation Act 1999; EN = Endangered, VU = Vulnerable.
- NAP National action plans; EN = Endangered, VU = Vulnerable, NT = Near Threatened, IK = insufficiently known.
- FFG Victorian Flora & Fauna Guarantee Act 1988; L = Listed threatened species or community.
- DSE Advisory list of Victorian threatened fauna (DSE 2003); CR = Critically Endangered, EN = Endangered, VU = Vulnerable; NT = Near Threatened, DD = Data Deficient.

## 8.4 Aquatic fauna

### Fish

Since its construction, Lake Mokoan has been a popular destination for anglers. In the late 1970s and early 1980s, the lake supported an important Redfin (*\*Perca fluviatilis*) fishery. Possibly as a result of young redfin being heavily preyed upon by stocked Golden Perch (*Macquaria ambigua*) and Murray Cod (*Maccullochella peelii peelii*), Redfin are now rare in the lake (Hall 2002). The lake has been regularly stocked with Murray Cod and Golden Perch since 1988/98. Lake Mokoan now supports a relatively large population of Golden Perch, and the stocked population of this species dominates the angler's catch. Catch rates are high compared to most recreational fisheries. However, these populations have a slow growth rate (taking four to seven years to reach the current legal size of 30 cm), possibly as a result of high population densities and/or current water level management regimes. In addition to Golden Perch and Murray Cod, other fish occasionally caught by anglers are Carp (*\*Cyprinus carpio*) and Goldfish (*\*Carassius auratus*) (Hall 2002).

Macquarie Perch (*Macquaria australasica*) were also caught at the Mokoan inlet channel in 2000. A stocked Macquarie Perch population exists in the Broken River between Lake Nillahcootie and Benalla at Swanpool, and a remnant population is supposed to be present in Holland Creek (URS 2003). These riverine fish are unlikely to be resident in Lake Mokoan.

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\* An asterisk (\*) denotes exotic species

Australian Smelt (*Retropinna semoni*), a small schooling species common in northern Victoria, has also been recorded from Lake Mokoan. Brown Trout (*\*Salmo trutta*) and Goldfish have been recorded from Lake Mokoan, however, the lake does not appear to provide good habitat for these species. Fish surveys at Lake Mokoan have largely been directed at larger species and little information is available regarding smaller fish. It is possible that the following small native species that are known to occur in the region may be recorded in Lake Mokoan: Mountain Galaxias (*Galaxias olidus*), Flat-headed Galaxias (*Galaxias rostratus*), Western Carp Gudgeon (*Hypseleleotris klunzingeri*), Crimson-spotted Rainbowfish (*Melanotaenia fluviatilis*) and Southern Pygmy Perch (*Nannoperca australis*). Exotic Tench (*\*Tinca tinca*) and Mosquitofish (*\*Gambusia holbrooki*) may also be present (URS 2003a).

Table 6: Fish species of Lake Mokoan

Common name	Scientific name	EPBC	NAP	FFG	DSE	Status
*Brown Trout	<i>Salmo trutta</i>					Feral, AVW
Australian Smelt	<i>Retropinna semoni</i>					AVW
*Goldfish	<i>Carassius auratus</i>					Feral, AVW
*Carp	<i>Cyprinus carpio</i>					Feral, AVW
*Tench	<i>Tinca tinca</i>					Feral, unconfirmed
*Mosquitofish	<i>Gambusia holbrooki</i>					Feral, unconfirmed
Murray Cod	<i>Maccullochella peellii peellii</i>	VU		L	EN	Stocked population, native to Victoria but not indigenous to Lake Mokoan; AVW
Golden Perch	<i>Macquaria ambigua</i>				VU	Stocked population, native to Victoria but not indigenous to Lake Mokoan; AVW
Macquarie Perch	<i>Macquaria australasica</i>	EN	PK	L	EN	Stocked population in Broken River, remnant population in Hollands Creek; caught in Mokoan inlet channel, but unlikely to occur in the lake.
Mountain Galaxias	<i>Galaxias olidus</i>					Unconfirmed; likely to occur
Flat-headed Galaxias	<i>Galaxias rostratus</i>				DD	Unconfirmed; likely to occur
Western Carp Gudgeon	<i>Hypseleleotris klunzingeri</i>					Unconfirmed; likely to occur
Crimson-spotted Rainbowfish	<i>Melanotaenia fluviatilis</i>				DD	Unconfirmed; likely to occur
Southern Pygmy Perch	<i>Nannoperca australis</i>					Unconfirmed; likely to occur

**Key:**

EPBC Federal Environment Protection &amp; Biodiversity Conservation Act 1999; EN = Endangered, VU = Vulnerable.

NAP National action plan (Wager &amp; Jackson 1993); PK = poorly known.

FFG Victorian Flora &amp; Fauna Guarantee Act 1988; L = Listed threatened species.

DSE Advisory list of Victorian threatened fauna (DSE 2003); CR = Critically Endangered, EN = Endangered, VU = Vulnerable; NT = Near Threatened, DD = Data Deficient.

\* = exotic species

### **Aquatic Macroinvertebrates**

Atkins et al. (1993) sampled the macroinvertebrate fauna at several locations around the lake. Areas sampled were 3 km west and 2 km east of Chesney Vale on the north central lake margin, the spit, channel inlet, the Duck Pond and near the Taminick shoreline. A total of 80 taxa were recorded in this study. They concluded that the lake had a relatively diverse macroinvertebrate fauna and attributed this to the lake's size and abundance of woody debris from River Red Gums drowned when the lake was created.

The part of the lake to record the lowest diversity was the wave swept shores of the spit, which at the time had little vegetation.

The fauna recorded by Atkins et al. (1993) was typical of that occurring in similar habitats in northern Victoria. The key features of these habitats include shallow slow-flowing or standing water with muddy sediments and eucalypt leaf litter and woody debris. Prominent species include the shrimp *Macrobranchium australiense* and the Yabby *Cherax destructor*, many common species of midge larvae, aquatic bugs, beetle larvae, dragonflies, damselflies, and mayfly nymphs.

### **Effects of Lake Mokoan on receiving waters**

An expert scientific panel commented on the effects of Lake Mokoan on the current environmental conditions and potential impacts on receiving waters (Cottingham et al. 2001). Poor water quality discharges from Lake Mokoan was considered a threat to environmental values. The Scientific Panel supported the decommissioning scenario of Lake Mokoan, as the Broken River is a lowland river (which would benefit from decommissioning) is considered to be in generally good health. The cessation of diversions into Lake Mokoan from the Broken River would enable flows in the Broken River downstream of Lake Mokoan to return somewhat to natural flow regimes, which would benefit Murray Cod, Trout Cod (*Maccullochella macquariensis*), Golden Perch and Two-spined Blackfish (*Gadopsis bispinosus*).

### **Environmental benefits of a return to Winton Swamp**

Converting the lake back to the original wetlands is predicted to improve aquatic environmental values, as it would increase vegetation biodiversity and regeneration of habitat for fauna such as waterbirds and frogs. While this fauna exists at the Lake in its current status, improved habitat would allow the existing fauna to thrive and possibly encourage other species to inhabit the area.

Winton Swamp is predicted to be unable to support current fish stocks. However, it would facilitate fish passage and possibly promote the movement of fish throughout the catchment.

Water quality may be improved as a result of returning the lake to a wetland. This would be achieved through wind/ sediment interaction, limiting turbidity and nutrient re-suspension (the

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main requirements of algal blooms). The water entering downstream rivers would also be of significantly higher quality, also reducing algal blooms in these systems (source Lake Mokoan Study – interim report, chapter 6).

The quality of runoff from the catchment of the proposed wetland system (i.e. Winton Swamp) poses the largest threat to this system supporting a sustainable and healthy system. Generally, the quality of the water currently entering Lake Mokoan from these intermittent catchment streams is poor, as they have generally high nutrient levels and turbidity. The Winton-Wattle creek system also has high salinities in the headwaters (AWT 2000b). Improvements in water quality have been reported to occur in the lower reaches of Eleven Mile, Seven Mile, Winton-Wattle and Snow Creeks, which could be attributed to stream improvement works conducted in these systems (AWT 2000b). Further catchment management activities should be conducted in these catchments to further improve the quality of flows entering Lake Mokoan and the future wetland system. Water quality monitoring and macroinvertebrate surveys would be valuable in assisting the CMA in focusing on appropriate actions and in describing how the condition of these streams change over future years.

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## 9 Key issues identified

### 9.1 Features

#### Flora and terrestrial fauna

The vegetation of the Lake Mokoan study area has been very highly modified as a result of former agricultural land uses, followed by the creation of a very large lake (a constructed wetland) on pre-existing swamp and woodland vegetation which was entirely transformed by the inundation. Despite these modifications at the landscape scale, a suite of flora and fauna values persist, although little is currently known about them. Features of the current vegetation and terrestrial fauna include:

- A very large constructed wetland essentially devoid of macrophytes and with limited flora values. This contrasts with the pre-existing vegetation (documented by Aston in the 1960's) which must have had outstanding values.
- A suite of smaller, essentially natural wetlands which existed prior to the creation of the lake and are frequently above the lakes water level but which are subsumed by the lake at FSL. These retain some flora and fauna values.
- Constructed wetlands of borrow-pits, the Duck Pond, Seven Mile and Eleven Mile wetlands which are substantially vegetated by indigenous wetland species. These are likely to have low to moderate flora values.
- Populations of plant species of State and National conservation significance which persist from the former dryland vegetation of slopes, or which colonised wetlands after construction (mostly by propagules dispersed by waterfowl).
- Remnants of woodlands on slopes, and outside FSL, which are of unknown quality, extent or distribution. These include remnants of two vegetation communities which are listed under Federal (EPBC Act) conservation legislation (e.g. White Box Woodland and Buloke Woodland).
- Planted native vegetation (trees and shrubs) of woodland or forest structure of potential significance as fauna habitat (e.g. for the threatened woodland bird community) and as a source of serious or potentially serious invasive environmental weed species (e.g. exotic *Acacia* species).
- Very extensive vegetation dominated by exotic species, notably grasses (e.g. *Phalaris*, \**Phalaris aquatica*) and other herbs, which will persist and expand by colonisation of the newly-available substrates after the drawdown of the lake if this proceeds. Such

exotic vegetation potentially presents serious management issues and will be a major constraint influencing possible revegetation scenarios.

- A suite of agricultural and environmental weed species which pose major threats to lands within and surrounding the study area.

It is clear that there is very wide scope with the decommissioning of the lake to create wetland habitats of much greater value than those currently existing. The same applies to dryland habitats that could be created by strategic revegetation, particularly to fulfil fauna habitat objectives. There are however numerous technical, economic and political issues, and time-frames for any wetland and dryland re-instatement/restoration scenarios would extend for a decade or more. It is also axiomatic that whatever the outcomes for vegetation and fauna habitats and land uses within the Lake Mokoan area, that there will be major ongoing management issues and obligations for management agencies and the community.

### **Aquatic fauna**

The studies conducted by Water ECOscience/ AWT focused on overcoming the blue-green algal blooms the lake experiences and returning it to a healthy and sustainable ecosystem capable of providing a valuable water resource. Much of this work was irrelevant to determining the ecological impact of returning Lake Mokoan to a natural wetland system that will not be part of the regional water supply system. Similarly, research on the fisheries at Lake Mokoan has focused on recreational fishing and has therefore addressed the status of recreational fisheries, whereas no substantial information exists on what smaller species are present.

The decommissioning of Lake Mokoan and returning the lake to a natural wetland system is predicted to support a more diverse and sustainable aquatic fauna. Furthermore, the removal of Lake Mokoan from the water supply system is predicted to enhance the ecological condition of the Broken River downstream of Lake Mokoan.

The natural wetland to be created from the decommissioning of Lake Mokoan is likely to be a macrophyte dominated system and is unlikely to be dominated by phytoplankton. Such a system is potentially able to support a diverse and productive aquatic ecosystem and become an important regional wetland ecosystem. Furthermore, this wetland should be able to treat runoff from its catchment and improve the water quality discharged into the Broken River.

The quality of catchment runoff will have a major impact on the ecological condition of the new wetland system. Considerable stream improvement works have been conducted in catchment streams and there are reports that these works have resulted in improvements to water quality. Water quality and macroinvertebrate monitoring should be conducted in these ephemeral catchment streams to ensure that they do not compromise the condition and ecological health of the new wetland system.

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## 9.2 Summary of Opportunities and Constraints

### 9.3 Opportunities

In ecological terms, the primary opportunity associated with the decommissioning of Lake Mokoan is the restoration of a high quality, diverse wetland system for conservation purposes. This brings with it numerous opportunities for involving the scientific community and local residents and may, once restoration has reached a reasonable level (and depending on the nature and use-objectives of the restored wetlands), attract tourists for recreational activities such as bird-watching, fishing, duck-shooting, walking and sightseeing. The restoration of the wetlands and the decommissioning of the lake also creates an opportunity for improved downstream water quality.

Opportunities for ecological benefits and enhanced biodiversity values also exist for restored dry-land areas. Existing dryland vegetation such as the natural River Red Gum recruitment near the south-eastern corner could be protected for conservation and enhanced through weed control and supplementary plantings. The creation of buffers along reclaimed creeklines and around wetland areas creates opportunities for dry-land revegetation with eucalypts and indigenous understorey species (either through natural recruitment, direct seeding or plantings). Revegetation and vegetation management activities may attract private funding through the Net Gain policy if proponents of vegetation clearance elsewhere in the region sought to meet their offset obligations in these areas.

### 9.4 Constraints

Inadequacies in available information are the major constraint with regard to predicting the ecological feasibility and desirability of future land uses (including wetland restoration). Areas that require investigation or resolution to provide background information essential to test options for the decommissioning of Lake Mokoan and to devise appropriate scenarios are discussed below. Other constraints apparent at this stage include inadequacy of funding for wetland and dryland restoration works, long time-frames for creating a functioning and aesthetically pleasing wetland system (10+ years), abundance of weeds capable of out-competing indigenous species if not appropriately managed and community opposition to large vegetated areas due to perceived fire risk.

#### 1. Data on physical attributes of the land

Predictions as to the suitability or likelihood of success of future land uses are not possible without accurate information concerning physical properties of the land. Specifically, it is necessary to establish:

- What soils occur within the primary study area and how have they been affected by the decades of inundation (e.g. changes in soil chemistry and extent of loss of topsoil);
- The topographic features of the lake-bed (ie. through a bathymetric study together with land surveying of the exposed areas).

## 2. Data on flora

There is a serious dearth of information on the distribution, extent, and condition (quality) of indigenous and exotic vegetation of the study area (wetland and dryland vegetation). This includes its floristic composition and structure, and hence probable changes (if any) under given land-use or management scenarios.

A floristic inventory of indigenous and exotic plant species is required to:

- Determine the presence, location and population status of species of conservation significance in the existing vegetation and potential impacts under changed land-use scenarios.
- Project possible vegetation scenarios under changed land uses.
- Provide details of floristic composition and structure for revegetation (wetland and dryland), as well as sources of supply of plant material for revegetation.
- Determine the response of exotic plant species under changed land-use scenarios. Note that this includes the ambient agricultural and environmental weed flora, as well as some planted native (but non-indigenous) trees and shrubs.

## 3. Data on fauna

- Limited information exists on the distribution and abundance of small species of fish in Lake Mokoan and receiving waters.
- The numerous deaths of tortoises in Lake Mokoan received considerable media interest in the early 1990s, when blue-green algal blooms frequently occurred in the lake. Yet, there appears to be no follow up surveys to assess the current population.
- Limited information exists on the distribution and abundance of woodland fauna utilising remnant, regrowth and planted woodland habitat around Lake Mokoan.
- There is no information on the distribution of frogs at Lake Mokoan.

## 4. Review of large-scale wetland restoration activities in southern Australia

Large-scale wetland decommissioning and restoration projects have been carried out or are underway in southern Australia (e.g. Lake Brewster on the Lachlan River in south-western

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NSW). A strategic review of these, as they relate to Lake Mokoan, is required. They doubtless deal with principles and details of technical (e.g. engineering and hydrological) and ecological relevance (flora and fauna and ecosystem function) to Lake Mokoan.

#### **5. Testing wetland and dryland revegetation options**

Studies and trials concerning revegetation have been conducted in a relatively piecemeal fashion so far in the study area. A rigorous evaluation and testing of options as a desk-top study is required. Options for wetland and dryland revegetation, objectives, implementation procedures, standards and time-lines need to be rigorously tested against a broad list of criteria. These criteria relate to technical feasibility, realistically achievable conservation goals and values (flora and fauna), ongoing management requirements, and economic and social implications. Relevant time-frames extend from the short-term to the long-term (decades).

#### **6. Quality of runoff**

The quality of runoff from the catchment of the proposed wetland system will be a limiting factor to the restoration of the wetlands and may inhibit the development of a sustainable and healthy ecosystem. This issue will need to be addressed through catchment management activities and the careful consideration of impacts of proposed future land uses.

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**Appendix 1: Fauna species observed at Lake Mokoan during field visits for this study**

+ = species present; highlighted = species of National or State conservation significance

Common name	Scientific name	Sites		
		Borrow Pits	Duck Pond	11 Mile woodland
Brown Quail	<i>Coturnix ypsilophora</i>			+
Australian Shelduck	<i>Tadorna tadornoides</i>		+	
Grey Teal	<i>Anas gracilis</i>	+	+	
Pacific Black Duck	<i>Anas superciliosa</i>	+	+	+
Australasian Shoveler	<i>Anas rhynchos</i>		+	
Hardhead	<i>Aythya australis</i>		+	
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>		+	
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>		+	
Great Cormorant	<i>Phalacrocorax carbo</i>	+		
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	+	+	
Australian Pelican	<i>Pelecanus conspicillatus</i>		+	
White-necked Heron	<i>Ardea pacifica</i>		+	
Great Egret	<i>Ardea alba</i>			
White-faced Heron	<i>Egretta novaehollandiae</i>		+	+
Yellow-billed Spoonbill	<i>Platalea flavipes</i>	+		
Black-shouldered Kite	<i>Elanus axillaris</i>	+	+	
Whistling Kite	<i>Haliastur sphenurus</i>		+	
Wedge-tailed Eagle	<i>Aquila audax</i>	+		
Nankeen Kestrel	<i>Falco cenchroides</i>	+		
Brown Falcon	<i>Falco berigora</i>			+
Peregrine Falcon	<i>Falco peregrinus</i>			+
White-headed Stilt	<i>Himantopus leucocephalus</i>			
Masked Lapwing	<i>Vanellus miles</i>	+		
Common Bronzewing	<i>Phaps chalcoptera</i>	+		
Crested Pigeon	<i>Ocyphaps lophotes</i>	+	+	+
Galah	<i>Eolophus roseicapillus</i>	+	+	+
Little Corella	<i>Cacatua sanguinea</i>	+	+	+
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>		+	+
Eastern Rosella	<i>Platycercus eximius</i>			+
Red-rumped Parrot	<i>Psephotus haematonotus</i>			+
Brown Treecreeper	<i>Climacteris picumnus victoriae</i>		+	+
Superb Fairy-wren	<i>Malurus cyaneus</i>	+	+	+
Striated Pardalote	<i>Pardalotus striatus</i>		+	+
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>	+	+	+
Noisy Miner	<i>Manorina melanocephala</i>	+	+	
Red Wattlebird	<i>Anthochaera carunculata</i>		+	
White-fronted Chat	<i>Epthianura albifrons</i>		+	
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	+		+
Restless Flycatcher	<i>Myiagra inquieta</i>		+	
Maggie-lark	<i>Grallina cyanoleuca</i>			+
Willie Wagtail	<i>Rhipidura leucophrys</i>		+	
Pied Butcherbird	<i>Cracticus nigrogularis</i>	+		
Australian Magpie	<i>Gymnorhina tibicen</i>	+	+	+
Australian Raven	<i>Corvus coronoides</i>		+	+
Little Raven	<i>Corvus mellori</i>			+
Diamond Firetail	<i>Stagonopleura guttata</i>		+	+
Welcome Swallow	<i>Hirundo neoxena</i>			+
Tree Martin	<i>Hirundo nigricans</i>		+	
Little Grassbird	<i>Megalurus gramineus</i>		+	
Golden-headed Cisticola	<i>Cisticola exilis</i>		+	
*Common Starling	<i>Sturnus vulgaris</i>	+		
Eastern Grey Kangaroo	<i>Macropus giganteus</i>	+	+	+
*Fox	<i>Vulpes vulpes</i>			+
*Brown Hare	<i>Lepus capensis</i>			+
Plains Froglet	<i>Crinia parinsignifera</i>	+	+	+
Common Eastern Froglet	<i>Crinia signifera</i>	+	+	+
Spotted Grass Frog	<i>Limnodynastes tasmaniensis</i> NCR	+		+

**Appendix 2: Fauna recorded from a 10km radius data review area (DRA) centred on Lake Mokoan**

**Lake Mokoan 10km radius fauna DRA**

Species list from irregular area bounded by the rectangle :

Latitude: -36°22'06" to -36°32'30" Longitude: +146°00'28" to +146°12'19"

Number of Surveys in Search Area = 542

Species range : 1 - 5999 Number of species found = 235

Data from Atlas of Victorian Wildlife - 24 March 2004

**Key:**

Last Most recent record (1970 to 2004 = AVW; 2005 = this study)

Recs Number of records

EPBC Federal *Environment Protection & Biodiversity Conservation Act 1999*; EN = Endangered, VU = Vulnerable.

DSE Advisory list of Victorian threatened fauna (DSE 2003); CR = Critically Endangered, EN = Endangered, VU = Vulnerable; NT = Near Threatened, DD = Data Deficient.

FFG Victorian *Flora & Fauna Guarantee Act 1988*; L = Listed threatened species.

Last	Recs	EPBC	DSE	FFG	Common Name	Scientific Name
2005	6		NT		Brown Quail	<i>Coturnix ypsilophora</i>
2001	4				Painted Button-quail	<i>Turnix varia</i>
1977	1		VU	L	Red-chested Button-quail	<i>Turnix pyrrhotorax</i>
2001	33				Peaceful Dove	<i>Geopelia striata</i>
2005	31				Common Bronzewing	<i>Phaps chalcoptera</i>
2005	27				Crested Pigeon	<i>Ocyphaps lophotes</i>
1978	1				Black-tailed Native-hen	<i>Gallinula ventralis</i>
2001	21				Dusky Moorhen	<i>Gallinula tenebrosa</i>
1990	7				Purple Swamphen	<i>Porphyrio porphyrio</i>
2003	50				Eurasian Coot	<i>Fulica atra</i>
1988	25				Great Crested Grebe	<i>Podiceps cristatus</i>
2005	31				Australasian Grebe	<i>Tachybaptus novaehollandiae</i>
2005	20				Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>
2005	38				Great Cormorant	<i>Phalacrocorax carbo</i>
2001	41				Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>
1999	14		NT		Pied Cormorant	<i>Phalacrocorax varius</i>
2005	62				Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>
2005	50				Darter	<i>Anhinga melanogaster</i>
2005	54				Australian Pelican	<i>Pelecanus conspicillatus</i>
1981	1		NT		Whiskered Tern	<i>Chlidonias hybridus</i>
2001	32				Silver Gull	<i>Larus novaehollandiae</i>
2000	9				Red-kneed Dotterel	<i>Erythrogonys cinctus</i>
2005	75				Masked Lapwing	<i>Vanellus miles</i>
1990	1				Red-capped Plover	<i>Charadrius ruficapillus</i>
2001	27				Black-fronted Dotterel	<i>Elsayornis melanops</i>
2005	5				Black-winged Stilt	<i>Himantopus himantopus</i>
1980	1				Common Greenshank	<i>Tringa nebularia</i>
1997	1				Curlew Sandpiper	<i>Calidris ferruginea</i>
1990	5		NT		Latham's Snipe	<i>Gallinago hardwickii</i>
2001	7		EN	L	Bush Stone-curlew	<i>Burhinus grallarius</i>
1991	2		VU	L	Brolga	<i>Grus rubicunda</i>
1991	1		NT		Glossy Ibis	<i>Plegadis falcinellus</i>
2005	66				Australian White Ibis	<i>Threskiornis molucca</i>
2005	47				Straw-necked Ibis	<i>Threskiornis spinicollis</i>
2000	14		VU		Royal Spoonbill	<i>Platalea regia</i>
2005	50				Yellow-billed Spoonbill	<i>Platalea flavipes</i>
1980	3		EN	L	Little Egret	<i>Egretta garzetta</i>
1980	7		CR	L	Intermediate Egret	<i>Ardea intermedia</i>
2005	44		VU	L	Great Egret	<i>Ardea alba</i>
2005	70				White-faced Heron	<i>Egretta novaehollandiae</i>
2005	41				White-necked Heron	<i>Ardea pacifica</i>
1981	6		NT		Nankeen Night Heron	<i>Nycticorax caledonicus</i>
1990	1		EN	L	Australasian Bittern	<i>Botaurus poiciloptilus</i>
1978	2				Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>
2005	90				Australian Wood Duck	<i>Chenonetta jubata</i>

Last	Recs	EPBC	DSE	FFG	Common Name	Scientific Name
2003	67				Black Swan	<i>Cygnus atratus</i>
1978	2				Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>
2005	56				Australian Shelduck	<i>Tadorna tadornoides</i>
2005	84				Pacific Black Duck	<i>Anas superciliosa</i>
2003	17				Chestnut Teal	<i>Anas castanea</i>
2005	66				Grey Teal	<i>Anas gracilis</i>
2005	29		VU		Australasian Shoveler	<i>Anas rhynchotis</i>
1991	15				Pink-eared Duck	<i>Malacorhynchus membranaceus</i>
1981	15		EN	L	Freckled Duck	<i>Stictonetta naevosa</i>
2005	26		VU		Hardhead	<i>Aythya australis</i>
1987	5		EN	L	Blue-billed Duck	<i>Oxyura australis</i>
1989	37		VU		Musk Duck	<i>Biziura lobata</i>
1977	2		NT		Spotted Harrier	<i>Circus assimilis</i>
2000	6				Swamp Harrier	<i>Circus approximans</i>
2000	8				Brown Goshawk	<i>Accipiter fasciatus</i>
2005	21				Wedge-tailed Eagle	<i>Aquila audax</i>
2000	16				Little Eagle	<i>Hieraaetus morphnoides</i>
2001	26		VU	L	White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>
2005	41				Whistling Kite	<i>Haliastur sphenurus</i>
2005	15				Black-shouldered Kite	<i>Elanus axillaris</i>
2000	6				Australian Hobby	<i>Falco longipennis</i>
2005	11				Peregrine Falcon	<i>Falco peregrinus</i>
2005	39				Brown Falcon	<i>Falco berigora</i>
2005	31				Nankeen Kestrel	<i>Falco cenchroides</i>
2000	5				Southern Boobook	<i>Ninox novaeseelandiae</i>
1999	2				Rainbow Lorikeet	<i>Trichoglossus haematodus</i>
1999	4				Musk Lorikeet	<i>Glossopsitta concinna</i>
2000	4				Little Lorikeet	<i>Glossopsitta pusilla</i>
2001	1				Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>
2005	96				Sulphur-crested Cockatoo	<i>Cacatua galerita</i>
2005	21				Little Corella	<i>Cacatua sanguinea</i>
2005	104				Galah	<i>Cacatua roseicapilla</i>
1998	20				Cockatiel	<i>Nymphicus hollandicus</i>
1992	1				Australian King-Parrot	<i>Alisterus scapularis</i>
2001	6				Crimson Rosella	<i>Platycercus elegans</i>
2005	97				Eastern Rosella	<i>Platycercus eximius</i>
2005	103				Red-rumped Parrot	<i>Psephotus haematotus</i>
2001	8		NT	L	Turquoise Parrot	<i>Neophema pulchella</i>
1999	2	EN	EN	L	Swift Parrot	<i>Lathamus discolor</i>
1995	2				Budgerigar	<i>Melopsittacus undulatus</i>
2000	10				Tawny Frogmouth	<i>Podargus strigoides</i>
2000	4				Australian Owllet-nightjar	<i>Aegotheles cristatus</i>
1980	7				Dollarbird	<i>Eurystomus orientalis</i>
2005	76				Laughing Kookaburra	<i>Dacelo novaeguineae</i>
2000	18				Sacred Kingfisher	<i>Todiramphus sanctus</i>
2001	30				Rainbow Bee-eater	<i>Merops ornatus</i>
2000	3				White-throated Needletail	<i>Hirundapus caudacutus</i>
2001	1				Fork-tailed Swift	<i>Apus pacificus</i>
2000	6				Pallid Cuckoo	<i>Cuculus pallidus</i>
2000	6				Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>
2000	3		NT		Black-eared Cuckoo	<i>Chrysococcyx osculans</i>
1999	10				Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>
1987	2				Shining Bronze-Cuckoo	<i>Chrysococcyx lucidus</i>
2005	95				Welcome Swallow	<i>Hirundo neoxena</i>
2005	42				Tree Martin	<i>Hirundo nigricans</i>
2000	23				Fairy Martin	<i>Hirundo ariel</i>
2001	46				Grey Fantail	<i>Rhipidura fuliginosa</i>
1980	1				Rufous Fantail	<i>Rhipidura rufifrons</i>
2005	111				Willie Wagtail	<i>Rhipidura leucophrys</i>
1979	1				Leaden Flycatcher	<i>Myiagra rubecula</i>
1979	2				Satin Flycatcher	<i>Myiagra cyanoleuca</i>
2005	52				Restless Flycatcher	<i>Myiagra inquieta</i>
2001	35				Jacky Winter	<i>Microeca fascinans</i>
2001	18				Scarlet Robin	<i>Petroica multicolor</i>
2001	17				Red-capped Robin	<i>Petroica goodenovii</i>
2005	29				Flame Robin	<i>Petroica phoenicea</i>
2001	26		NT	L	Hooded Robin	<i>Melanodryas cucullata</i>
2002	14				Eastern Yellow Robin	<i>Eopsaltria australis</i>
2001	12				Golden Whistler	<i>Pachycephala pectoralis</i>

Last	Recs	EPBC	DSE	FFG	Common Name	Scientific Name
2002	26				Rufous Whistler	<i>Pachycephala rufiventris</i>
2005	60				Grey Shrike-thrush	<i>Colluricincla harmonica</i>
2005	95				Magpie-lark	<i>Grallina cyanoleuca</i>
2001	18				Crested Shrike-tit	<i>Falcunculus frontatus</i>
1978	1		VU	L	Ground Cuckoo-shrike	<i>Coracina maxima</i>
2005	59				Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>
1987	2				White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>
1998	10				White-winged Triller	<i>Lalage sueurii</i>
2002	31		EN	L	Grey-crowned Babbler	<i>Pomatostomus temporalis</i>
2001	27				White-browed Babbler	<i>Pomatostomus superciliosus</i>
2005	16				White-fronted Chat	<i>Ephianura albifrons</i>
1981	3				White-throated Gerygone	<i>Gerygone olivacea</i>
2002	10				Western Gerygone	<i>Gerygone fusca</i>
2002	14				Weebill	<i>Smicrornis brevirostris</i>
2000	4				Southern White face	<i>Aphelocephala leucopsis</i>
2001	12				Striated Thornbill	<i>Acanthiza lineata</i>
2000	9				Yellow Thornbill	<i>Acanthiza nana</i>
2002	10				Brown Thornbill	<i>Acanthiza pusilla</i>
2000	4				Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>
2001	18				Buff-rumped Thornbill	<i>Acanthiza reguloides</i>
2002	41				Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>
1976	1				White-browed Scrubwren	<i>Sericornis frontalis</i>
2001	18		VU	L	Speckled Warbler	<i>Chthonicola sagittata</i>
1995	12				Brown Songlark	<i>Cincloramphus cruralis</i>
2000	23				Rufous Songlark	<i>Cincloramphus mathewsi</i>
2005	3				Little Grassbird	<i>Megalurus gramineus</i>
1999	16				Clamorous Reed Warbler	<i>Acrocephalus stentoreus</i>
2005	8				Golden-headed Cisticola	<i>Cisticola exilis</i>
2005	64				Superb Fairy-wren	<i>Malurus cyaneus</i>
2001	14				White-breasted Woodswallow	<i>Artamus leucorhynchus</i>
1980	3				Masked Woodswallow	<i>Artamus personatus</i>
1999	8				White-browed Woodswallow	<i>Artamus superciliosus</i>
2001	41				Dusky Woodswallow	<i>Artamus cyanopterus</i>
2002	16				Varied Sittella	<i>Daphoenositta chrysoptera</i>
2005	51		NT		Brown Treecreeper	<i>Climacteris picumnus</i>
2002	32				White-throated Treecreeper	<i>Cormobates leucophaeus</i>
2000	15				Mistletoebird	<i>Dicaeum hirundinaceum</i>
2000	25				Spotted Pardalote	<i>Pardalotus punctatus</i>
2000	14				Silvereye	<i>Zosterops lateralis</i>
2001	5				White-naped Honeyeater	<i>Melithreptus lunatus</i>
2001	5		NT		Black-chinned Honeyeater	<i>Melithreptus gularis</i>
1999	11				Brown-headed Honeyeater	<i>Melithreptus brevirostris</i>
1999	2				Black Honeyeater	<i>Certhionyx niger</i>
2001	1				Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>
1995	1		VU	L	Painted Honeyeater	<i>Grantiella picta</i>
1990	1	EN	CR	L	Regent Honeyeater	<i>Xanthomyza phrygia</i>
2001	1				Singing Honeyeater	<i>Lichenostomus virescens</i>
2001	11				Fuscous Honeyeater	<i>Lichenostomus fuscus</i>
1999	1				Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>
2001	23				Yellow-tufted Honeyeater	<i>Lichenostomus melanops</i>
2005	103				White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>
2005	114				Noisy Miner	<i>Manorina melanocephala</i>
2005	34				Red Wattlebird	<i>Anthochaera carunculata</i>
2001	11				Noisy Friarbird	<i>Philemon corniculatus</i>
2001	17				Little Friarbird	<i>Philemon citreogularis</i>
2001	29				Richard's Pipit	<i>Anthus novaeseelandiae</i>
2005	27		VU	L	Diamond Firetail	<i>Stagonopleura guttata</i>
2001	2				Zebra Finch	<i>Taeniopygia guttata</i>
1998	1				Double-barred Finch	<i>Taeniopygia bichenovii</i>
1981	2				Red-browed Finch	<i>Neochmia temporalis</i>
2001	3				Olive-backed Oriole	<i>Oriolus sagittatus</i>
2001	43				White-winged Chough	<i>Corcorax melanorhamphos</i>
2001	12				Pied Currawong	<i>Strepera graculina</i>
2005	5				Pied Butcherbird	<i>Cracticus nigrogularis</i>
2000	4				Grey Butcherbird	<i>Cracticus torquatus</i>
2005	128				Australian Magpie	<i>Gymnorhina tibicen</i>
2005	71				Australian Raven	<i>Corvus coronoides</i>
2005	21				Little Raven	<i>Corvus mellori</i>
2005	78				Striated Pardalote	<i>Pardalotus striatus</i>

Last	Recs	EPBC	DSE	FFG	Common Name	Scientific Name
1988	3				Cattle Egret	<i>Ardea ibis</i>
2005	7		*		Common Blackbird	<i>Turdus merula</i>
1977	2		*		Skylark	<i>Alauda arvensis</i>
2001	34		*		House Sparrow	<i>Passer domesticus</i>
2005	10		*		European Goldfinch	<i>Carduelis carduelis</i>
1999	2		*		Common Myna	<i>Acridotheres tristis</i>
2005	77		*		Common Starling	<i>Sturnus vulgaris</i>
2002	4				Short-beaked Echidna	<i>Tachyglossus aculeatus</i>
1996	3				Yellow-footed Antechinus	<i>Antechinus flavipes</i>
1991	5				Common Brushtail Possum	<i>Trichosurus vulpecula</i>
1992	7				Common Ringtail Possum	<i>Pseudocheirus peregrinus</i>
1995	4				Koala	<i>Phascolarctos cinereus</i>
1995	1				Common Wombat	<i>Vombatus ursinus</i>
1997	2				Black Wallaby	<i>Wallabia bicolor</i>
2005	9				Eastern Grey Kangaroo	<i>Macropus giganteus</i>
1992	3		*		House Mouse	<i>Mus musculus</i>
1980	2				Water Rat	<i>Hydromys chrysogaster</i>
2005	5		*		European Rabbit	<i>Oryctolagus cuniculus</i>
2005	2		*		Brown Hare	<i>Lepus capensis</i>
2005	5		*		Red Fox	<i>Canis vulpes</i>
1993	2				Common Long-necked Tortoise	<i>Chelodina longicollis</i>
1994	6				Marbled Gecko	<i>Phyllodactylus marmoratus</i>
1995	1				Burton's Snake-Lizard	<i>Lialis burtonis</i>
1982	1		DD		Eastern Bearded Dragon	<i>Pogona barbata</i>
2003	13		VU		Tree Goanna	<i>Varanus varius</i>
1995	1				Southern Rainbow Skink	<i>Carlia tetradactyla</i>
1995	1				Carnaby's Wall Skink	<i>Cryptoblepharus carnabyi</i>
1970	1				Bougainville's Skink	<i>Lerista bougainvillii</i>
1995	1				Boulenger's Skink	<i>Morethia boulengeri</i>
1982	2				Common Blue-tongued Lizard	<i>Tiliqua scincoides</i>
1995	4				Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>
1991	1				Eastern Brown Snake	<i>Pseudonaja textilis</i>
1970	1				Dwyer's Snake	<i>Suta dwyeri</i>
1995	1				Black Rock Skink	<i>Egernia saxatilis intermedia</i>
2004	12		EN	L	Carpet Python	<i>Morelia spilota metcalfei</i>
1987	1				Southern Bullfrog	<i>Limnodynastes dumerilii</i>
2005	6				Spotted Marsh Frog	<i>Limnodynastes tasmaniensis</i>
1970	2		EN	L	Brown Toadlet	<i>Pseudophryne bibronii</i>
2005	4				Plains Froglet	<i>Crinia parinsignifera</i>
2005	5				Common Froglet	<i>Crinia signifera</i>
1970	2	VU	EN	L	Growling Grass Frog	<i>Litoria raniformis</i>
1994	50		*		Brown Trout	<i>Salmo trutta</i>
1994	52				Australian Smelt	<i>Retropinna semoni</i>
1994	183		*		Goldfish	<i>Carassius auratus</i>
1994	423		*		Carp	<i>Cyprinus carpio</i>
1990	16		*		Mosquitofish	<i>Gambusia holbrooki</i>
1993	132	VU	EN	L	Murray Cod	<i>Maccullochella peelii peelii</i>
1994	489		VU		Golden Perch	<i>Macquaria ambigua</i>
1994	411		*		Redfin	<i>Perca fluviatilis</i>

*Appendix 3: Fauna & flora significance criteria*

Criteria for assessing **zoological significance of taxa:**

<b>Local</b>	All indigenous fauna is considered significant at a Local level, because of the overall decline in the fauna since European settlement, and the continued incremental loss of habitat and reduction in abundance due to development.
<b>Regional</b>	A taxon is considered significant at a Regional level if: <ul style="list-style-type: none"> <li>▪ it has a disjunct distribution in the bioregion; or</li> <li>▪ it is represented in high concentrations in terms of colonial nesting, roosting or feeding sites; or</li> <li>▪ it is substantially depleted or restricted in the bioregion; or</li> <li>▪ it has an unusual ecological or biogeographical occurrence,</li> <li>▪ if the study area is within the Melbourne metropolitan area, the above four points pertain to the region of ‘Greater Melbourne’ as described by Beardsell (1997).</li> </ul>
<b>State</b>	A taxon is considered significant at a State level if it is: <ul style="list-style-type: none"> <li>▪ listed under Schedule 2 of the Victorian <i>Flora and Fauna Guarantee Act 1988</i>; or</li> <li>▪ listed under the <i>Advisory List of Threatened Vertebrate Fauna in Victoria – 2003</i> (DSE 2003); or</li> <li>▪ Listed as Data Deficient or Insufficiently Known under the following <b>Australian Action Plans</b>: Bannister <i>et al.</i> (1996), Cogger <i>et al.</i> (1993), Duncan <i>et al.</i> (1999), Garnett and Crowley (2000), Lee (1995), Maxwell <i>et al.</i> (1996), Pogonoski <i>et al.</i> (2002), Tyler (1997), Wager and Jackson (1993), or Sands and New (2003).</li> </ul>
<b>National</b>	A taxon is considered significant at a National level if it is: <ul style="list-style-type: none"> <li>▪ listed as Critically Endangered, Endangered, Vulnerable, Conservation Dependant or Presumed Extinct on the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>; or</li> <li>▪ listed as Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable Rare or Lower Risk (near threatened or conservation dependent) under the following <b>Australian Action Plans</b>: Bannister <i>et al.</i> (1996), Cogger <i>et al.</i> (1993), Duncan <i>et al.</i> (1999), Garnett and Crowley (2000), Lee (1995), Maxwell <i>et al.</i> (1996), Pogonoski <i>et al.</i> (2002), Tyler (1997), Wager and Jackson (1993), or Sands and New (2003).</li> </ul>

Guidelines for determining **significant sites for fauna:**

<b>Local</b>	All sites are generally considered at least Locally significant if they contain indigenous and/or exotic vegetation which supports indigenous fauna.  A site is also designated as being of Local significance if: <ul style="list-style-type: none"> <li>▪ it has moderate to high potential for serving as a habitat link between two sites of Regional significance or as a link to suburban areas to enable native taxa to disperse into such areas; or</li> <li>▪ it has moderate to high potential for rehabilitation and management for the public appreciation of fauna values.</li> </ul>
<b>Regional</b>	A site is designated as being of Regional significance if: <ul style="list-style-type: none"> <li>▪ it regularly supports taxa that are classified as Regionally significant; or</li> <li>▪ it regularly supports individuals of a disjunct population, unusual ecological or biogeographical occurrence or extraordinary concentration in a regional context of a naturally restricted (eg. colonial nesting, roosting or feeding) or substantially depleted or restricted taxon in the region; or</li> </ul>

	<ul style="list-style-type: none"> <li>▪ it supports a high level of species richness for the bioregion<sup>1</sup>; or</li> <li>▪ it contains a partial habitat link between two sites of state fauna significance, or a Regional and State site, or a primary habitat link between two sites of regional significance, or between a site of State significance and large urban areas.</li> </ul>
<b>State</b>	<p>A site is designated as being of State significance if:</p> <ul style="list-style-type: none"> <li>▪ it, at least occasionally, supports individuals of a taxon listed under the <i>Flora and Fauna Guarantee Act 1988</i> or listed as Critically Endangered or Endangered in Victoria (DSE 2003); or</li> <li>▪ it regularly supports taxa listed as Vulnerable in Victoria (DSE 2003). For birds this only includes records of breeding, a single sighting of a large population or repeated sightings of individuals; or</li> <li>▪ it regularly supports individuals of a taxon listed as Low Risk – near threatened or Data Deficient in Victoria (DSE 2003), or listed as Data Deficient or Insufficiently Known under the following <b>Australian Action Plans</b>: Bannister <i>et al.</i> (1996), Cogger <i>et al.</i> (1993), Duncan <i>et al.</i> (1999), Garnett and Crowley (2000), Lee (1995), Maxwell <i>et al.</i> (1996), Pogonoski <i>et al.</i> (2002), Tyler (1997), Wager and Jackson (1993), or Sands and New (2003), or supports a roosting colony of cave-dwelling bats; or</li> <li>▪ it supports very high species richness in the bioregion<sup>2</sup>; or</li> <li>▪ it regularly supports 5% or more of the Victorian population, or an extraordinary concentration in a State context of any taxa; or</li> <li>▪ it represents an intact primary habitat link containing comparable habitat attributes to two connecting sites or series of sites of State or higher zoological significance; or</li> <li>▪ it has high scientific significance, eg. it forms a long-term study or monitoring site.</li> </ul>
<b>National</b>	<p>A site is designated as being of National significance if:</p> <ul style="list-style-type: none"> <li>▪ it supports individuals of a taxon listed as Critically Endangered or Endangered under the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>, or the following <b>Australian Action Plans</b>: Bannister <i>et al.</i> (1996), Cogger <i>et al.</i> (1993), Duncan <i>et al.</i> (1999), Garnett and Crowley (2000), Lee (1995), Maxwell <i>et al.</i> (1996), Pogonoski <i>et al.</i> (2002), Tyler (1997), Wager and Jackson (1993), or Sands and New (2003); or</li> <li>▪ it regularly supports taxa listed as Vulnerable under the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>, or the following <b>Australian Action Plans</b>: Cogger <i>et al.</i> (1993), Duncan <i>et al.</i> (1999), Garnett and Crowley (2000), Lee (1995), Maxwell <i>et al.</i> (1996), Tyler (1997), Wager and Jackson (1993), or Sands and New (2003); or</li> <li>▪ it regularly supports a large population (exceeding 5% of the total known population) of a taxon listed as Conservation Dependant under the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>, or listed as Rare or Lower Risk (near threatened, conservation dependent or least concern) in the following <b>Australian Action Plans</b>: Bannister <i>et al.</i> (1996), Cogger <i>et al.</i> (1993), Duncan <i>et al.</i> (1999), Garnett and Crowley (2000), Lee (1995), Maxwell <i>et al.</i> (1996), Pogonoski <i>et al.</i> (2002), Tyler (1997), Wager and Jackson (1993), or Sands and New (2003)</li> <li>▪ it contains areas declared as ‘Critical Habitat’ under the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>.</li> </ul>

<sup>1</sup>The number of taxa required to fulfil this criterion will vary depending on the size, scope and season of the survey. For the Greater Melbourne region Schulz *et al.* (1991) used 2' latitude by 2' longitude blocks with a six year survey period. Their species richness criteria required 7 to 21 native mammal taxa, 50 to 100 native bird taxa, or 8 to 24 taxa of native frogs and reptiles.

<sup>2</sup> For the Greater Melbourne region, Schulz *et al.* (1991) specified 22 or more native mammal species, 110 to 150 native bird species, or 25 or more species of native frogs and reptiles for 2' latitude by 2' longitude blocks surveyed over six years. The number of species required to fulfil this criterion will vary depending on the size, scope and season of the survey, and a knowledge of the fauna of the region.

Watkins (1993) Criteria for determining National and International **significant sites for shorebirds**<sup>1</sup>

<b>National</b>	<p>A site is designated as being of National significance for shorebirds if:</p> <ul style="list-style-type: none"> <li>▪ it supports 10,000 or more shorebirds; or</li> <li>▪ it supports 1% or more of the individuals of the Australian population of a taxon or sub-taxon of shorebird.</li> </ul>
<b>International</b>	<p>A site is designated as being of International significance for shorebirds if:</p> <ul style="list-style-type: none"> <li>▪ it supports 20,000 or more shorebirds; or</li> <li>▪ it supports 1% or more of the individuals in a population<sup>2</sup> of a taxon or sub-taxon of shorebird.</li> </ul>

<sup>1</sup>These criteria are modelled on the RAMSAR Convention criteria for identifying sites of significance for waterbirds.

<sup>2</sup>For taxon and sub-taxon that also occur outside Australia, the population is defined as all of the birds of that taxa or sub-taxa occurring in the East Asian-Australasian Flyway.

#### Appendix 4: A summary of the ecological literature on Lake Mokoan.

An asterisk (\*) after the study name indicates the report was not accessed directly but the main findings and scope were ascertained by reference to AWT's 2000 report 'Documentation of Historical Vegetation Studies at Lake Mokoan'

Study	Scope	Major Findings
Conservation Forests and Lands (1950)*	Vegetation species lists compiled for northern edge of what is now LM	377 species were identified: 267 indigenous and 110 exotic. Several taxa now regarded as rare or threatened were recorded.
Aston (1959 and 1962)	Described the Winton Swamp complex prior to the creation of Lake Mokoan. Compiled a list of plant species observed during 6 visits carried out in 1959 and 1960	Four major botanical regions described in terms of floristics: A. Timbered NE section (Green Swamp); B. Large expanse of semi-open water dominated by Cane Grass ( <i>E. infecundua</i> ) (central and western sections of the swamp); C. Timbered edged to the central and western sections; D. Damp areas just above present water level and subject to irregular inundation.
<b>THE LAKE MOKOAN RESTORATION PROGRAM STUDIES</b>		
DNRE (1990)*	Three quadrats sampled during April on the northwestern side of the lake near the wall (purpose of work and agency involved not known)	No rare or threatened species recorded. Quadrats contained between 22 and 34 species, approximately a third of which were exotic.
Roberts and Mitchell (1991) Murray Darling Freshwater Research Centre, Albury*	Report covering general ecology of aquatic macrophytes at Lake Mokoan and the requirement for natural re-establishment. It provides a strategy for the re-establishment of vegetation and describes the implementation processes.	Concluded that revegetation of the shoreline was feasible with a success of at least 50%. Water level manipulation would require careful management to ensure the vegetation was maintained. The probability of reducing turbidity by replanting aquatic plants was not more than 25%. A number of recommendations for revegetation and for further studies were made.
Cooling (1992) DCE*	A pilot study of littoral vegetation of LM for future restoration work. Aimed to identify plants present, the ecological conditions under which they exist and which species might have a role in future restoration works. Involved establishment of 6 transects around the lake.	Species diversity was greatest at the sites with a gradual rather than a sudden transition from wetland to terrestrial vegetation. Cooling identified several issues needing further investigation, including the possible requirement for seasonally fluctuating water levels in the life cycles of the littoral vegetation.
Purcell (1993) Monash University*	Study of the soil seedbank potential from five locations around the lake.	A viable seedbank did exist. Submerged conditions produced fewer seedlings. Suggested water level be drawn down to expose an extensive area of the lake as available habitat for mud flat species as the water recedes. Concluded changes in water level at LM would need to be slow so seedlings can set seed and restock the seedbank to ensure future revegetation potential.
Clark (1993) DCNR*	Set up a grazing study which included the following studies: effects of grazing on existing vegetation; effects of grazing on manually planted propagules; long term grazing impacts; the use of pasture plants; vegetation fire hazards and grazing and vegetation data analysis	establishment report only
Ward (1994)*	Flora Survey of 12 dams near LM to determine their botanical composition. Possibly undertaken to identify a seed source for revegetation of LM and potential trial sites.	91 species were recorded across the 12 dam sites (41 exotics and 50 indigenous). Aquatic component was typical of shallow wetlands holding water for extended periods (>6months).
Clark (1994)*	Progress report on the Lake Mokoan Grazing exclusion Trials (see Clark 1993).	Data after 12 months suggest grazing exclusion does not increase fuel load for fire and in fact vegetation in exclusion plots had higher moisture content thus a lower risk of ignition than grazed plots.
Undocumented monitoring and revegetation works - 1995/1999	Various works were carried out including revegetation trials of Moira Grass, Cane Grass and Water Milfoil. A wall was built behind the Spit in 1996 to pond water so as to create a sheltered wetland for potential use as a source of vegetation for future revegetation of the lake.	
Loone (1995)*	Report on the status of restoration works at the Duckpond. Aimed to determine the effect of water level manipulation on natural regeneration of aquatic veg, the success of manually planted cereal crops in stabilizing lake bed sediments and the success of manually planting aquatic species.	Manual planting of both pasture and aquatic species as well as natural regeneration at the Duckpond following water level manipulation proved successful.
Lloyd (1995)*	Documents the construction of the Seven Mile Creek Wetland and its purpose	Wetland established and monitoring program recommended.
Water ECOscience/AWT (1996)*	Revegetation plan based on initial strategy set out by Roberts and Mitchell (1991). Provides a discussion on the present condition of the margins of Lake Mokoan as determined by an assessment undertaken in spring 1996	Advantages and disadvantages of various revegetation methods summarized. Following this report an aquatic plant revegetation program was established to implement and monitor some of the recommendations.
Ward (1997) DNRE*	List of suitable aquatic and terrestrial plants to revegetate Lake Mokoan and their habitat requirements of these species.	Identifies length of optimal inundation, depth to which each species grows and the flowering season and requirements for flowering in terms of moisture. (List produced as draft only)
Putt and Sandercock (1998) GMW	Annual inspection visit as part of major Storages Operational Monitoring Program. Focused on areas of submerged and emergent macrophyte populations - was a broad visual assessment with species noted.	
AWT (1999)	<i>Series of technical reports, the most relevant to the current Ecological review being:</i>	
	<b>Revegetation Monitoring (Report 3/99):</b> Trial planting using Jutemat and JuteLogs with the following species: <i>Carex tereticaulis</i> , <i>Carex appressa</i> , <i>Juncus subsecundus</i> , <i>Eragrostis infecunda</i> , <i>Pseudoraphis spinescens</i> and <i>Eleocharis acuta</i> . Monitoring of revegetation works carried out in previous years.	Jutemat likely to be most effective for revegetation success if used in areas inundated for some time each year and protected from wave action. Poor success of revegetation trials attributed mainly to wave and wind action and in some cases lack of water supply.
	<b>Bio-manipulation Workshop (4/99):</b> A workshop with AWT and GMW was held to examine the potential effectiveness for LM of a number of bio-manipulation techniques and identify the basis of trial designs for any recommended bio-manipulation techniques	The preferred combination for bio-manipulation trial designed generally involved combinations of measures to clear the water, revegetation and/or manipulate the fish.
	<b>Literature Review of Light Requirements for Plants at Lake Mokoan (Report 7/99):</b> Review of literature (including international journal papers) on light requirements of aquatic plants formally and presently found at LM (e.g. <i>Chara</i> spp., <i>Myriophyllum</i> spp., <i>Phragmites</i> spp., <i>Potamogeton</i> spp.) and development of a reference database on these citations.	Although most submerged aquatic plants are inhibited by high turbidity and consequent low light levels emergent species have better tolerance to these conditions. It is concluded that factors such as wave action, water regime and potential lack of a viable seed bank may be preventing establishment of many aquatic plant species. Produced a summary table of light requirements of various taxa relevant to LM.
	<b>The distribution and ecological effects of blue green algal blooms on the fish community (Report 11/99):</b>	
	<b>Floating Pondweed Trial (Report 12/99):</b> Floating pondweed was removed from Yarrowonga Weir and replanted at two sites in the SW area of LM, the success of the transplant was then monitored and reported on.	Available observations suggest plants may have died as not floating leaves were apparent - possibly as a result of wave action or interference by carp.
AWT (2000)	<i>Series of technical reports, the most relevant to the current Ecological review being:</i>	
	<b>Mokoan Creek River Health Monitoring (Report 2/00):</b> Macroinvertebrate monitoring of three inflowing streams over two sampling events.	Streams were uniformly degraded and typical in their biology of intermittent stream systems in Northern Victoria. Local catchments issues included loss of riverine habitat, nutrient inputs and high stream turbidity (all characteristic of agricultural disturbance). Remedial measures on Seven Mile Creek have been effective in improving river health.
	<b>LM Vegetation Survey (5/00):</b> Veg survey of 25 sites on LM to determine vegetation coverage and plant species distribution. Earlier revegetation trials were monitored.	A total of 46 common species recorded, including 9 exotics. Highest diversity was found in areas sheltered from wind and wave action (e.g. Seven and Eleven Mile Wetlands and Duckpond). Some vegetation was attributed to successful revegetation trials from two years prior, other plants had apparently generated from existing seed bank.

	<b>LM Feasibility of Direct Seeding for Revegetation of Aquatic Species (Report 6/00):</b> Investigation of the feasibility of using direct seeding methods to revegetate the margins of the lake, carried out through review of literature and discussions with contractors/nurseries etc.	Germination from seed is considered a secondary method by which wetland plants establish themselves. A number of environmental factors are known to effect germination including nutrient availability, temperature, salinity and the activity of seed eating animals. Water availability most important factor - most species occur on moist but not inundated soils. No seeding methods have a strong history of use in wetland situations. Success rates are undetermined. Possibility of direct seeding with agricultural species is discussed.
	<b>Documentation of Historical Vegetation Studies at Lake Mokoan (Report 10/00):</b> Review of studies and works conducted to date (mainly as summarized above)	Most projects have been undertaken to establish baseline information on vegetation currently occurring in and around LM. Water regime management was suggested most frequently throughout the literature reviewed as being an important feature for further investigation. Other recommendations made repeatedly include monitoring of vegetation, fencing a buffer zone to exclude grazing, investigating appropriate species for revegetation, carp eradication and the influence of turbidity and light on regeneration.
	<b>Lake Mokoan Seed Bank Investigation (Report 11/00):</b> Sediment cores taken from three bank heights along 5 transects around LM. Germination trials included submerged and emergent water conditions and under turbid or clear conditions. Germination was monitored over 18 weeks.	Emerged conditions better for germination (high diversity). Seed bank differed in both diversity and abundance between various locations around the lake. Higher bank levels had higher diversity and abundance levels (common plants were Rush, grasses, common sneezeweed and Loosestrife). Low mat forming taxa were the only abundant aquatic species. Seedling density higher than recorded by Purcell in 1993. Turbid water had no detectable effect on germination. At least 28 taxa found in the seedbank (including about a third exotics)
	<b>Eleven Mile Wetland Vegetation Assessment and Sediment Level Monitoring (Report 16/00):</b> Determine the success of regeneration of aquatic vegetation as a result of the construction of the Eleven Mile Wetland in March 1999. to collect information at a number of sites across the wetland as a base line for future comparisons of sediment deposition/erosion.	The diversity of vegetation at Eleven Mile Wetland was found to be good (62 species) and the regeneration of aquatic species healthy. 39% of taxa observed were indigenous and 38% introduced (the remainder were immature and not identifiable).
	<b>LM Restoration Program Review:</b> A report on the workshop held in September 2000 with technical experts. Purpose was to review the strategy established in 1996.	The revised vision acknowledges that LM may be restored to a stable and diverse ecosystem supporting diverse vegetation without necessarily being a clear water system. Minimizing the occurrence of blue-green algal blooms and enhancing habitat for vegetation and wildlife was emphasized. Future strategies include data collation, target species for revegetation and modeling of shear stress, hydrology and ecology.
AWT (2001)	<i>Series of technical reports, the most relevant to the current Ecological review being:</i>	
	<b>Duckpond monitoring overview:</b> overview of water quality monitoring for Duckpond between 1993 and 2000. Discussion of changes in the Duckpond.	Duckpond has undergone significant transformations from an algal-dominated to an aquatic macrophyte-dominated system. After 1999, as aquatic macrophytes became more dominant, turbidity and algal pigment levels decreased.
	<b>LM Vegetation Survey and Trial Plots:</b> Broad veg survey around lake margins to allow comparison with data from 2000. Survey conducted by boat and did not include revegetation plots and wetlands. Trial replanting of Common Reed.	Recorded presence of 22 taxa (including 7 exotics) at 7 locations. A rise in water level apparently flooded Juncus which was dominant in 2000 survey however new aquatic species such as Cane Grass and Moira Grass had established, immersed in approximately 1 m of water. Not known whether these species entered the system from the inlet channel or germinated from seed dormant in the seed bank. Common Reed transplants initially died back but some new shoots appeared later - success of the transplant was not certain.
AWT (2002)	Photopoints - seasonal photos taken during 2001 and 2002 at six photopoints around LM.	Series of photos taken at: the Duckpond; the Waterhole; the Spit; Seven Mile Wetland; the Wall at the 0.5 km mark; and the Wall at the 5.0km mark.
AWT (2003)	Photopoints (update)	As above, with photos from 2002-2003
AWT (2004)	Photopoints (update)	As above, with photos from 2003-2004
<b>DECOMMISSIONING INVESTIGATIONS</b>		
SKM (2002)	"Water Savings in Bulk Water Systems in Northern Victoria": Study aimed at identifying how and where water savings could be made and to identify potential impact on water customers, the environment and regional economics.	Numerous potential savings were studied however many were found to be impractical or not economically viable. Three options involving changes to Lake Mokoan were considered: taking the lake offline and reverting to Winton swamp; partitioning the lake to reduce its size and (a variant on the second option) partitioning the lake and running it as an annual storage. The first option is regarded as preferable for ecological values, as reducing the storage is expected to increase turbidity and encourage carp and blue-green algae. Lake Mokoan presents best opportunities for water savings in the region.
URS (for GBCMA) (2003)	"Lake Mokoan Study" (5 Volume report): sets out to determine feasibility of the options presented by SKM to provide Government with sufficient info to make a decision about the future of the lake. In the process (which included community input) options were revised to wider set of options composed of different physical configurations and FSLs. Options were considered from perspective of: water supply; socio-economic impacts and effects on the environment. This report also considers potential uses of reclaimed land.	Environmental issues associated with each of the 6 refined options are described based on literature review (e.g. Lake Mokoan Restoration Program studies), reference to ecological theory of Alternative Stable States and knowledge of the expert team brought together for the study.
Lloyd (2004)	"One scenario for the rehabilitation of wetlands and marginal lands at the Lake Mokoan site" - Looks at the option of restoring Winton Swamp and associated wetlands and identifies major ecological considerations. It does not cover the actions required for the inlet or outlet channel. This study did not involve primary data collection.	